# ASSESSMENT OF FEED RESOURCES AND RANGELAND CONDITION IN METEMA DISTRICT OF NORTH GONDAR ZONE, ETHIOPIA

**M.Sc. Thesis**

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**APRIL 2008**

**Haramaya University**

# ASSESSMENT OF FEED RESOURCES AND RANGELAND CONDITION IN METEMA DISTRICT OF NORTH GONDAR ZONE, ETHIOPIA

**A Thesis Submitted to the Department of**
**Animal Sciences, School of Graduate Studies**
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**In Partial Fulfillment of the Requirements for the Degree of**
**MASTER OF SCIENCE IN AGRICULTURE**
**(RANGE ECOLOGY AND MANAGEMENT)**

**BY**
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**APRIL 2008**
**HARAMAYA UNIVERSITY**

## SCHOOL OF GRADUATE STUDIES

## HARAMAYA UNIVERSITY

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# DEDICATION

This thesis is dedicated to my father Ato Desalew Adal due to whose proper guidance and effort in my school inspired a great interest of learning in my mind and to my mother W/ro Bifa Arega who provide me all her love and sacrificed her interests for my success while I was in school and that will be remembered for ever.

# STATEMENT OF THE AUTHOR

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

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Name: Tesfaye Desalew

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Date of Submission: April 2008

# LIST OF ABBREVIATIONS

| | |
|---|---|
| ADF | Acid Detergent Fiber |
| ADL | Acid Detergent Lignin |
| AEZ | Agro-ecological Zone |
| ANOVA | Analysis Of Variance |
| ANRS | Amhara National Regional State |
| AOAC | Association of Official Analytical Chemist |
| BOA | Bureau of Agriculture |
| $^{O}C$ | Degree Celsius |
| CACC | Central Agricultural Census Commission |
| CBFS | Cotton Based Farming System |
| CRs | Crop Residues |
| CSA | Central Statistic Authority |
| DCP | Digestible Crude Protein |
| DM | Dry Matter |
| FAO | Food and Agricultural Organization of the united nation |
| GLM | General Linear Model |
| Ha | hectare |
| HHC | House Hold Count |
| HH | House Hold |
| ILCA | International Livestock Center for Africa |
| ILRI | International Livestock Research Institute |
| IVDMD | Invitro Dry Matter Digestibility |
| LSM | Least square mean |
| Masl | Meter above sea level |
| ME | Metabolizable Energy |
| MOA | Ministry of Agriculture |
| NDF | Neutral Detergent Fiber |
| OARD | Office of Agriculture and Rural Development |
| OM | Organic Matter |

## LIST OF ABBREVIATIONS *(Continued)*

| | |
|---|---|
| PAs | Peasant Associations |
| SE | Standard error |
| SBFS | Sesame Based Farming System |
| SPSS | Statistical Package for Social Science |
| SSA | Sub -Saharan Africa |
| SRM | Society of Range management |
| TLU | Tropical Livestock Unit |

# BIOGRAPHICAL SKETCH

The author, Tesfaye Desalew, was born in North Shoa Zone, Dera District in 1970. He attended elementary school at Selelkula Junior secondary School and his high school education at Merhabete Patriots Higher Secondary School. He joined the Alemaya University of Agriculture in 1986/87 academic year. He graduated with Bachelor of Science Degree in Animal Sciences in 1990. After his graduation, he was employed in the Ministry of Agriculture in South Wollo Zone, Department of Agriculture and has worked with different capacities districts and to zones. In September 2006, he joined the School of Graduate Studies of the Haramaya University to pursue his MSc study in Range Ecology and Management.

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# ASSESSMENT OF FEED RESOURCES AND RANGELAND CONDITION IN METEMA DISTRICT OF NORTH GONDAR ZONE, ETHIOPIA


## ABSTRACT

*The study was conducted in Metema District of Amhara Region and the objectives of the study were to assess the major livestock feed resources, to analyze the chemical composition of major feeds, to assess the rangeland condition and investigate the floristic composition and dry matter biomass yields of herbaceous species in the District.The livestock feed resources were assessed by formal and informal survey and analyzed by descriptive statistics. In the assessment range condition, grass species composition, basal cover, litter cover, soil erosion, soil compaction, seedling count, age distribution and woody density enumeration, canopy cover and hedging effect were collected and analyzed by GLM and LSD is used for mean comparision. The chemical analysis of the major feeds, a statistical model $Yij= \mu + Si + Lj + eij$ were used. Natural pasture (55.7 %), crop residues (20.7 %), stubble (14.3 %) and hay (9.3 %) were the major feed resources for dry season where as in the wet season, only natural pasture serves as feed resource. The estimated feeds from crop residues (827.16) ton DM per annum, grazing land and stubble (780750 and (51954) ton DM per annum could be obtained, respectively and total estimated available feed supply was 833531.16 ton DM per annum. Crop residues utilization, hay making and amount of supplementation is not appropriate. 33 herbaceous species were identified; of these, 14 and 19 were different grasses and non-grass species. From the non-grass species 6 legumes and 13 sedges and others species were recorded. Of the grasses, 23.07 %, 38.46 % and 30.77% were highly desirable, desirable and less desirable, respectively. Of the identified 20 woody species, 15 %, 35 %, and 50 % were highly desirable, desirable and less desirable, respectively.The height of 41.2% of trees and shrubs in communal grazing areas, 38.5% in road side grazing and 33.3% in enclosed areas were grouped within the height class of (1- 3 m) .The range condition assessment factors (basal cover, litter cover, grass species composition, woody vegetation density, canopy cover, hedging effect, age distribution and total condition score) in communal grazing areas of SBFS were significantly ($P<0.05$) higher than CBFS. The grass species composition, basal cover, litter cover, age distribution, and woody species density score in enclosed areas had a significantly ($P< 0.05$) higher than in communal grazing areas and roadside grazing areas. The total grass biomass, highly desirable grasses, desirable grasses species and legumes and others in the SBFS were significantly ($P<0.05$) higher than in the CBFS. The total dry matter biomass, dry matter biomass of grass and highly desirable grasses, and legumes were significantly ($P<0.05$) higher in the enclosed areas than the communal and the road side grazing areas. The finding of this study indicate that the rangeland condition of communal and roadside grazing areas of the district need rehabilitation, proper management and regulatory activity.The duration and managements of feed conservation and amounts of supplementation should be improved.*

# 1. INTRODUCTION

Ethiopia is known as an African country with the richest livestock resources. About 62 % of the total land surface in the country is suitable for grazing (Hogg, 1997; Alemayehu, 1998). The lowlands of the country are found below 1500 masl and are estimated to cover about 78 million ha, which is about 61-65 % of the total land area of the country (FAO, 1992; Friedel *et al.*, 2000). They are home for about 12 % of human and 26 % of livestock population (Beruk *et al.*, 2003). Relatively, low human population densities and highly variable and uncertain rainfall have characterized the lowland areas. Due to this, the low land areas of the country are difficult for humans to live in comfortably concentrated ways. In the pastoral community, grazing biomasses are entirely determined by the amount, pattern and timing of rainfall in that particular year. Therefore, the amount and distribution of rainfall is the prime limiting factor, which in addition to high temperature, affects the quality of the rangelands. Furthermore, the intensity of grazing and browsing and restriction in livestock mobility are factors that exert strong impact on the rangelands than the number of animals owned by the pastoralists.

In most of the developing countries, rangelands have contributed to the major portion of feed consumed by ruminants. As in other developing countries, livestock production in Ethiopia heavily relies on rangeland. Rangeland is defined as a land on which the indigenous vegetation (climax or natural potential) is predominantly grasses, grass-like plants, forbs or shrubs. Rangeland is largely managed as a natural ecosystem. If plants are introduced, they are managed similarly. Rangelands include natural grasslands, savannas, shrub lands, many deserts, tundra, alpine communities, marshes and wet meadows (SRM 1999). Most rangelands are rarely suitable for arable cropping. In Ethiopia, there are extensive areas where the raising of livestock on the natural vegetation is the only possible types of land use (Coppock, 1994). The rangelands of Ethiopia are presently being extensively deteriorated both in quantity and quality (Tamene, 1990; Belaynesh, 2006).In seasonally dry environments, the main limitations to animal production are lack of green feed for at least half of the year. The other is the low nutritive quality of forages during most of the period of active pasture growth (Jones and Wilson, 1987). The low nutritive quality of the forage is due mainly to environmental stresses such as high temperatures (Van

Soest, 1988) and infertile soils (Roberts, 1987). The major reducer of livestock productivity is dry-matter intake which, in turn, is influenced by the palatability, chemical composition and physical attributes of the diet.

The Amhara National Regional State (ARNS) is located in the northwestern part of Ethiopia. The regional state has 11 administrative zones and more than 100 districts. The Metema District is one of the 104 districts of the ARNS found in North Gondar Administrative Zone near the border of Sudan. The district is broadly categorized under the low-land agro-ecological zone of in the northwestern parts of the country. Livestock production in the district is an integral part of the land use system. Cattle and goat rearing is a common practice in the area. According to Sisay (2006), the major livestock feed resources in the study areas are natural pasture, crop residues, crop aftermath and hay. The area has relatively reliable natural pasture during wet season (ILRI, 2005; Elias *et. al*., 2007). As indicated on the district's land use data out of the total area of land, there are extensive grazing lands in the study area. As a result, about 72 % of the land is covered by grazing and forest land. Despite large extensive grazing lands in the district, the district is known for critical livestock feed shortage in dry season. Continuous settlement program by the government caused increase in population, which in turn increased the need for farmlands. The scramble for farmlands caused decline in the rangeland. The other cause for reduction in the size of rangeland is the increasing demands for farmlands by investors and the transhumant large livestock seasonal movements into the district from the neighboring three highland districts of Chilga, Dembia and Gondar Zuria. The factors together exerted a negative impact on the productivity and situation of rangeland of the district.

To maintain the optimum productivity and sustainable use of the rangeland resources for the future, knowledge about the current rangeland resources is indispensable. Absence of adequate base-line information about the available rangeland resources had been identified as one of the bottle-necks that hindered the development of rangelands in Ethiopia (Amsalu, 2000). The study area was no exception. Therefore, it is important to gather data on the rangeland conditions, assessments of the quality of livestock feed resources and the constraining circumstances in the area. Thus, the main purpose of this study is to generate base-line information on livestock feed and rangeland resources. The objectives of the study were to:

- assess the major livestock feed resources in the district;
- analyze the chemical composition of the major livestock feed resources,
- assess the rangeland condition of the district based on herbaceous, woody and soil layers and
- investigate the floristic composition and dry-matter biomass yields of herbaceous species.

# 2. LITERATURE REVIEW

This chapter reviews relevant literatures on vegetation as an indicator of the environments. It also discusses the types of livestock feed resources in Ethiopia. What is more, the chapter deals with the rangeland potential of the country and it's the traditional rangeland management practices. The causes of degradation (deterioration) of the rangelands and the compositions of species of the diferse vegetations in the rangelands will be discussed as adequately as possible. In addition, rangeland condition assessment procedures, dry matter biomass estimation methods and applications are thoroughly analyused in the chapter.

## 2.1 Vegetation as an Indication of Environment

Natural vegetation integration reflects the entire natural environment. If the natural vegetation is left undisturbed, it may be used as the broad guides to rainfall. If topography, geology and soil conditions of the natural vegetation do not show remarkable change, change in vegetation usually reflects change in rainfall (Coaldrake *et al*., 1976). Basically, the vegetation of an area is the product of the material available and the nature of the ecological environment including landform, soil and climatic conditions and the impacts of socially induced factors like fire, grazing and modification, circulation of minerals and plant decay. Furthermore, to completely understand vegetation, it is necessary to consider the past as well as the present condition of vegetations, vegetations have their own history. Often, the present vegetation represents a stage of regression from a more highly developed or vigorous community that has been brought under stress, perhaps through overgrazing. The vegetation may also show the changes that have occurred to the environment. The factors that affect vegetation are basically inseparable as they exert their pressures together. However, just for the purposes of discussion, it is convenient to see them separately (Pratt and Gwynne, 1977)

## 2.2. Major livestock feed resources in Ethiopia

Livestock in the Sub-Saharan Africa are dependent primarily on native grasslands and crop residues (Ibrahim, 1999). According to Alemayehu (2003), Ethiopia's Livestock feed resources are mainly natural grazing and browse, crop residues, improved pasture, and agro-industrial by-products. The feeding systems 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 (Stubble). The availability and quality of forage are not favorable year round. As a result, the gains made in the wet season are totally or partially lost in the dry season (Alemayehu, 2003). Inadequate feed during the dry season is a major that causes decline in the productivity of ruminants. In the Sub-Saharan Africa, human population is increasing rapidly, forcing farmers to use grazing areas for arable farming. As a result, the smallholder farmers in in this part of Africa have integrated their livestock into their cropping systems and used crop residues as a main livestock feed resources (Ibrahim, 1999).

### 2.2.1. Feed availability and nutritive value of range forage

#### 2.2.1.1. Natural pasture

Natural pastures include annual and perennial species of grasses, forbs and trees (Masiiwa, 1998). They comprise the largest feed resource, but estimates of the contribution of this feed resource vary greatly. Alemayehu, (1998a) estimated that 80-85 % of the livestock feed in Ethiopia comes from natural pasture. Other works estimated that the natural pasture provides 88-90 % of the feed. This is because the quantity and quality of native pasture varies with altitude, rainfall, soil and cropping intensity. The total area of grazing and browsing in the country is 62,280 million hectares. Out of this, 12% is in the farming areas (more than 600 mm rainfall) and the rest is around the pastoral areas (Alemayehu, 1985). In extensive and semi-extensive systems, natural rangeland is a major feed resource (Gambiza, 1996). Communal grazing is normal and managed as a common property resource (Behnke and Schoones, 1993; Wolmer, 1997). The carrying capacity of the grazing area, if calculated on plant availability, should allow a plant use of 30–50% (de Leeuw and Toothill, 1993). A major variable in the system is rainfall, which affects the productivity rangeland and the supply of other feed resources. As listed by (Gammon, 1984), the important principles of rangeland management are stocking rate, rest and the frequency of grazing. In communal rangelands, high stocking rates, few rest periods and frequent close grazing, and fire are factors causing debilitating impacts on rangelands. In addition, the unavailability of adequate water points are other debilitating factor (Gammon, 1984).Trees are an important components of the rangelands and have major roles such as environmental conservation (Atta-Krah, 1989), a source of fuel wood and building materials (UNESCO, 1996), feed for browsers (Atta-Krah 1989). As a result of this, a combination of grazers and browsers should increase the carrying capacity of rangeland. In semi-arid areas, the value of tree litter as cattle feed and a source of shade should not be underestimated (Smith *et al*., 1995a).

Seasonal fluctuations of feed resources in the tropics follow the pattern of vegetation growth that is affected by the availability of rainfall. This resulted in a seasonal pattern of wet season gain and dry season loss of live weight. Seasonal fluctuations in the availability and the poor quality of feeds are considered to be the main constraints on sheep production in arid regions (Guada, 1989).

According to NRC (1962**),** chemical analysis of range forage plants serves as a comparative measure of differences between species and change with season. They are also useful for measuring differences on the effect of the stage of growth and the quality of sites on chemical constituents**.** Simbaya (1998) reported that the quality of natural pastures is also influenced by the absence of legume species in communal grasslands. This tends to limit the nutritional quality of available fodder. As a result, animals are unable to meet their protein, energy and mineral requirements. Osuji *et.al* (1993) suggested that poor nutrition is one of the major constraints to livestock productivity in the sub-Saharan Africa (SSA). This is because, in this part of the continent, animals predominantly depend for their feed on high-fiber feeds (straws, Stover's and native pasture hay) which are deficient in nutrients (nitrogen, Sulphure, minerals, phosphorus etc) and suitable for microbial fermentation. Consequently, the digestibility and intake of digestible nutrients are unavoidably low. However, these deficiencies can partly be mitigated by supplementing roughage diets with feeds containing the deficient nutrients.

Table 1. Percentage nutritional quality characteristics of major feed resources in Metema district as influenced by seasonal changes

| *Feed types* | *Season* | *% chemical compositions* | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | DM | ASH | CP | ADF | ADL | NDF | IVDMD |
| Natural pasture | August | 93.4 | 9.4 | 6.4 | 45.8 | 4.7 | 78.3 | 57.8 |
| | October | 94.1 | 10.3 | 5.7 | 47.8 | 5.5 | 78.5 | 56.9 |
| Fodder | | 92.9 | 8.6 | 13.2 | 40.6 | 13.2 | 54.5 | 47.9 |
| Hay | | 94.5 | 10.5 | 7.2 | 41.2 | 4.8 | 76.8 | 54.3 |
| Sorghum stover | | 92.4 | 7.9 | 3.1 | 44.9 | 6.3 | 75.5 | 46.9 |
| Teff straw | | 93.2 | 8.9 | 4.3 | 46.9 | 8.0 | 76.0 | 41.0 |
| Millet straw | | 92.4 | 9.8 | 4.2 | 44.2 | 5.9 | 72.3 | 52.8 |

Source: Sisay (2006)

To feed the increasing human population, continuous cereal growing has been undergoing. Parallely, the carrying capacity and quality of the grazing land is on the decline. In general, feed shortages and nutrient deficiencies become more acute in the dry season in both the highlands and lowlands (Alemayehu, 2003). For various reasons, crop residues and agro-industrial by-products are not adequately utilized. Cultivation of forage is not widely adopted. Again, commercial feed production is not developed. In the lowlands, livestock production is almost totally dependent on natural grazing. However, grazing lands do not fulfill the nutritional requirements of animals, particularly in the dry season, due to poor management and the inherent low productivity and poor quality.

Range forage varies in quality from time to time and from place to place. It is during the growth stages that plants are most nutritious (See Table 1 above). Once mature, plants are subjected to leaching and dilution of nutrients. Reduction in the nutritional values, declines in nutrient composition and leaching are especially serious in the case of herbaceous plants (Alemayehu, 2006). As plants mature, crude protein, the more readily digested carbohydrates, and phosphorus decrease. In contrast, fiber, lignin and cellulose increase (Stoddart *et al*., 1975). Most grasses and tree leaves in arid environments are low in nutritional values because of high contents of lignin and relatively indigestible cellulose and hemi-cellulose. The plants require such substances to protect themselves from high temperatures and evapo-transpiration. Unfortunately, they lower their nutritional contents and digestibility (Mathur *et al*. 1991). The stage of growth, maturity of grasses and taste influence the nutritional values of these sources of feed.

#### 2.2.1.2. Crop residues

Crop residues (CRs) are roughages that become available as livestock feeds after crops have been harvested. They are distinct from agricultural by-products (such as brans, oil cakes, etc), which are generated when crops are processed. Residues can usually be grouped along crop types-cereals, grain legumes, roots and tubers, and so on (World Bank, 1989; Nordblom and Shomo, 1995). Apart from being a source of animal feed, residues are sources of building, roofing and fencing materials. They are used also as fuel and as fertilizers or as surface mulch in cropland (Van Raay and de Leeuw, 1970, 1974). Their value as feed depends on the demand from livestock owners, which varies with the overall supply and demand situation for feeds. This, in turn, depends on the density of livestock, usually expressed in tropical livestock units per square kilo meter (TLU $km^{-2}$) and the supply of other feed resources, in particular, forage and browse from natural vegetation (de Leeuw and Rey, 1995). The supply of CRs is a function of the proportion of land used for cropping and the amount of edible feed yields per unit of land. Where consumable livestock feeds from CRs exceeds from natural pastures (expressed in t DM $ha^{-1}$), the expansion of cropland has a positive effect on overall feed supplies.

### 2.3. Rangeland Potential of Ethiopia

The pastoral rangelands of Ethiopia are located around the peripheral or the outer edge of the country, almost surrounding the central highland mass (Alemayehu 2004). The areas are classified as marginally arable and non-arable land. They comprise about 62 % (767,600 $kms^2$) of the country's land area. Most of these areas are below 1500 meters above sea level with the south west and the south eastern areas having an altitude of around 1,000 meters above sea level and the south eastern and south western rangelands rising up to 1,700 meters above sea level (Kidane, 1993). The lowland climates are arid (64%), semi-arid (21 %) and sub-humid (15%) and the zones are largely characterized by four rainfalls and temperature regimes. These zones also vary markedly in terms of the number of plant growing days per year, forage production, common plant associations, livestock and human carrying capacities and incidence of livestock diseases. Today, Ethiopia has over 70 million heads of livestock. The lowlands are home to 12% of the human population and 26% of the livestock (that is about 21 million heads of livestock). Various forms of pastoralism and agropastoralism dominate land use by the 29 ethnic groups of living in the lowlands of the country. In the lowland areas of the country, livestock depends upon rangelands consisting of native pasture. As calculated for the lowlands overall, roughly six people/$km^2$ depend on 11 Tropical Livestock Units (TLUs), which are composed of cattle (49%), goats (16%), equines (16%), camels (12%) and sheep (7%).

### 2.3.1. Traditional grazing land management

Traditional knowledge in natural resources management and utilization has been playing important role in improving and developing land use system in the world (Angello, 1996). The pastoralists have been using the traditional grazing management in order to cope up with the relatively arid condition of the environment, prevent overgrazing and ensure the sustainability of the resources base. Pastoralists use flexible grazing strategies. Overall, their gazing management is the result of their cumulative knowledge about resources, assessment of range condition and distribution of rainfall (Ayana, 1999). These traditional practices are good experiences on the basis of which it is possible to develop improved pastoral system.

## 2.4. Causes of Range Land Degradation

Rangeland degradation may be defined as the loss of utility or potential utility or the reduction, loss or change of the features of rangeland ecosystem (Chrisholm and Dumsday 1987). In general, rangeland degradation is reduction in the rank or status of natural vegetation. This includes, among other things, loss of topsoil, change in simple floral/fauna composition or transition from one organic form to a lower organic form, and continuous decline in the productivity/biomass of the ecosystem. Generally speaking, a lower biological diversity is supposed to occur in a degraded rangeland although more rigorous research should be done to show more reliable information about why and how degradation occurs. From ecological point of view, degradation can be treated as retrogression of an ecosystem and recovery of degraded rangeland as secondary succession (Numata, 1969)

### 2.4.1. Drought and shortage of rain

Prolonged drought and erratic rainfall can cause serious range degradation. During the drought periods, the rainfall is generally inadequate to allow growth of grasses (Helland, 1980) and to fill the surface water ponds (Cossins and Upton, 1987).

### 2.4.2. Bush encroachment

The ecological succession in the Borana rangelands indicates that the potential of grassland is threatened by bush encroachment (Alemayehu, 2004). Over all, woody vegetation reduces grass cover by increasing the competition for available water and nutrients and by reducing the amount of light that reaches the grass layer. In addition to competing with grasses, some noxious woody plants are commonly thorny and thicket forming. Therefore, they extremely affect the grazing capacity of the rangeland (Alemayehu, 2004). It is important to understand the factors that contribute to invasion process of undesirable woody vegetation. Many factors may be involved in bush encroachment. However, overgrazing is claimed to be the major problem. High concentrations of woody plants are found around Ollas and water points where the stocking densities and grazing intensities are relatively high (Cossins and Upton, 1988). Archer *et al* (2003) revealed that the common characteristics of woody species that increase in grazed environments include high seed production, seeds that persist in soil for many years, the ability to disperse long distances and sprout following top removal. The other is the level of tolerance available to low levels of water and nutrients, and low palatability.

2.4.3. Over population and overstocking

The growth of animal and human populations is increasing at an alarming rate. In contrast, the size of pasture resource on which they depend on is diminishing both in size and productivity (Grandin, 1987; Coppock, 1994). Usually, increase in human population implies increase in livestock population in order to maintain survival. Increase in the size of population and overstocking are in turn causing imbalances, for example, in Borana range system and have already resulted in overgrazing and range degradation (Alemayehu, 2004). Gamedo (2004) reported that overgrazing has been one of the major factors that have caused degradation in rangeland in Borena. In this area, the relatively good rangeland condition in ranches and *kalos* may show that overgrazing is a major cause of degradation in rangeland.

## 2.5. Factors Affecting Rangeland Vegetation

### 2.5.1. Climate and soil

Climate plays a primary role in determining the types of vegetations used for grazing and the subsequent growth responses (Moore and Russel, 1976; MCcown, 1981; Whiteman, 1980). The quantity and distribution of rainfall are the two most important criteria that determine the form and productivity of vegetations. Brawn (1963) defined high potential areas as those receiving more than 900mm of rain while cropping is risky in the range of 650-900mm if rain is scattered over months. Edaphic characteristics may substantially modify climatic factors in various ways. On its part, the high level of fertility in the natural soil increases the level of response of vegetations to moisture. In addition, the volume and the water holding and storing capacity of soil are other influential factors. The surface and subsurface characteristics of soil also determine the amount of run off, infiltration of water and the level of drainage. Usually, uncontrolled overgrazing leads to bareness and loss of topsoil by erosion to such an extent that the vegetation assumes a drier appearance than rainfall data suggests.

### 2.5.2. Animals

The poor animal production experienced on rangeland has long been attributed to the poor quality of forage. This is generally determined by the amount of the protein, mineral and energy contents of the range plants. However, the samples taken from such materials often overlooked selective grazing by animals between species and different parts of species although selectivity is of considerable importance as a procedural issue in research (Holechek *et. al.,* 1994). Livestock grazing has a profound impact on vegetation. Since several years ago, the general pattern of grazing-induced vegetation change has been well documented (Stoddart *et. al*., 1975). It is generally known that less palatable plants increase at the expense of more palatable species. A study conducted in the southern and eastern rangelands of Ethiopia revealed that, community structure is largely changed with continuation of improper grazing over along period of time (Coppock, 1993; SERP, 1995; Ayana, 1999).

## 2.6. Factors Influencing Vegetation Composition of the Rangeland

The species composition of rangeland varies depending on topography, climate and soil types (Skerman, 1977). Different grasslands contain diverse types of grasses, legumes, and other herbaceous species. The botanical composition of plant community can also change due to factors like altitude, grazing practices, burning, drought, and temperature effects, pest, and erosion. Therefore, due to, the productivity of an area in terms of its capacity to support livestock may change. Change in plant composition results as a result of the adaptability of the plant species to these influences over a period of time (Stoddart *et al.,* 1975; Butterworth, 1985).

### 2.6.1 The effects of grazing on vegetation composition

Natural pasture communities are very complex. They consist of a large range of grasses, shrubs and herbaceous species. From among these, only few species are palatable. Livestock are able to selectively graze a small proportion of the palatable herbage available and ignore the undesirable ones. The most palatable species are selected first and closely defoliated. High pressure on grazing causes decline in the quality and productivity of rangeland (Lazenby and Swain, 1979; Cossins and Upton, 1985). Decline in the quality and productivity of rangeland, in turn, reduces the vigor of plants, causes poor seed production and eventually leads to the ultimate death of the plants. Overgrazing can also lead to extensive sheet and gully erosion (Heady, 1975; Pratt and Gwynne, 1977). Naturally, the entire systems of plants react to the trampling or grazing it receives. Weakening the top growth results in a lighter short root system that dies back from the bottom. Grass roots continue their normal growth when not more than about 40-50 % of their vegetative parts are removed during the active growth. Hence, the adverse effects of overgrazing can be overcome if rangelands are properly managed. According to Lazeby and Swain (1969), grasses naturally need rest periods to develop, seed and build reserves for their subsequent growing season.

### 2.6.2. Response of plants for grazing

Various plants' response to grazing is dependent on the extent to which the vigor of the grazed plants has been repeatedly reduced without the opportunity to replenish food reserves. Plants' response is also dependent on the degree of selectivity exhibited by grazing livestock. Usually, cattle prefer grasses, sheep prefer forbs, and goat prefers browses. Within each category, there are ice cream plants (decreasers), which grazing animals usually want as feed. Repeated grazing is as harmful to rangelands as repeated clipping. A third factor that plays significant role in plant-animal interaction is the presence or absence of the climax plant community. The classification of decreaser and increaser is based largely on the preference exhibited by the livestock. This is dependent on the range site and the livestock. The range site is important as it limits the selectivity available. This is why some plants are decreasers on one site and increasers on the other sites. In the first case, they are the most palatable species. In the second case, there are plants that are more palatable. The type of grazing livestock will also determine the general *categories of preferences.*

## 2.7. Vegetation Sampling

According to Shaw and Bryan (1976), knowledge of the vegetation of a region and their relations in the environment helps define suitable farming practices or agricultural activities. It also helps select sites for conducting experiments to solve problems. There are several ways by which the percentage of the composition of species occupying a rangeland can be known. As early as 1963, T'Mannetje and Haydock have distinguished four methods of making quick and accurate botanical analysis of grassland on dry-matter weight basis. These are (a) hand separation and weighting of cut herbage, (b) estimation of percentage within cut herbage, (c) estimation of percentage weight in the field and (d) estimation in unit of the weight of species in the field. Among these methods, the first one is the most accurate provider that a sufficiently large number of samples are used. Nevertheless, the method is time consuming and requires drying facilities. Generally, the weight of plants' material is expressed on the dry matter basis rather than on the fresh (green) basis. This is because, DM is a solid substance that is not subjected to daily fluctuation in content, unlike fresh weight (FAO, 1980). Species (or floristic) composition refers to the proportion of the plant species found in association within a given area (Tothill, 1978).

## 2.8. Range Condition Assessment

Range condition is the present status of vegetation in relation to the climax plant community for that site. It is an expression of the relative degree to which the kinds, proportions, and amounts of plants in a plant community resemble that of the climax plant community for the site (SRM, 1999).

According to Pratt and Gwynne (1977), range condition is the state and health of the range and it can be assessed, among other things, on the basis of the composition of vegetation on an area, plant vigor, ground cover and soil status. The concept of 'condition' implies that an optimal or desired vegetation cover in terms of quantity and composition exists for each particular land system. However, since it will often be uncertain what the desired or 'optimum' condition is, particularly in areas which have undergone misuse for a considerable period of time, and since the optimum range condition will differ according to the manner in which the range is used (e.g. cattle, sheep, wildlife), the comparison used should be clearly stated. Again, whether comparison is based on actual measurements or simply assumed is the other side of the uncertainty. Amaha (2006) pointed out that rangeland condition is a concept that encompasses the levels of specific indicators such as plant species composition, vegetation cover (basal cover), forage production (productivity), land condition (soil erosion and compaction) and management at a particular location(s) aimed at sustained livestock production (Trollope *et al.*, 1990; Friedel *et al.*, 2000). According to Mannetje *et al* (1976), determining the botanical composition of rangeland is an important step towards understanding the fodder value of individual species as well as their reaction to biotic and edaphic factors, which may be explained in terms of the type of species, the amount of yield, and the frequency of occurrence and density of basal cover. Plant dry matter yield is often directly related to animal production while the other parameters are useful to describe and quantify the plant population and the successional trends of the rangeland vegetation (DuToit and Aucamp, 1985), and to assess the rangeland condition (Foran *et al*., 1978; Tainton, 1986; Throw *et al*., 1988; Van der Westhuizen *et al*., 1999; 2001). The methods used to classify range conditions have influenced the composition of species (Dyksterhuis, 1949).

According to Gartner (1976), when overuse is excessive or continued over a long period of time, usually invaders or undesirable plants are found. The invader plants were found to be absent in the original vegetation, but with grazing pressure, they replaced the decreaser and increaser plants. In favorable years, invaders can provide considerable forage for a short period of time, but sound range management cannot be based on this uncertain forage production. The four classes of range condition are based on percentage of the production of the decreasers and increasers when compared to the original vegetation. A site composed of decreasers and increasers indicates a high condition range. Replacement of decreasers on the site with increasers and invaders means that the site needs improvement. The four range conditions are as the following. With excellent Condition, 76-100 % of allowable vegetation is mixed of original highly palatable, desirable perennial decreasers and increasers. Legumes and desirable forbs may be present. With good condition, 51-75 % of vegetation is mixed from original highly palatable, desirable perennial decreasers and increasers. Some legumes and forbs may be present in this condition. About 26-50 % of allowable vegetation is mixed of original highly palatable, desirable perennial decreasers and increasers. Some legumes may occur, but most forbs are increasers and invaders. The overall vegetation appearance is shorter and amount of bare ground is increasing. With poor condition, less than 25 % of all vegetation is composed of highly palatable, desirable perennial decreasers and increasers. Generally, invader plants and unallowable increasers comprise the majority of vegetation

### 2.8.1. Estimating range condition

Range condition refers to the present ecological status of the productivity of a vegetation community relative to its natural potential for particular range site and the types of land use (SRM, 1974). In other words, the concept 'condition' implies that an optimal or desired vegetation cover in terms of quantity and composition exists for each particular land system. Range condition of vegetations is based on the species composition of the plant community as estimated by the percentage of the total annual air-dry weight of each species. Species must be classified as decreasers, increasers, or invaders. Each species has an allowable percentage that occurs in climax.

### 2.8.2 Range sites

Before range condition can be assessed, the range sites must be located. Range sites are the basic units of land of practical use. Ideally, each range site should respond to climatic variation in the same manner, have uniform topography and productivity and respond uniformly to experimental treatments (Alemayehu, 2006).

### 2.8.3. Range trend

Range trend is the direction of change in ecological status or resource value rating observed over time (SRM, 1999). It describes the current health of the range. The range trend indicates whether it is getting better, worse or staying intact. Range trend, therefore, is the best single indicator about the success or failure of the existing management practices (ILCA, 1975).

### 2.8.4 Range condition classification

Range condition classification is often included in a range inventory changes. In range condition scores overtimes are usually the basis for monitoring management effectiveness. Range condition classification provides an induction of management necessary. If ranges are in good or excellent condition, maintaining them in a stable condition may be the best management strategy. However, if they are in poor or fair condition, management is aimed at "improvement "may be indicated. Generally, four or five condition classes are recognized. These are excellent, good, fair and poor. Sometimes, a fifth category is added. Many approaches have been used to determine range condition on different range sites or habitat types. Of these, the most familiar method is the developed by Dyksterhuis (1949, 1958). This approach is ecological. Range condition is measured by the extent to which it departs from climax. The approach assumes that climax can be determined for each range sites. Excellent class would represent climax, i.e., Excellent (76-100), good (50-75), Fair (26-50), and poor (0-25) respectively. Originally, species occurring on each site were classified, by their reaction to grazing, as Decreasers, Increasers, or Invaders. Dcreasers are highly palatable plants that decline in abundance with grazing pressure. Plants classified as increaser I types are moderately palatable and serve secondary forage plants.

They may increase slightly or remain stable under moderate grazing condition reaches fair condition. Other plant species are present in the climax vegetation, but those that are unpalatable may increase under grazing pressure or as site deterioration occurs. These species are classified as increaser II plants. Invaders are species that encroach on to the sites from adjacent sites in a latter stage of deterioration. Type I invaders may eventually decrease if forced utilization occurs at later stages of deterioration. Type II invaders are generally unpalatable and increase though final stages of deterioration.

### 2.9. Biomass Estimation Methods and applications

Biomass is the weight of organic matter per unit area. The organic matter might include weight of new growth herbage above ground, wild animals, roots, dead organic matter or mature trees. In vegetation studies this is usually done based on unit area measurement, which is square centimeter or square meter. In measuring biomass, the plants are clipped to constant weight in the laboratory and then weighed. The plant biomass for the larger area is then found through multiplication. The relative biomass of animal species and plant species is of primary concern to range managers. However, this is difficult to find as it involves tedious work to find the weight of different species clipped together. This requires a timely consuming process of separation by hand of the clipped species (Alemayehu, 2006).

The measurements of biomass are of great value to range managers as it provides a quantitative evaluation of production of organic matter over a period of time. Measurements taken over spaced period of time, like seasons, allow range managers to know the amount of forage available in the different seasons and the information necessary in estimating the stocking capacity of an area. Measuring biomass also provides insights about forage utilization by animals by taking measurements before and after grazing or by taking measurements in paired plots, where one is grazed and the other is serving as control. Again, information on animal forage utilization is important to determine the number of given animal species which can forage in a given area (Alemayehu, 2006). Herbaceous above ground biomass is measured to determine the amount of available forage for animal, or to assess rangeland condition and/or to measure the effects of management on the vegetation (Mannetje, 2000). Moreover, from a grazing point of view, production or yield is one of the most important measures used to assess rangeland. Plant dry matter yield is often directly related to animal production while the other parameters are useful to describe and quantify the plant population and the successional trends of the rangeland vegetation, and finally to assess the rangeland condition (Foran *et al.,* 1978; Amaha, 2006).

# 2. MATERIALS AND METHODS

In this chapter, the materials and methods of the study are discussed. The chapter deals mainly with the technical specifications and quantities and their sources or preparation, the data and methods of collecting and analyzing them. In addition, the design of the experiment, the experimental units used and their descriptions and the assumptions made will be discussed one after the other.

## 3.1 Description of the Study Area

### 3.1.1. Geographical location

The study was conducted in Metema District which is found in North Gondar Zone of the Amhara Regional State (Figure 1). The district is located between $12^0$ 40' 00" N and $36^0$ 8' 00" E, and at about 925 km North West of Addis Ababa and at about 180 km west of the Gondar Town. The Metema District is bordered by the districts of Quarra and Alefa to the south, Chilga to the east, Tach Armachoho to the north in the North Gondar Zone and it boarders the country Sudan to the west. The district has an international boundary of more than 60 kms between Ethiopia and Sudan. The district has 18 rural and 2 town Kebeles.

### 3.1.2 Climate and topography

The agro-ecological map of the district (ILRI, 2005) reveals that the majority of the study area lies under moist kola agro-ecological zone (AEZ). About 88.89 % of the 18 kebeles were categorized under moist kola agro-ecological zones whereas the remaining 11.11 % of them were categorized under dry kola zones respectively. The district is characterized by mean annual temperature which ranges between $22^o$c and 28 $^o$c. The daily temperature becomes high during the month of March to May and it reaches 43 $^o$c. The mean annual rainfall for the area ranges from about 850 mms to around 1,100 mms (ILRI, 2005). About 90 % of the district receives mean annual rainfall of 850 to 1,000 mms. The district has unimodal rainfall and the rainy period extends from June to the end of September. The district is characterized by an altitude range of 550 to 1,068 masl. OoARD (2007) shows that about 60% of the district area is plain and the rest 20%, 15%, and 5% are sloppy, undulating and valley, respectively.

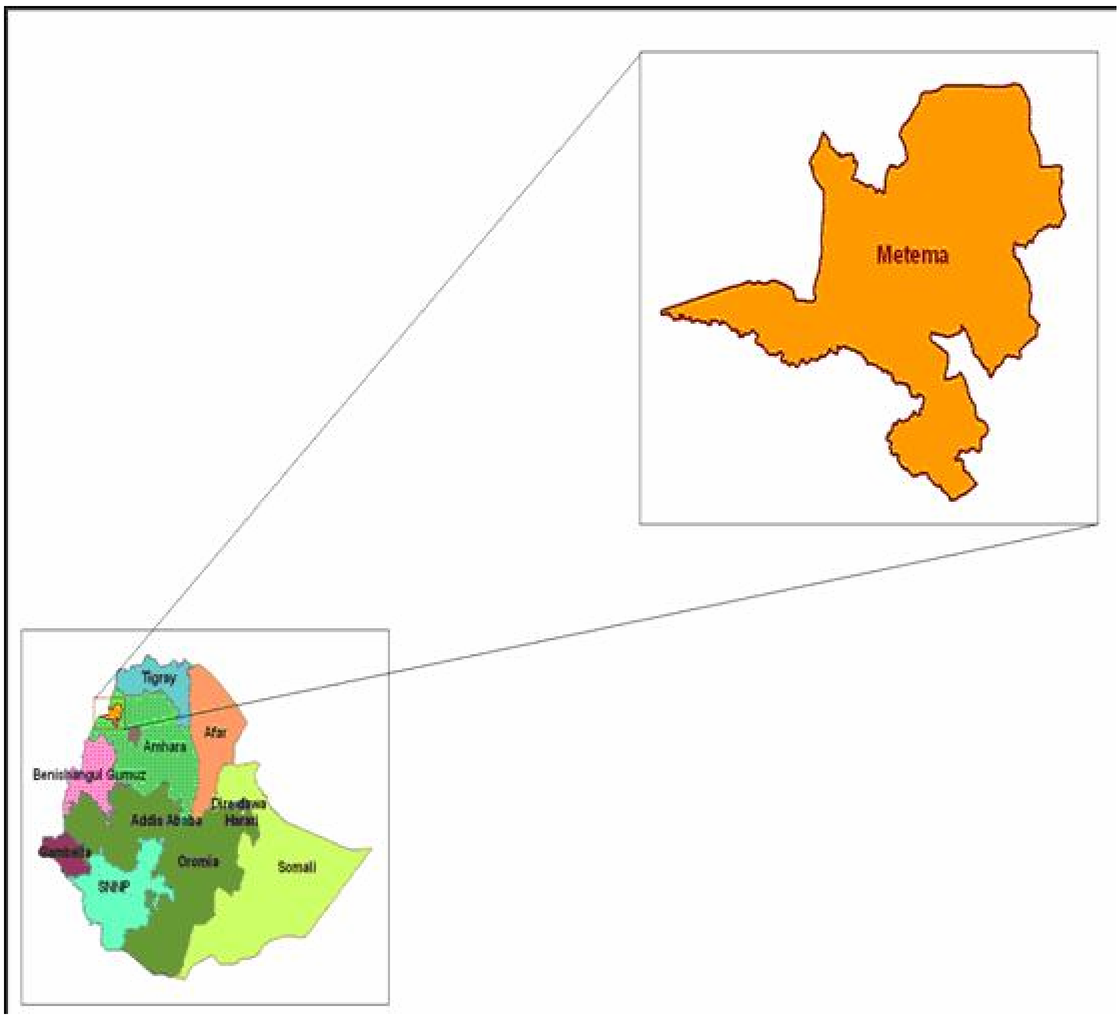


Figure 1. Map of Ethiopia at the bottom left corner and map of the study area (Metema), in orange color, at the top right corner.

### 3.1.3. Vegetation and soil

The vegetation of the study district is predominantly composed of different woody and herbaceous species. Among the woody species of the genera are *Acacia*, *Anogeissus, Balanites, Boswelia, Combretum, Commiphora, Dichrostachys, Ficus, Fluegea, Grewia, piliostigma, Pterocarpus, Terminalia, Ximenia and Ziziphus*. The undergrowth (storey) Grass species, of the genera: *Bracheria, Cenchrus, Cynodon, Cyprus, Erochloa, Eurochloa, Eleusine Hyparrhenia, Panicum, Pennisetum, Rhamphicarpa, Setaria, and Sporobolus* were the dominant/common species. The legume species of the genera are *Ahiya abish* (Local name), *Alysicarpus, Bidens, commelina, Dismodium, Hibiscus, Indigofera* and *Vigna*. Others are genera of *Corchorus, Cyanotis, Euphorbia, Hygrophilla, Spermacoce* and *Zennia*. The soil map of the district (ILRI, 2005) indicates that there are four types of soils in the area. These are Luvisols, vertisols, Nitosols and Cambisols in their order of proportion from high to low in the area coverage respectively.

### 3.1.4. Livestock population

Livestock production is an integral part of the land use system. Production of cattle (as draft power, milk, and meat), shoat (income and meat), donkey and camel (as *Karoo* and transport) and poultry were commonly practiced. OoARD (2007) shows that the livestock population of the district is composed of 136,910 cattle, 32,024 goats, 1,686 sheep, 7,164 male donkeys, 7,127 poultry, 400 camels and 23,789 beehives. In TLU (tropical livestock unit) equivalent to 250 kg live weight, cattle are 95,837 TLU and goat, sheep, donkey and camel are 3,202, 169, 3582 and 400 TLU, respectively. The cattle in the district were exported both legally and illegally (through smuggling to Sudan while goats were mainly sold in local markets. Transhumance production system was commonly practiced by the highlanders. The fieldwork showed that the majority of the inhabitants in Chilga district (94.4 %), Dembia district (87.8%) and Gondar Zuria district (60.0 %) seasonally mobilize their livestock to the Metema District in search mainly of feed resources. About 84.0 % of the communities from the three districts seasonally move during the rainy seasons and stay in Metema District for six months, that is, from May to October for six months. The major cattle breeds of the study area were Fogera and Simada types. The Ruthana cattle were originally from Sudan. The Felata cattle from Niger and Nigeria also constituted a smaller proportion of the cattle population.

### 3.1.5 Human population

According to CSA (2005), there are about 76,084 rural and 18,467 urban populations, of which 41,202 heads are male and 34,882 heads were females in rural area. In the urban areas, 9,108 and 8,360 were both male and female respectively. The original residents of the area were Gumuze. Until recently, they have practiced slash and burning, and hunting wild animals. They have also been engaged in making household furniture like chair, bed, pot and others. When the area became gradually populated, the natives were dominated by the new settlers. They original settlers are now found only in three peasant associations, that is, Kumer Aftit, Tumet and Shinfa. The total number of the indigenous people is around 500 (ILRI, 2005). Hence, much of the area is recently occupied by settlers from the highlands part of the region. According to OoARD (2007), in three consecutive years of 2003, 2004 and 2005 when new settlement programs occurred, 12,777, 4,124 and 16,258 new settlers were settled in the district respectively. This shows that there is an aggregate of 33159 settlers per three years and the trend were increasing.

### 3.1.6 Land use pattern

In the district, forest and rangeland are estimated to be 72 % (312,300 hectare), cultivated land 23.6 % (103,908 hectare). Of the cultivated land, 16% (71,324 hectare), 3% (13,908 hectare) and 4 % (18,676 hectare) are smallholder farms, commercial farms, and potential cultivable land respectively. The uncultivable land has a proportion of 5 % (23,879 hectare). The digital map of land use and pattern of the district is presented in (Appendix Figure 2) (ILRI, 2005).

### 3.1.7 Farming systems

There are two types of farming systems used in the study district (Appendix Figure 1), namely cotton based farming system and sesame based farming systems. Each has its own characteristic features.

#### 3.1.7.1 Cotton based farming system

According to ILRI (2005), 4 out of 18 PAs belong to this farming system. They are Maka, Awlala, Genda Wuha and Kemechela. They are found in the northeast parts of the district. The peasant associations predominantly grow cotton and sorghum and sesame in little amount. The PAs in this farming system have different features in terms of suitability for crop production and amount of rainfall received. The PAs are relatively colder in temperature, have higher altitude and rainfall. Their soils are black and water logging is a problem. Farmers in the PAs practice slightly early planting of crops. The majority of the soils in this farming system have vertic property. Many of the areas are also flat. As a result, the majority of the soils are only suitable for growing cotton and rice. Cotton is grown in wide areas while sorghum and sesame are planted in very smaller areas.

#### 3.1.7.2. Sesame based farming system

Fourteen PAs belong to this farming system. In order of importance, sesame, cotton and sorghum are the major crops produced in this farming system. A farmer could grow any one of these crops as the environmental conditions are equally suitable for these crops. The choice is set by the farmer upon observation of the season, high or low rainfall, and possible market prices. The altitude and rainfall in this farming system is less than the cotton based farming system. Some literatures indicate that rainfall ranges between 700 mms and 900 mms, but the digital data indicate that it is more than that. This farming system would receive rainfall at the lower range. The altitude range for this farming system is between 550 and 700 masl (ILRI, 2005). Farmers and agriculturists believe that the underground water table is high. In some places, sufficient amount of water could be obtained at less than 10m deep. Besides, three rivers are found in this farming system. These rivers make the area more potential for crop and livestock development. This farming system also has extensive grazing areas. What is more, there is a place where the natural plantations for gum and incense are located.

### 3.2. Livestock feed resources assessment in the study district

A single-visit formal survey method (ILCA, 1990) was used to collect information on livestock feed resources assessment in the district. Bsed on the two farming systems, 4 PAs (Peasant associations) from SBFS and 3 PAs from CBFS were selected by lottery method. Then, a purposeful sampling technique was employed to select the respondents for the primary data collection and a total of 140 respondents were identified and interviewed. Purposeful sampling method was used because the target groups were livestock owners. A structured questionnaire was prepared and translated into Amharic. Then seven relevant enumerators with adequate animal husbandry skill were selected and trained for four consecutive days. Prior to the commencement of actual survey, pre-testing of the questionnaire was made. In addition to interviews, out of the total PAs (18) in the district, 12 PAs were covered by the reconnaissance survey and five group discussions were made with elders, development agents and key informant in 5 selected PAs. The secondary data were browsed. In addition, documents available at ILRI and the district office of agriculture were reviewed to strengthen the information. The quantity of DM feed obtained from different feed resources has been estimated to calculate the balance between feed availability and requirement by the livestock in the study area. DM output from grazing land was estimated by multiplying the grazing land by 2.5 t/ha, which was obtained during this study. For the other land use types, DM yield per hectare was determined by multiplying the hectare under each land use category by their respective estimated annual DM yield per household (FAO, 1987). The DM outputs were as follows: for 24 aftermaths grazing 0.5 t/ha, for bush and shrub land 1.2 ts/ha and for uncultivable land 0.7t/ha (FAO, 1987).

### 3.3. Rangeland Condition Assessment

#### 3.3.1. Range sites selection

Discussion was made with the community members (elders), experts, supervisors and development agents in the agricultural office to select the range sites for the study. After that, reconnaissance survey was under taken. In addition the district land use and land cover digital map was used to select the grazing areas.

Table 2. Numbers of range sites selected for condition assessments in the district

| *Farming system* | *Grazing types* | | | |
|---|---|---|---|---|
| | CG | RS | EN | Total |
| CBFS | 3 | 3 | 2 | **8** |
| SBFS | 3 | 3 | 3 | **9** |
| **Total** | **6** | **6** | **5** | ***17*** |

CBFS= Cotton Based Farming System, SBFS= Sesame Based Farming system,
CG= communal grazing, RS= Road side grazing, EN= Enclosed areas

Table 2: Experimental units used in the range sites

| Farming systems | | Grazing types | | | | |
|---|---|---|---|---|---|---|
| | | Communal | Road side | Enclosed areas | Sub-total | Quadrats/Belts transects |
| CBFS | **Herbaceous layer** | 12 | 12 | 8 | 32 | 128 |
| SBFS | | 12 | 12 | 12 | 36 | 144 |
| **Sub Total** | | **24** | **24** | **20** | **68** | **272** |
| CBFS | **Woody layer** | 4 | 4 | 2 | 10 | 30 |
| SBFS | | 4 | 4 | 3 | 11 | 33 |
| **Sub Total** | | **8** | **8** | **5** | **21** | **63** |
| **Grand Total** | | **32** | **32** | **25** | **89** | **335** |

CBFS= Cotton Based Farming System, SBFS= Sesame Based Farming system;

### 3.3.2. Sampling procedures

The samples were collected by stratifying the district into two farming systems: cotton based farming system (CBFS) and sesame based farming system (SBFS) (ILRI, 2005). Within these farming systems categories, the grazing lands were further stratified into three sampling areas. These are communal, roadside, and enclosed grazing areas, using systematically stratified random sampling technique. The enclosed grazing areas were selected from the protected areas in school compounds and government protected acacia wooded grass land for SBFS. Roadside grazing were selected 200 meters away from the main roads in order to avoid the edge effect. Roadside grazing lands were parts of the communal grazing lands and are generally exposed for mismanagements due to the fact that it is out of the control of the communities. The transhumant and the inhabitants can graze and clear trees when passing through the roads.

In each of the range site, a sampling block of 4 km x 1 km was demarcated in a separate way. The sites were considered to be homogenous and representatives of the vegetation cover under investigation. This was further stratified into four sampling plots having equal size (1km x 1km each). This type of layout was preferred in order to encompass both vegetations herbaceous and woody layers. In each of the plot, a belt transect of 50 meters x 4 meters was randomly laid out. Then, $1x1m^2$ quadrats for herbaceous species, and 50 mx 4 m belt transect for woody vegetation assessment were used. On the whole, 68 composite sampling units (4 quadrats per composite sample unit) for herbaceous and 21 composite sampling units (3 belts transect per composite sample unit) for woody vegetations and 89 composite sampling units were employed. That is, in the assessment of herbaceous vegetation in CBFS and SBFS, 24 composite sampling units for communal, 24 composite sampling units for road sides grazing and 8 and 12 composite sampling units for enclosed grazing areas were used, respectively (See Table 3). Compass and GPS were used to measure the transect locations and coordinates. Sampling was conducted from August 10 to September10, 2007, with almost all the pasture plants were fully-grown and to over 50 % of them flowering stage.

### 3.3.3. Species composition assessment and dry matter biomass

At each of the sample site, the herbaceous species composition and yields were assessed by harvesting three quadrat (1 $m^2$) per sampling sites of CBFS and four quadrats (1 $m^2$) per sampling sites in SBFS areas (depending on the homogeneity and proportion of the range sites assessed in the farming systems) randomly by throwing the quadrat towards the back. The herbaceous species within the quadrats was cut to ground level. The cut samples were weighed using spring balance immediately and were transferred into properly labeled paper bags and fastened at the top. The samples were kept under shade area until sampling for the day was completed. Each of the samples in the paper bag was hand separated into different species and then weighed. After this, they were sun dried until the work was completed. Finally, the dry matter (DM) of each species was determined in an oven (60 $^oC$ for 72 hours) at ILRI laboratory Addis Ababa. The percent composition of each species was determined on DM weight basis (ILCA, 1990). The percentage of dry matter biomass of grasses, legumes and other species were further categorized as highly desirable, intermediate and less desirable were again determined from each the weight of dry species dry.

### 3.3.4 Identification of species

To help in identify the collected species, representative plants with flowering head and other vegetative parts from each species were collected and dried in presses. Following drying, the specimens were mounted. Very few common species were identified right in the field using books (Azene *et al*., 1993) and almost all of the species were given code numbers and transported to the National Herbarium of Addis Ababa University for identification and proper nomenclature.

### 3.3.5. Range condition assessment

The rangeland condition assessment was done by considering three layers, that is, grass, woody and soil (Friedel, 1991). Eight-plant factors, that is, grass species composition, basal cover, litter cover, age distribution and seedling counts of grass layer; density, canopy cover, hedging of woody layer, and two-soil factors, that is, soil erosion and compaction, were considered as criteria (Appendix Tables 1-2). The factors for grass and soil layers were considered based on the criteria developed for semi-arid rangelands in south and eastern Africa (Tainton, 1981) and the assessment of rangeland condition was performed using the methodology adapted by Baars *et al*. (1997). The factors for woody layer determination were considered and adapted based on the criteria developed for southeast rangeland of Ethiopia (Kuchar, 1995). The assessment factors based on grasses, soil and woody parameters sum up to a total of 65 points (Appendix Tables 1-2). The overall range condition rating was interpreted as excellent when the score was (53-65 points), good (39-52 points), fair (27-39 points), poor (14-26 points) and very poor when the rating was less or equal to (0-13) points.

#### 3.3.5.1. Grass species composition

At each sample site, the grass species composition was assessed by randomly harvested four quadrats and then rated 1 to 10 points accordingly (Appendix Table 1). In each 1m$^2$ quadrats, herbaceous covers (grasses) were considered. Then the grass species was divided into desirable species likely to decline with heavy grazing pressure (deceasers), intermediate species likely to increase with heavy grazing pressure (increaser), and undesirable species likely to invade with heavy grazing pressure (invaders), according to the succession theory (Dkyesterhuis, 1949; Tainton, 1981). Classification of grasses into decreaser, increasers and invaders was done by conducting detailed interview with the local community members about the palatability and distribution of each identified grass species in relation to the intensity of grazing and cross checking with the list of grasses from the literature.

#### 3.3.5.2. Basal and litter cover

Basal cover or area, the area occupied at the intersections of the plant-soil interface, of the living plant parts were estimated in three randomly laid out quadrats of 1m$^2$ areas for detail assessments of basal and litter cover. For the surface of basal cover of tufted grasses, the distribution was assessed as follows. The 1 m$^2$ was divided into halves. One half of it was then divided into eighths. All plants in the selected 1m$^2$ area was removed and transferred to the eighth for the purpose of visual estimation. Only basal cover of living plants was considered. The rating of basal cover for tufted species (erect) and creeping plants (e.g. cynodon dyctlon) was considered excellent if the eighth was completely covered (12.5) or very poor if the cover becomes less than 3%. Accordingly, classes of <3%, 6-9%, and 9-12% were categorized. Lower scores (0, 1 and 2 points) were given for basal cover with < 3%. The rating of litter cover within 1m$^2$ was given the maximum score, that is 10 points, when it exceeds 40 % and the minimum score, when the amount of litter cover was less than 3 % (Appendix Table 1).

#### 3.3.5.3. Number of seedlings and age distribution

The number of seedlings was counted using three areas equal to the size of an **A4** sheet of paper (30cm x 21cm) chosen at random (appendix Table 1). The sheet was dropped from an approximate height of 2 meter above the ground. The category: ‘no seedlings’, was given 0 points, and more than 4 seedlings were given the maximum score of 5 points. Similarly, for all age categories (that is, young, medium and old plants of the dominated species), the maximum scores, that is 5, was given. If there was only young plants, their minimum score (1) was given (Appendix Table1).

### 3.3.5.4. Soil erosion and compaction

The amount of soil erosion and compaction in each of the quadrats of $1m^2$ was evaluated subjectively by visual observations. Soil erosion assessment was done by taking into consideration the presence of pedestals and pavements. Soil pedestal is the higher parts of soil held together by plant roots with eroded soil around the tuft while soil pavement is terraces of flat soil, normally without basal cover and with a line of tufts between pavements. The score was given as 5 points for no signs of erosion, 4 points for slight sand mulch, 3 points for weak pedestals, 2 points for steep-sided pedestals, 1 point for pavements and 0 point for gullies. Soil compaction assessment was done based on the level of capping or crust formation of the soil surfaces. The highest score (that is 5 points) was given for a soil surface with no capping, 4 points for isolated capping, 3 points for greater than 50% capping, 2 points for greater than 75% capping and 1 point for almost 100% capping (Appendix Table1).

### 3.3.5.5 Woody vegetation layer

In the woody vegetation assessment, the species composition, density, canopy cover, plant height and hedge effect were considered. Again, all species in the belt transect were recorded and identified. The desirability and palatability of each species was also recorded based on the discussion with the livestock owners (farmers) and by giving attention to the woody plants' sensitivity to grazing, abundance and preferences of the livestock as a feed resource. This was also supported by literature (Azene.*et.al*. 1993).The criteria which Kuchar (1995) used to score the percentage of canopy cover of woody species were the height of the species in the belt measured using calibrated poles of appropriate size for different woody species. The five height classes (>0.5-1m, >1-2m, >2-3m, 3-4m and >4-5) were employed (Amaha, 2006). The density of woody species were enumerated from each belt transects (200 $m^2$) areas. Only live woody plants irrespective of whether they were single stemmed or multiple stemmed were counted and recorded to estimate the woody vegetation density in the 200 $m^2$ belt transect. The lowest score (0 point) was used for the largest density: i.e., 0 = >5000/ha, 1 = 4001-5000/ha, 2 = 3001-4000/ha, 3 = 2001-3000/ha, 4 = 1001-2000/ha, 5 = 0-1000/ha (Kuchar (1995). On the other hand, the percentage of canopy cover of the species in the belt transect were measured by tape meter. The ratio was then computed as the measured canopy area by the remaining tape length and the canopy cover for the woody vegetation was rated following the guidelines suggested by Kuchar (1995). The scores given to canopy cover ranged from 1-5 points. The highest score (5 points) was given for a woody cover >45% cover, 4 = 36-45%, 3 = 26-35%, 2 = 15-25%, 1 = <15% cover. The rating for hedging was based on visual assessment, mainly on the state of the palatable (hedgeable) species. Hedging was estimated on visual assessment, based on the palatability condition of the species. The rating scale that ranged from 1-5 points for hedging the effect of woody species was also considered (Appendix Table 2).

### 3.4. Evaluation of the Quality of Major Feed Resources

#### 3.4.1. Samples preparation

The representative samples of the two grass species (*Pennisetum spheslatu* and *Cenchrus ciliaris*) and one fordder species (*Pterocarpus lucens*) which are dominantly grown and used as major livestock feed resources in the district were collected using 1 $m^2$ quadrat from different grazing areas of the farming systems. The collection process was done in the same day in the morning. The samples were stratified based on type of species and in two seasons (August and October), where the sampled feeds were available and there is hay making in the area. After the samples were collected, the same feed types were bulked together on seasonal basis and then thoroughly mixed and further sub-sampled. That is, 3 samples per each species from the two farming system grazing areas and a total of 18 samples were subjected for chemical analysis. The samples were immediately weighed after sampling and put in a cloth sack and hung in the shade area until samples transported to the ILRI laboratory in Addis Ababa and then dispatched to the laboratory. Finally, the samples were dried in an oven at 65 $^oC$ for 72 h and ground in

Willey Mill to pass through 1mm sieve. After this, they were finally kept in airtight containers before they were finally subjected to analysis for chemical composition (Van Soest and Robertson, 1985).

### 3.4.2. Analytical procedures for chemical composition

Feed samples were analyzed for DM and ash using the method of AOAC (1990). Nitrogen was determined by micro-Kejeldhal method. Then crude protein (CP) was calculated as N x 6.25. Neutral detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed with the help of a method developed by Van Soest *et al* (1991). The method of Tilley and Terry which were modified by Van Soest and Robertson (1985) was used to determine IVDMD.

## 3.5. Statistical Analysis

The collected household data were organized and analyzed with the help of Statistical Package for the Social Sciences (SPSS, 1996). Descriptive statistics such as frequency, means, percentages, range and standard error of the means were used to present the results of the 140 households in the district. The dry matter biomass, mean of the four measurements and composite samples from four quadrats of 1 $m^2$ from each belt transect of 50 m x 4 m were considered as an experimental unit for data analysis, respectively. Before the data were subjected to analysis, the experimental units were sorted by two farming systems and three grazing types. Accordingly, a total of 68 experimental units (Table 3) were used for data analysis. For the woody vegetation, a belt transect of 50 m x 4 m from each sample site was considered as an experimental unit for data analysis. In this respect, a total of 63 experimental units (Table 3) were used for data analysis. The grass, soil and woody vegetation parameters were subjected to ANOVA, using the GLM procedure of SPSS, Version 12) computer software. Two-way analysis of variance was computed to see the interaction effect of farming system versus grazing types for all range condition as well as above ground biomass analysis. The least significant difference (LSD) was used to make mean comparison. Furthermore, linear correlation and regression procedures were used to verify the magnitude and direction of relationships between the different variables and relationships between the total dry matter biomass and range condition rating. For chemical analysis of the major feeds, a statistical model $Yij = \mu + Si + Lj + eij$ were used. Where, $Yij$ = quality of feeds, $\mu$ = over all mean, $Si$ = the effect of $i^{th}$ season, $Lj$ = the effect of $j^{th}$ species types, and $Eij$ = Random error.

# 3. RESULTS AND DISCUSSION

In the result and discussion section, the findings of the socio-economic characteristics; major livestock feed resources; the chemical composition of dominant feed resources; the major constraints of the district; floristic composition; range condition assessement and the dry-matter biomass production of the district are orderly discussed and interpreted as per the objectives of the study.

## 4.1 Socio–Economic Conditions of the Study District

### 4.1.1 House hold characteristics

Among the interviewed households in sesame based farming system (SBFS) 80 (83.8 %) were husbands, 12.5 %, 1.3 % and 2.5 % were spouses, sons and daughters respectively. In cotton based farming systems (CBFS) 60 (91.7%, 6.7% and 1.7 %) were husbands, spouses and sons, respectively. Overall, 87.1% were husbands, 10.0 % were spouse, 1.4 % was sons and 1.4 % was daughters. From overall respondents, 88.6 % and 11.4 % were males and females, respectively. There were five ethnic groups in the district. In terms of numerical preponderance, the Amhara are the dominant ethnic groups in both farming systems. Next to the Amhara are the Tigrians, the Gumuze, the Agew and the Qimant, respectively. There is more ethnic diversification in SBFS than in CBFS. The possible reason could be resettlement program that has been undergoing in the area over the last several years.

Table 3. Respondents' status, sex, ethnic group, education, and major occupation under CBFS and SBFS in the district

| Variables | CBFS | | SBFS | | *Total* | |
|---|---|---|---|---|---|---|
| | HHC | % | HHC | % | HHC | % |
| **Respondent status** | N=60 | | N=80 | | N=140 | |
| Husband | 55 | 91.7 | 67 | 83.8 | 122 | 87.1 |
| spouse | 4 | 6.7 | 10 | 12.5 | 14 | 10.0 |
| Son | 1 | 1.7 | 1 | 1.3 | 2 | 1.4 |
| Daughter | | | 2 | 2.5 | 2 | 1.4 |
| **Sex of house hold** | | | | | | |
| Male | 56 | 93.3 | 68 | 85.0 | 124 | 88.6 |
| Female | 4 | 6.7 | 12 | 15.0 | 16 | 11.4 |
| **Ethnic group of house hold** | | | | | | |
| Amhara | 60 | 100.0 | 61 | 76.3 | 121 | 86.4 |
| Agew | | | 3 | 3.8 | 3 | 2.1 |
| Tigrie | | | 10 | 12.5 | 10 | 7.1 |
| Gumuze | | | 5 | 6.3 | 5 | 3.6 |
| Other | | | 1 | 1.3 | 1 | 0.7 |
| **Education status of house hold** | | | | | | |
| Non school attendant | 35 | 58.3 | 33 | 41.3 | 68 | 48.6 |
| Reading writing only | 18 | 30.0 | 29 | 36.3 | 47 | 33.6 |
| Grade 1-3 | 3 | 5.0 | 7 | 8.8 | 9 | 6.4 |
| Grade 4-6 | 2 | 3.3 | 9 | 11.3 | 9 | 6.4 |
| Grade 7-9 | 2 | 3.3 | 2 | 2.5 | 7 | 5.0 |
| **Major occupation** | | | | | | |
| Trade | | | 4 | 5.0 | 4 | 2.9 |
| Livestock rearing only | 1 | 1.67 | 3 | 3.8 | 4 | 2.9 |
| Crop production only | 2 | 3.33 | 10 | 12.5 | 12 | 8.6 |
| Mixed farming | 55 | 91.67 | 61 | 76.3 | 116 | 82.9 |
| Others | 2 | 3.33 | 2 | 2.5 | 3 | 2.1 |

Note: SBFS denotes sesame based farming system, CBFS denotes cotton based farming system, HHC= house hold count

The proportion of non attendants of school in CBFS is 58.3 %. This is signicantly ($P<0.05$) higher than SBFS (41.3 %), but those who can only read and write are 36.3 %. Those who learned up to grade 1-3 and 4-6 are 8.8 % and 11.3 % respectively. In SBFS these are higher than the respondents in CBFS, that is, 30.0 %, 5.0 % and 3.3 % for read and write, grade 1-3 and grade 4-6, respectively (Table 4). The result could be that most of the inhabitants in SBFS were new settlers and these new settlers coming from other areas could be low in their educational status. The low level of educational status in the district was similar with many other areas in rural Ethiopia. This situation may exert adverse impact on technology transfer and hamper the productivity of the interventions being made in the district. The finding implicated that it is important to introduce education in the area. The result is in line with cases reported for pastoralists in South Omo and Bale zones (Admasu, 2006 and Teshome, 2006). As far as the major occupation of the households were concerned, from the overall 140 interviewed households, the majority of them (82.9 %) pointed out that they were practicing mixed farming agriculture (i.e., crop-livestock mixed farming) whereas 8.6 %, 2.9 %, 3.6 % and 2.1 % indicated that they were practicing solely crop production, solely livestock production, trade, and others respectively. Unlike in other lowland parts of the country, inhabitants in Metema District were practicing mixed farming system. This could be because most of the settlers came to the district from highland and medium altitude areas of the region, like Gondar, Wollo, North Shoa and Gojjam zones. In their original places, these settlers practiced predominantly mixed farming system and continued with their previous practices in their new homes. In contrast, the 'Gumuze', who are the native settlers of the area, had made no influence on the late comers and they are still practicing hunting and gathering together with farming (ILRI, 2005).

### 4.1.2 Age composition and family size

The age categories of the family members, age > 60 years, 16-60 years, 6-15 years and < 6 years in CBFS were 2.21%, 48.23 % 32.30 %, and 17.26 %, respectively. In SBFS, age > 60 years, 16-60 years, 6-15 years and < 6 years 2.74 %, 51.37 %, 28.42 % and 17.47 % and, totally in the district, 2.51 %, 50.0 %, 30.12 %, 17.37 % respectively (table 5). The majority of the age categories (48.23 %) in CBFS, (51.37 %) SBFS 51.37 %, total of age of the family members 50.0 %, were under the age class of 16-60 years. The youngest and child age categories (6-15 years) in the district were the second dominant age category. These age structures found in the study district, however, could be categorized under the active labor forces to the farming families. In Ethiopia, all age groups who are above ten years old in the rural areas were involved in agricultural activities undertaken in the household (CSA, 2003).

The mean family size in cotton based farming (5.37 ± (0.28) persons per household was not different from the mean family size of sesame based farming systems (5.26 ± (0.27) and the overall mean family size of the district was 5.31 ± (0.20) person per family. The mean family size obtained in the study district was higher than the national average (5.2) as reported by CACC (2002) and smaller than the result reported as reported by Sisay (2006) for the same district (6.6 ± 0.31) and Admasu (2006) for Hamer and Bena-Tsemay (7.3). The average age of the respondents in the SBFS was (41.05 ± (1.431) and that of CBFS was 39.49 ± (1.01). The overall mean age of the respondents were 40.16± (0.84) (Table 5). This result was smaller than the mean age of 44.26 years reported by Teshome (2006) in Fogera District of the Amhara region, where as the result is in agreement with the mean age of 41.2 ± (0.65) which Tesfaye (2008) reported for Metema District.

Table 4. Age of family members, family size and age of respondents in farming systems of Metema district

| *Variables* | *CBFS* | *SBFS* | *Total* |
|---|---|---|---|
| | % | % | % |
| **Age of family members** | (N = 60) | N = 80) | (N = 140) |
| Age > 60 years | 2.21 | 2.74 | 2.51 |
| Age b/n 16 and 60 years | 48.23 | 51.37 | 50.0 |
| Age b/n 6 and 15 years | 32.30 | 28.42 | 30.12 |
| Age < 6 years | 17.26 | 17.47 | 17.37 |
| **Family size:** | Mean ± ( SE) (N = 60) | Mean ± (SE) (N = 80) | Mean ± (SE) (N = 140) |
| Male | 5.47 ± (0.34) | 5.32 ± (0.32) | 5.41 ± (0.24) |
| Female | 6.02 ± (1.32) | 4.98 ± (0.25) | 5.44 ± (0.65) |
| Total | 5.37 ± (0.28)[a] | 5.26 ± (0.27)[a] | 5.31 ± (0.20)[a] |
| **Age of respondents:** | 41.05 ± (1.43) | 39.49 ± (1.01) | 40.16 ± (0.84) |

Family size with same superscript with in the same rows does not significantly differ at (P<0.05) level significances, SE= standard error

## 4.2 Land holding and land use pattern

The majority of the households in 43.3 % in CBFS, 50.0 % in SBFS and 47.14 % in the district possessed 1-5 hectares. On the other hand, 23.4 % of the households in CBFS and 21.25 % of them in the SBFS and 22.16 in the district possessed 5.1-10 hectares of land (Table 6). There was a significant ($P<0.05$) difference between the two farming systems in land possession. The possible reason could be that the previous settlers in CBFS have more than five hectares whereas the majority of the SBFS inhabitants were new settlers and only 1-2 ha of farmland was allocated per settler as one formation from OoARD, Settlement Desk, suggested. This result is in agreement with the land holdings per house hold reported for the same area ($6.17 \pm 0.31$) and much greater than the average land holding of Debark and Layarmachiho districts, which are 1.66 and 2.03 hectares per household, respectively (Sisay, 2006). ILRI (2005) reported that land is not a problem in Metema District. Previously settled and the indigenous farmers were officially given 5 hectares each, but many farmers cultivate more than 5 hectares and some farmers have even reported that they have up to 30 hectares of land.

During the survey, 40 (91.4 %) of the households revealed that their farm land were allocated for annual crop production. The rest of them (0.8 %, 3.1 % and 4.7 %) indicated that they use their land for perennial cropping, private grazing and fallowing, respectively (Table 6). The trend was similar to the result reported by (Sisay, 2006). According to the survey results, privately owned grazing lands were very small (3.1 %) as compared to individual farm land sizes in the study area. The communities considered their fallow land as private gazing land. This fallow land was associated with the widely practiced shifting cultivation in the area as means to soil fertility improvement. Based on the group discussion held with elders during the study, the fallowing practice was currently decreasing as compared. About 10 years ago, the fallowing of farmland was carried on for about 5-8 years and commonly practiced by every one. However, currently the trend was decreasing from 2-4 years because of increase in human population in the area and extension of private investment lands.

Table 5. Percentage of land holding and land use pattern of the farming systems in the study district

| *Variables* | *CBFS* | | *SBFS* | | *Total* | |
|---|---|---|---|---|---|---|
| | HHC | % | HHC | % | HHC | % |
| **Land holding** | N=60 | | N= 80 | | N= 140 | |
| 1-5 ha | 26 | 43.3 | 40 | 50.0 | 66 | 47.14 |
| 5.1-10 ha | 14 | 23.4 | 17 | 21.25 | 31 | 22.16 |
| 10.1-20 ha | 9 | 15.0 | 15 | 18.75 | 24 | 17.10 |
| >20 ha | 11 | 18.3 | 8 | 10.0 | 19 | 13.60 |
| **Land use :** | | | | | | |
| Annual crop | 51 | 89.5 | 66 | 93 | 117 | 91.4 |
| Perennial crop | - | - | 1 | 1.4 | 1 | 0.8 |
| Private grazing | - | - | 4 | 5.6 | 4 | 3.1 |
| fallow | 6 | 10.5 | - | - | 6 | 4.7 |

HHC= house hold count, CBFS = cotton based farming system, SBFS= Sesame based farming system

### 4.3 Livestock holdings and composition

The mean holding of cattle 6.34 ± 0.59) TLU per household in the Sesame based farming system was not significantly ($P<0.05$) different from the mean cattle holding in the cotton based farming system (6.24 ± 0.45) TLU per HH). The goat, sheep, donkey, and camel were 0.43 ± 0.6), 0.11 ± 0.03), 0.31 ± 0.04) and 0.06 ± .04), respectively. This is greater than the cotton based farming system of 0.36 ± 0.04), (0.01± 0.1), and (0.34 ± 0.03) for goat, sheep, and donkey respectively. The total livestock holding per household was 27.58 ± (13.72) TLU. This finding was comparable with that of Sisay (2006) which reported that 9.41±.03, 9.4±0.33, 0.3±0.33, and 0.9 ± 0.08 for cattle, goat, sheep and donkey in number for the same area. With regard to livestock composition of the area, cattle were the dominant, followed by goat, donkey, sheep and camel in that order. The result is also similar with the findings reported by the above mentioned authors.

Table 6 Livestock holding of households in the two farming systems (TLU)

| Livestock species | *CBFS* | *SBFS* | *Total* |
|---|---|---|---|
| | Mean± (SE) | Mean± (SE) | Mean± (SE) |
| Cattle | 6.24±(0.45)$^{b}$ | 6.34± (0.59)$^{b}$ | 12.52± (6.23)$^{a}$ |
| Goats | 0.36± (0.04)$^{b}$ | 0.43± (0.6)$^{b}$ | 0.80± (0.40)$^{a}$ |
| Sheep | 0.01± (0.1)$^{b}$ | 0.11± (0.03)$^{a}$ | 0.13± (0.07)$^{a}$ |
| Donkey | 0.34± (0.03)$^{b}$ | 0.31± (0.04)$^{b}$ | 0.65± (0.32)$^{a}$ |
| Camel | 0.00$^{b}$ | 0.06± (.04)$^{a}$ | 0.07± (0.04)$^{a}$ |
| Poultry (No) | 15.7$^{c}$ | 17.2$^{a}$ | 16.6$^{b}$ |

CBFS= cotton based farming system; SBFS= Sesame based farming system;
TLU= Tropical livestock unit, The means with different superscript letters in the row Was significantly (P<0.05) different

### 4.3.1. Livestock herd structures

The herd composition of cattle in cotton based farming system was dominated by cow and then followed by calves, oxen, heifers, and steers, respectively. Similarly, in sesame based farming system, cows dominated the herd, followed by calves, heifers, oxen and steer (Table 8). Generally, in both farming systems the herd structure was female dominated as compared to male. This shows that male animals are preferable to sale than female animals and calves. Cows and calves are retained for breeding stock. Besides, female animals are highly valued and counted as resources than male animals. Having a large number of cows are considered by the communities as a prestige and used as markers of wealth status in the study district. There is also a practice of buying oxen during farming activities. When plowing is over, they sell the oxen. Young bulls (locally called *Shelba)* were highly demanded in Sudan. As a result, the communities tend to sale them than females when in need of cash for sesame weeding and other household cases

Similarly, the trend of herd structures in small ruminant were female dominated and kids and males, respectively (Table 8). The number of males was smaller than females because the males were the first to be sold and slaughtered for cash and consumption respectively while females were retained as breeding stock. Camel and sheep were small in number as compared to other species of livestock. In case of camel, there is no female sock in the area. Male camels are brought from Afar region and the neighing Sudan mainly for sesame oil processing (locally called *Ansara*). Donkeys are the third largest stock next to cattle and goat. Unlike others only male donkeys were found in the district. This could be because of the male donkeys are demanded for the heavy burden of donkey cart (*Caroo)* and transportation activities than the female. Besides, the respondents revealed their views that the environment was not contusive for female donkeys during group discussion. Different studies also reported the idea that a herd structure dominated by female stock was also used to offset long calving interval and to stabilize milk production. This is a typical characteristic of pastoralists living in other parts of Ethiopia (Coppock, 1994; Admasu, 2006, Teshome, 2006). In the study area, chicken are kept mainly as immediate source of cash for family needs and occasionally as source of meat. Chicken are reared traditionally as free ranging and scavenging their feed. During the study period, it was noted that many farmers in the area were practicing cross breeding the local chicken with the wild birds (*Jigra*). Depending on the type and availability of grain, chicken were supplemented with maize, sorghum and other food crops. The study revealed that almost all of the households owned at least one chicken (Table 8).

Table 7. Livestock herd structure of the house holds in the farming systems of the study areas

| Variables | *CBFS* | *SBFS* | *Total* |
|---|---|---|---|
| | Mean± (SE) | Mean± (SE) | Mean(SE) |
| Oxen | 1.19± (0.09) | 1.06± (0.15) | 2.21± (1.10) |
| Cow | 2.04± (0.19) | 2.08± (0.26) | 4.10± (2.04) |
| Heifer | 1.02± (0.13) | 1.17± (0.15) | 2.19± (1.09) |
| Steer | 0.71± (0.13) | 0.73± (0.11) | 1.43± (0.71) |
| Calves | 1.30± (0.13) | 1.30± (0.18) | 2.58± (1.29) |
| **Total** | 6.24± (0.45) | 6.34± (0.59) | 12.52± (6.23) |
| male goat | 0.03± (0.01) | 0.01± (0.01) | 0.04± (0.02) |
| female goat | 0.23± (0.03) | 0.22± (0.03) | 0.45± (0.22) |
| Kids | 0.11± (0.02) | 0.20± (0.04) | 0.31± (0.16) |
| **Total** | 0.36± (0.04) | 0.43± (0.6) | 0.80± (0.40) |
| male sheep | 0.01± (0.01) | 0.06± (0.02) | 0.07± (0.04) |
| female sheep | 0.0$^{b}$ | 0.01± (0.01)$^{a}$ | 0.02± (0.01) |
| Lambs | 0.01± (0.0) | 0.04± (0.01) | 0.04± (0.02) |
| **Total** | 0.01± (0.1) | 0.11± (0.03) | 0.13± (0.07) |
| Donkey | 0.34± (0.03) | 0.31± (0.04) | 0.65± (0.32) |
| Camel | 00 | 0.06± (.04) | 0.07± (0.04) |
| Poultry(No) | 15.7$^{b}$ | 17.2$^{a}$ | 16.6 |

CBFS= cotton based farming system; Sesame farming system; SE= standard error, Tol

The means with different superscript letter in the rows was significantly (P<0.05) different

### 4.4. Major Livestock Feed Resources of the study area

The major dry season feed resources for cattle in the district are natural pasture (55.7 %), crop residues (20.7 %), stubble (14.3 %) and hay (9.3 %). For sheep, natural pasture, crop residues, and stubble were 73.6 %, 12.1 %, and 14.3 %, respectively. For goat 72.9 % and 27.1 % natural pasture and crop aftermath. For donkey, crop residues constituted 65.7 %, natural pasture 17.9 %

and aftermath 16.4 %. In the wet season natural pasture is the sole feed sources of livestock (Table 9). Among the major feed resources described above, the proportion of natural pasture is 50 % for cattle feed in CBFS. This is lower than the share of natural pasture (60 %) in SBFS. The crop residue, stubbles and hay in CBFS were higher than SBFS. This could be why a large amount of extensive grazing lands are found in SBFS and the communities depend on this land than on crop residues in CBFS. Natural pasture, crop residues, stubble and hay were the main livestock feed sources in the study area. The natural pastures in the study district were able to support the productivity of the animals in the rainy season. However, in the dry season, these pastures can hardly maintain the animals as most of the feed resources are unavailable. Crop residues for donkey feed in both farming systems was higher than the others because when donkeys finish their work at night they are given the already collected and stored feeds. This result is in line with the previous studies (Simbaya, 1998; Ibrahim, 1999; Alemayehu, 2006; Sisay, 2006; Elias, 2007).

Table 8. Percentage of respondents indicating the livestock feeding systems, major feed resources in two seasons and farming systems in Metema district

| Feeding system And major feed sources | CBFS | | | | SBFS | | | | Total | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wet | | Dry | | Wet | | Dry | | Wet | | Dry | |
| | HHC | % | HHC | % | HHC | % | HHC | % | HHC | % | HHC | % |
| **Feeding system:** | **N=60** | | **N=60** | | N=80 | | N=80 | | 140 | | N= 140 | |
| **Cattle** | | | | | | | | | | | | |
| Tethering | 6 | 10.0 | 2 | 3.3 | 4 | 5 | 4 | 5 | 10 | 7.14 | 6 | 4.3 |
| Free grazing | 54 | 90.0 | 58 | 96.7 | 68 | 85 | 73 | 91.25 | 122 | 87.14 | 131 | 93.6 |
| Cut and carry | - | - | - | - | 8 | 10 | 3 | 4.75 | 8 | 5.72 | 3 | 2.1 |
| **Goat** | | | | | | | | | | | | |
| Tethering | 13 | 21.67 | - | - | 11 | 13.75 | - | - | 24 | 17.14 | | |
| Free Browsing | 47 | 78.33 | 60 | 100.0 | 69 | 86.25 | 80 | 100.0 | 116 | 82.86 | 140 | 100 |
| **Sheep** | | | | | | | | | | | | |
| Free grazing | 60 | 100.0 | 60 | 100.0 | 80 | 100.0 | 80 | 100.0 | 140 | 100.0 | 140 | 100 |
| **Donkey** | | | | | | | | | | | | |
| Tethering | 14 | 23.33 | 39 | 65.0 | 15 | 18.75 | 49 | 61.25 | 29 | 20.71 | 88 | 62.9 |
| Free grazing | 46 | 81..67 | 21 | 35.0 | 65 | 81.25 | 26 | 32.5 | 111 | 79.29 | 47 | 33.6 |
| Cut & carry | | | | | | | 5 | 6.25 | | | 5 | 3.5 |
| **Major feed for:** | | | | | | | | | | | | |
| **Cattle:** | | | | | | | | | | | | |
| Natural pasture | 60 | 100.0 | 30 | 50 | 80 | 100.0 | 48 | 60.0 | 140 | 100.0 | 78 | 55.7 |
| Crop residues | | | 14 | 23.3 | | | 15 | 18.75 | | | 29 | 20.7 |
| Aftermath | | | 9 | 15 | | | 11 | 13.75 | | | 20 | 14.3 |
| Hay | | | 7 | 11.7 | | | 6 | 7.5 | | | 13 | 9.3 |
| **Goat** | | | | | | | | | | | | |
| Trees & shrubs | 60 | 100.0 | 45 | 75 | 80 | 100.0 | 57 | 71.25 | 140 | 100.0 | 102 | 72.9 |
| Aftermath | | | 15 | 25 | | | 23 | 28.75 | | | 38 | 27.1 |
| **Sheep** | | | | | | | | | | | | |
| Natural pasture | 60 | 100.0 | 41 | 68.4 | 80 | 100.0 | 62 | 77.5 | 140 | 100.0 | 103 | 73.6 |
| Crop residues | | | 8 | 13.3 | | | 9 | 11.25 | | | 17 | 12.1 |
| Aftermath | | | 11 | 18.3 | | | 9 | 11.25 | | | 20 | 14.3 |
| **Donkey** | | | | | | | | | | | | |
| Natural pasture | 60 | 100.0 | 13 | 21.7 | 80 | 100.0 | 12 | 15 | 140 | 100.0 | 25 | 17.9 |
| Crop residues | | | 35 | 58.3 | | | 57 | 71.25 | | | 92 | 65.7 |
| crop aftermath | | - | 12 | 20 | | | 11 | 13.75 | | | 23 | 16.4 |

HHC= house hold count, CBFS= cotton based farming, SBFS= Sesame farming system

### 4.4.1 Availability of Natural Pasture

The respondents said that the availability of cattle feeds during dry seasons in cotton based farming system was inadequate (61.67%). They indicated that it is lower than those who said it is inadequate (65 %) in the SBFS. Overall, the availability of feed for dry season in the district is (63.57 %) and that is shows the inadequacy of the feed. This could be because the majority of the grazing lands were subjected to fire during the dry season and most of the dry feeds turned to ash. The availability of goat feed was in the cotton based farming system and is prioritized as adequate (75 %) and inadequate (25 %), respectively. Similarly, in sesame based farming system, 70 % of goat feed was adequate and 30% was inadequate (Table 10). This could be because for the feed goats largely depend on the browse species that are available in abundance in the woody vegetation of the study area. In the availability of sheep feed, the respondents in CBFS indicated that 45 % was adequate. On their part, 44.75 % of the respondents in SBFS pointed out that it is adequate. The inadequacy could be because sheep are favored by the availability of perennial forbs that support them. However, the availability of livestock feeds in the wet season in both farming system were found to be adequate (50%), abundant (42.86 %) and inadequate (7. 14 %), respectively. This result is in agreement with the other research findings (Alemayehu, 2006; Sisay, 2006; Elias, 2007).

Table 9. Percentage respondents indicating feed resources availability in the study district

| *Variables* | *CBFS* | | *SBFS* | | *Totall* | |
|---|---|---|---|---|---|---|
| | HHC | % | HHC | % | HHC | % |
| **Availability of feeds:** | | | **Dry season** | | | |
| Cattle: | | | | | | |
| Adequate | 23 | 38.3 | 28 | 35.0 | 51 | 36.43 |
| Inadequate | 37 | 61.67 | 52 | 65 | 89 | 63.57 |
| Goat | | | | | | |
| Adequate | 45 | 75 | 56 | 70 | 101 | 72.14 |
| Inadequate | 15 | 25 | 24 | 30 | 39 | 27.86 |
| Sheep | | | | | | |
| Adequate | 33 | 55 | 45 | 56.25 | 78 | 55.71 |
| Inadequate | 27 | 45 | 35 | 44.75 | 62 | 44.29 |
| Donkey | | | | | | |
| Adequate | 51 | 85 | 62 | 77.5 | 113 | 80.71 |
| Inadequate | 9 | 15 | 18 | 22.05 | 27 | 19.29 |
| | | | **Wet season** | | | |
| **Feed availability** | | | | | | |
| Adequate | 28 | 48.3 | 42 | 52.5 | 70 | 50.0 |
| Inadequate | 10 | 16.7 | | | 10 | 7.14 |
| Abundance | 22 | 36.7 | 38 | 47.5 | 60 | 42.86 |

N=60 for CBFS; N= 80 for SBFS, CBFS= cotton based farming system, SBFS= sesame based farming system, HHC= house hold count.

### 4.4.2. Hay making

As noted from the group discussion with elders, haymaking in the study area started recently. Before 9 years ago, there was no shortage of dry season feeds in the area. This was because bamboo trees were shedding leaves at dry seasons. In the area, during dry seasons foliages of the leaves that come off trees are the principal sources of livestock for during dry seasons. Following the gradual disappearance of the bamboo forests by livestock, human population pressure and drought, their livestock became challenged by the long dry season. As a result, the communities were forced to start the conservation and collection of hay. Hay conservation and making is done from the end of October to the end of November. Curring takes places for two weeks to one month. This shows that hay was not well practiced and was not even properly prepared in time. This was confirmed during the field work. The study generally made clear that there is strong association between low extension services delivered to farmers and the short duration of hay making practiced in the area. which is in agreement with the report of Sisay (2006).

### 4.4.3. The production and availability of Crop residues

In the cotton based farming system, the main crops grown by farmers are cotton, rice, sorghum, maize, and sesame, finger millet and fruits. In the sesame based farming system, sesame, cotton, sorghum, maize, soya bean, teff, chick pea, groundnut and fruits are widely grown. Among the cereal crops, sorghum is the most widely crop grown in the district of which 89.51 % of the total crop-residues are generated in the area. The proportion of maize is 8.4 % while teff 1.31 % respectively (Table 9). Next to natural pastures, crop-residues are the other main source of livestock feeds for ruminant animals in the dry season of the district. That is, in CBFS, 23.3%, 13.3% and 58.3 % are crop residues used for cattle, sheep and donkey respectively. On the other hand, the crop-residues used as feed for different livestock species in SBFS are 18.75 %, 11.25 % and 71.25 % for cattle, sheep and donkeys respectively. The total percentage of crop residues used for livestock feed in the district are 20 %, 12.1 % and 65.7 % for cattle sheep and donkey respectively (Table11). The difference in crop residues between the two farming systems could be attributed to the production of sorghum in sesame based farming and better access to it CBFS than to SBFS. Crop residues used by donkeys are also higher than the other species. That could be because donkeys are at heavy work during day times and they are tethered and given crop residues when not at work. This finding is in agreement with the reports of Dixon *et al*, (1987). The value of crop-residues produced in a particular area will depend on the amount and type of crops grown in that area. Smallholder farmers usually practice mixed agriculture and, as a result, have crop-residues.

Table 10. The major crops cultivated and produced (ton) together with the amount of crop residues generated (tons DM) in the district

| Types of Crops | Cultivated(ha) | Produced (Qt) | CRs (ton) | G:CR ratio | % share |
|---|---|---|---|---|---|
| Teff | 1005 | 8033 | 12.05 | 1.5 | 1.31 |
| Finger millet | 365 | 2555 | 1.25 | 2.04 | 0.14 |
| Sorghum | 15820 | 329056 | 822.64 | 2.5 | 89.51 |
| Maize | 1809 | 40143 | 80.29 | 2.0 | |
| chick pea | 86 | 344 | 0.41 | 1.2 | |
| rice | 117 | 2340 | 2.34 | 1 | 0.25 |
| Soya bean | 15.5 | 93 | 0.09 | 1 | |
| Total | | | 919.07 | | |

Sources: OoARD (2006); CRs = crop residues; G:CR = grain : crop residues ratio

#### 4.4.3.1. Utilization practices of crop residues

The quantity of DM that can be obtained from crop residue is estimated from grain yield (FAO, 1987) based on estabilished conversion factors with a utilization factor of about 90 % and 10 % is used for other purposes like fuel and wastage (Table 10**)**The mean ton of sorghum residue used as animal feed 38.15± (4.23) in CBFS is significantly (P< 0.05) different from the mean utilization of sorghum as feed in the SBFS 10.72± (3.66). This situation is associated with difference in practice of crop residues conservation and utilization between the two farming systems. The overall mean ton of sorghum residues utilization (22.23 ± 2.98) as livestock feed in the district is significantly (P<0.05) lower than the crop residues burned in the field (24.06 ± 2.63) and left as mulch (22.43 ± 2.63). The mean ton of sorghum residues utilization per household 13.39 ± 2.54) in CBFS is significantly (P<0.05) higher in proportion than the residues of maize (13.5± (3.15), peanut (20.83 ± 5.19) and teff (3.98 ± 2.17) respectively. On the other hand, in the SBFS, sorghum residues used as livestock feed is 10.72± 3.66) ton while that of maize, peanut, and teff were (15.63 ± 3.56), (5.63 ± 2.35), (4.11 ± 1.87), respectively. The total mean crop residue utilization as livestock feed of sorghum, maize, teff, and peanut are (22.23 ± 2.98) ton, (14.71± 2.67), (14.96 ± 2.98), (0.28 ± 0.18), respectively (Table 10). From this one can infer that the total crop residues that are produced in the district are not fully utilized as livestock feeds; rather, they are used as mulch. They are also burnt at the field, house and shade (*Arakuba*) construction. They are also used for other purposes (Table 12). The finding is in congruence with other studies carried out in the past (Van Raay and de Leeuw, 1970, 1974). These studies reported that crop residues, apart from being sources of animal feed, are used as building, roofing and fencing materials. In addition, the studies indicated that they are used as sources of fuel, fertilizer or surface mulch in cropland.

Table 11. The Mean ± (SE) utilization of crop residues (tons/ha) for different purposes in the district

| Variables | CBFS | SBFS | Over all |
|---|---|---|---|
| Sorghum stover as feed | 38.15±(4.23)[a] | 10.72± (3.66)[c] | 22.23± (2.98)[b] |
| Sorghum stover as housing | 13.39± (2.54)[a] | 5.0± (2.19)[c] | 8.52± (1.68)[b] |
| Sorghum stover as Compost | 22.08± (4.06)[a] | 22.97± (3.50)[a] | 22.43± (2.63)[a] |
| Sorghum stover Burned | 28.81± (4.25)[a] | 20.82± (3.67)[b] | 24.06± (2.63)[b] |
| Sorghum stover sold | 6.84± (1.96)[a] | 1.26 ± (1.69)[c] | 3.62± (1.29)[b] |
| Maize stover used as feed | 13.72± (4.12)[a] | 15.63 ± (3.56)[a] | 14.71± (2.67)[a] |
| Maize stover as housing | 13.72± (3.30)[a] | 8.16± (2.92)[b] | 10.54± (2.17)[a] |
| Maize stover as compost | 3.22± (2.04)[a] | 7.46± (2.13)[a] | 5.67± (1.61)[a] |
| Maize stover burned | 10.00± (2.04)[a] | 2.72 ± (1.76)[c] | 5.79± (1.35)[b] |
| Maize stover sold | 18.47(2.34)[a] | 0.13± (2.02)[c] | 7.91± (1.69)[b] |
| Peanut used as feed | 20.83± (5.19)[a] | 5.63 ± (2.35)[b] | 3.23± (1.37)[c] |
| Peanut used as housing | 0.00± (1.46)[c] | 4.17± (1.26)[b] | 9.71± (2.42)[a] |
| Peanut used as compost | 21.18± (3.52)[a] | 1.26 ± (3.04)[b] | 0.28± (0.18)[c] |
| Teff straw used as feed | 3.98± (2.17)[b] | 4.11 ± (1.87)[b] | 14.96± (2.98)[a] |
| Teff straw used as housing | 31.61± (4.16)[a] | 2.53 ± (3.6)[b] | 3.33± (1.41)[b] |
| Teff straw used as compost | 0.60± (0.41)[c] | 5.69± (1.80)[a] | 1.25± (0.88)[b] |
| Teff straw burned | 0.00± (0.77)[b] | 1.26± (0.67)[a] | 0.44± (0.31)[a] |

CBFS= cotton based farming system; SBFS= sesame based farming system; SE= standard error; means with different superscript letters in a row are significantly (P<0.05) different

### 4.4.4 Supplementation

Crop residues, sesame oil by-products (*Embaze*), noug cake, hay, and wheat bran are the sources of supplementation of dry season feed in the district. The proportion of crop residues (28.33%) used as supplementation in CBFS is significantly ($P<0.05$) higher than the proportion of crop residues (20%) and used as supplement in SBFS. This difference may be due to the availability of residues and experiences of the farmers in collecting and utilizing crop residues in CBFS, which is higher as compared to sesame based farming. The proportion of supplementation of e*mbaze* (6.7%) in the CBFS is lower than the proportion of e*mbaze* (26.25%) of SBFS. This could be that the proportion of sesame production in the latter case is higher and the majority of the farmers might have obtained better access.

The supplementation of *Embaze* + crop residues, noug cake, hay, and wheat bran in CBFS are e 16.67 %, 15 %, 13.3 %, and 8.33 %, respectively. On the other hand, in SBFS the supplementation are 15 %, 8.75 %, 12.5 %, and 11.25 %. The percentage accounts for *Embaze* + crop residues, noug cake, hay and wheat bran, respectively. The supplementation of grain and crop residues are 60 % and 33.33 % respectively for donkey in the cotton based farming system. This is higher ($P<0.05$) than the amount of supplementation of the sesame based farming system grain, and crop residues, which is 55 % and 36.25 % respectively. The study revealed that the amount of hay (6.67 %) in cotton based farming is smaller than the amount of hay (8.75 %) in the sesame based farming system (Table 14).

#### 4.4.4.1 The amount of supplementation

Out of the 60 respondents in the CBFS, 55% were given 1 kg crop residues /hay/ animal for cattle. This is significantly higher than ($P<0.05$) the proportion of supplementation (51.25 %) in SBFS. In contrast, the farmers were given 0.5 kg/d/anim. sesame cake (*Embaze)* supplementation (10 %) in CBFS. This is significantly ($P<0.05$) different from the proportion of *Embaze* supplementation (25 %) in the SBFS (Table 12). The proportion of crop residues plus *Embaze*, noug cake and hay supplementation for cattle are (25 %), (3.33 %) and (6.67 %) in cotton based farming system. This is different from sesame based farming system (7.5 %), (5.0 %) and (11.25 %) respectively. Generally, the major proportion of supplementations in the district were 1 kg crop residues /day /animal, 1.5 kg Crop residues + Embaz /day/animal, 0.5kg *Emaze* / day/ animal, 2 kg hay /day/animal and 0.75 kg Noug cake /day/animal. The proportions for these feed types were 52.86 %, 22.14%, 18.57 %, 5.4 % and 4.21%, respectively (Table 14). However, wheat bran was not estimated. It was noted in the field work that the amount of supplementation, especially sesame cake, noug cake and wheat bran, are very small. The major purpose why the farmers do supplementation is just to sustain their animal's life from death out of shortage of feed, not to increase productivity. During supplementation, the farmers give priority for highly susceptible animals, for animals that are drastically affected by feed shortage (drought), weak animals, lactating cows and calves respectively.

Table 12.The types and amounts of supplementation used by respondents in the study district

| Variables | CBFS | | SBFS | | Over all | |
|---|---|---|---|---|---|---|
| | HH | % | HH | % | HH | % |
| **Types of supplementation** | | | | | | |
| **Cattle** | | | | | | |
| Crop residues | 17 | 28.33 | 16 | 20 | 31 | 12.9 |
| Crop residues + Embaze | 10 | 16.67 | 12 | 15 | 22 | 15.71 |
| Embaze | 4 | 6.7 | 21 | 26.25 | 25 | 17.68 |
| Noug cake | 9 | 15.0 | 7 | 8.75 | 16 | 11.43 |
| Hay | 8 | 13.3 | 10 | 12.5 | 18 | 12.86 |
| Wheat bran (Furiska) | 5 | 8.33 | 9 | 11.25 | 14 | 10 |
| **Donkey** | | | | | | |
| Crop residues | 20 | 33.33 | 29 | 36.25 | 49 | 35 |
| Hay only | 4 | 6.67 | 7 | 8.75 | 11 | 7.86 |
| Grains | 36 | 60 | 44 | 55 | 80 | 57.14 |
| **Amount Supplementation** | | | | | | |
| **Cattle:** | | | | | | |
| 1 kg/day/animal | 33 | 55.0 | 41 | 51.25 | 74 | 52.86 |
| 1.5 kg/day/ animal | 15 | 25 | 6 | 7.5 | 31 | 22.14 |
| 0.5 kg/day/ animal | 6 | 10.0 | 20 | 25.0 | 26 | 18.57 |
| 0.75 kg/day/ animal | 2 | 3.33 | 4 | 5.0 | 6 | 4.21 |
| 2 kg/day/ animal | 4 | 6.67 | 9 | 11.25 | 13 | 5.4 |
| **Donkey:** | | | | | | |
| 1.5 kg/day/animal | 19 | 31.67 | 24 | 30 | 43 | 30.71 |
| 2 kg/day/animal | 1 | 1.67 | 4 | 5 | 5 | 3.57 |
| 1 kg/day/animal | 40 | 66.66 | 52 | 65 | 92 | 65.71 |

N=60 for CBFS; N= 80 for SBFS; 1kg = Crop residues only; 1.5kg = Crop residues +Embaze; 0.5 kg= Embaze (Sesame cake); 0.75 kg = Noug cake; 2 kg = Hay.

### 4.4.5. Feeding calendar and Seasonal availability of feed resources

Information about the seasonal availability of livestock feed resources in the study area was obtained from group discussions and observations during the field work. Table 15 below shows the result. It was learned that the pattern of availability of feed resources in the district is influenced by similar factors reported by other researchers (e.g. Gryseels, 1988; Ahmed, 2006) for the highland areas and the trend of the pattern is also similar with trend of the patterns discovered in other studies (e.g. Sisay, 2006).

Table 13.The Periods during which, different feed resources is available in the district

| Types of feeds | months of the year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May |
| Natural pasture | * | * | * | * | * | * | ----- | ---- | ----- | ---- | ----- | ----- |
| Crop residues | | | | | | | | | * | * | * | * |
| Stubble grazing | | | | | ---- | * | * | * | | | | |
| Hay | | | | | | | | | * | * | * | * |
| Supplementation | | | | | | | | | | --- | * | * |
| Fodder trees | * | | | | | | | | | * | * | * |

----- = Availability of few green browse species and dry grasses; * = Abundant

### 4.4.6. Water Resources

The availability of water sources in the grazing area is a good opportunity for livestock as well as human beings living in the lowland agro-ecology like the Metema District. From the group discussions with the respondents it was learned that there has not been water problem in the study district. The responses of the research participants confirmed ILRI's (2005) report that generally farmers and agriculturists in the district are of the belief that the underground water table is abundant and in some places sufficient amount of water could be obtained in shallow distance, for example, at the depth of 10m.

In the district, there are three large perennial rivers and they are used for livestock drinking and irrigation activities. Table 19 below shows that the sources of water in the cotton based farming system was 65% river, and 18.33%, 13.33%, and 3.3%. These percentages are for ponds, springs, and wells, respectively. On the other hand, in sesame based farming system, river, ponds, and springs and well are 63.75%, 5%, 27.5% and 3.75 %, respectively. According to this study, there is no significant difference in water sources between the two farming systems. River (64.29%) is the major source of drinks for livestock in the study district. As can bee seen from Table 19, river is followed by springs (21.43%), ponds (10.71%) and wells (3.57%), respectively. The frequency of watering animals is indicated in Table 6. The majority of the respondents pointed out that 69.29 % of their animals drink water once a day while remaining 30.71% of them indicated that their animals drink water twice per day. The finding here is in congruence with Teshoma's (2006) findings.

Table 14. The sources of water and watering frequency of animals in the district

| Parameter | CBFS | | SBFS | | Over all | |
|---|---|---|---|---|---|---|
| | HHC | % | HHC | % | HHC | % |
| Sources of water: | | | | | | |
| River | 39 | 65 | 51 | 63.75 | 90 | 64.29 |
| Pond | 11 | 18.33 | 4 | 5 | 15 | 10.71 |
| Spring | 8 | 13.33 | 22 | 27.5 | 30 | 21.43 |
| Well | 2 | 3.33 | 3 | 3.75 | 5 | 3.57 |
| Watering frequency: | | | | | | |
| Once a day | 37 | 61.67 | 60 | 75 | 97 | 69.29 |
| Twice a day | 23 | 38.33 | 20 | 25 | 43 | 30.71 |

Watering frequency = for cattle, CBFS= cotton based farming system; SBFS= Sesame based farming system

## 4.5. Chemical Composition of dominant Feed resources in the study district

### 4.5.1. The effects of season on chemical composition

The effect of season on chemical composition of the dominantly growing two grass and one fodder species in the study district are shown in Table 16. The nutrient contents of the feed resources are affected by season. The contents of DM, OM, NDF, ADF and ADL feeds in October are significantly ($P<0.05$) higher than those in August. On the other hand, the contents of ASH, CP and IVDMD feeds in October are significantly ($P<0.05$) lower than that of August (Table 16). This may be attributed to the impact of temperature, the stages of growth and the plant species that influenced the quality of feeds. This finding confirmed the findings of other studies (e.g. Alemayehu, 2006; Stoddart *et al*., 1975; Sisay (2006). In other words, the findings of the current study confirmed the fact that the structural constituents of plant materials (lignin, cellulose and hemi-cellulose) increase with maturity in both temperate and tropical species. It is during the growth stages that plants are most nutritious. Once mature, they are subjected to leaching and dilution of nutrients and reduction in nutritive value. Declines in nutrient composition and leaching are more serious, of course, in herbaceous plants. As plants mature, the amount of crude protein, a more readily digested carbohydrates and phosphorus decrease while the amount of fiber, lignin and cellulose increase. Decline in the nutritive value of these feeds during October indicated that the feed conservation which the communities practiced after mid October and November in the district was outside its appropriate time and should be changed.

Table 15. Chemical composition (Mean±SE) of feeds in different seasons in the district

| % of chemical composition | Seasons | |
|---|---|---|
| | August | October |
| DM | 88.87 ±(0.11)$^{b}$ | 90.47±(0.11)$^{a}$ |
| ASH | 18.24 ± (2.07)$^{a}$ | 10.48 ± (2.07)$^{b}$ |
| OM | 81.75 ±(2.07)$^{b}$ | 89.51± (2.07)$^{a}$ |
| CP | 10.84± (0.35)$^{a}$ | 8.21± (0.35)$^{b}$ |
| NDF | 60.76±( 0.52)$^{b}$ | 73.92± (0.52)$^{a}$ |
| ADF | 40.30±(0. 45)$^{a}$ | 49.59± (0.45)$^{a}$ |
| ADL | 10.09 ±(0.60)$^{b}$ | 13.45 ±(0.60)$^{a}$ |
| IVDMD | 50.74 ±(0.96)$^{a}$ | 37.90± (0.96)$^{b}$ |

Means with different superscript letters in the rows are significantly (P<0.05) different

### 4.5.2. The effect of species types on chemical composition

The chemical composition of different species of feed resources in the district is shown in (Table 17). According to NRC (1962**),** the chemical analysis of range forage plants serves as a comparative measure of differences between species and change with season. The comparison of the three major species of *Pennisetum spheslatum*, *Cenchrus ciliaris* and *Pterocarpus lucens* indicated that there is difference in nutrient contents between the species. The mean proportion of DM, and ASH, contents in *Pennisetum spheslatum* (PS) is significantly (P<0.05) larger than the mean in *Pterocarpus lucens* (PT) and *Cenchrus ciliaris* (CC). Similarly, the mean proportion of ADF, ADL in *Pennisetum spheslatum* is significantly (P<0.05) higher than that of *Pterocarpus lucens* (PT). The mean proportion of the DM, ASH, NDF and ADF contents of *Pterocarpus lucens* is significantly (P<0.05) lower than the mean proportion of the DM, ASH, NAF and ADF contents of *Cenchrus ciliaris* (Table 17). On the other hand, the mean proportions of OM, CP in *Cenchrus ciliaris* were greater than that in Pennisetum *spheslatum*. In addition, the mean proportion of the contents of NDF and ADF in *Cenchrus ciliaris* is significantly (P<0.05) higher than that of *Pennisetum spheslatum* and *Cenchrus ciliaris*. In contrast, the mean proportion of OM, CP and IVDMD contents in *Pterocarpus lucens* (PT) is significantly (P< 0.05) higher than that in *Cenchrus ciliaris* and *Pennisetum spheslatum* (Table 17). Differences in nutrient content between and within the species types could be associated with the inherent nature of the species. In other words, the fodder trees contain more protein sources than grass species. Of course, there could be morphological and anatomical differences within the smame species. Mathur *et al* (1991) indicated that most grasses and tree leaves in arid environments are low in nutritive values mainly because of the high contents of lignin and relatively indigestible cellulose and hemi-cellulose.

Table 16. The mean chemical composition (Mean±SE) of different feeds in the study districts

| % of chemical composition | Types of species | | |
|---|---|---|---|
| | PS | CC | PT |
| DM | 90.18 ± (0.14)$^{a}$ | 89.85± (0.14)$^{ab}$ | 88.98± (0.14)$^{b}$ |
| ASH | 20.09 ± (2.54)$^{a}$ | 15.25 ± (2.54)$^{ab}$ | 7.74 ± (2.54)$^{b}$ |
| OM | 79.91± (2.54)$^{ab}$ | 84.74 ± (2.54)$^{ab}$ | 92.25±( 2.54)$^{a}$ |
| CP | 6.31± (0.43)$^{ab}$ | 6.43± (0.43)$^{ab}$ | 15.78 ± (0.43)$^{a}$ |
| NDF | 69.31± (0.64)$^{b}$ | 74.55±( 0.64)$^{a}$ | 58.17± (0.64)$^{c}$ |
| ADF | 45.82± (0.55)$^{a}$ | 45.95± (0.55)$^{a}$ | 43.07 ± (0.55)$^{b}$ |
| ADL | 8.13± (0.74)$^{ab}$ | 5.86 ± (0.74)$^{ab}$ | 21.33± (0.74)$^{a}$ |
| IVDMD | 45.85± (1.18) $^{b}$ | 39.3± (1.18)$^{c}$ | 47.79 ± (1.18)$^{a}$ |

PS= *Pennisetum spheslatum;* CC= *Cenchrus ciliaris;* Pt= *Pterocarpus lucens*
Means with different superscript letters in a rows are significantly (P<0.05) different.

### 4.5.3. Interaction effects of season and species type on chemical composition

The interaction effects of season and species type on chemical composition of the analyzed feed resources in % DM, % ASH, % OM**, %** CP, % NDF, % ADF, % ADL, and % IVDMD contents were highly influenced by season and species types. As a result, there is significantly (P<0.05) high interaction effects with season and species types (Appendix table 13-20).This result is in agreement with the study result reported by Sisay (2006).

### 4.6. Feed balances in the study district

The estimate of the total available feeds in terms of dry matter calculated from grazing land, cultivated land (crop residues and stubble), and forest land is presented in (Table 17). However, the total estimated crop residues is 827.16 ton DM per annum and that from grazing land and stubble are 780750 and 51954 ton DM per annum, respectively. The total estimated available feed supply is 833531.16 ton DM per annum. On the other hand, the total livestock population in TLU (tropical livestock unit) is 103190 (Table 18). The daily DM requirement to maintain one TLU is estimated as 2.5% of the body weight (ILCA, 1990,) ,that is, 250 x 2.5 % = 6.25 kgDM per day and per annum. Therefore, based on the estimated values obtained (Table 17), the feeds in DM basis available to maintain the livestock in the district is found to be over. This finding is confirmed the finding of Sisay (2006), in which the researcher argued that the nutrient balance in the DM supply of the feed in Metema District is sufficient to support the livestock per household. However, in the current study the quality of the available feeds were found to be very poor as the feeds contain high fiber and, as a result, are unable to supply the required amount of energy and protein for the animals.

Table 17. The feed balance estimate in the study district

| Livestock | *A (TLU)* | *B* | *AxB* | *C* | *C-(AxB)* | *D* |
|---|---|---|---|---|---|---|
| Cattle | 95837 | 2.28 | 218508.36 | | | |
| Goat | 3202 | 2.28 | 7300.56 | | | |
| Sheep | 169 | 2.28 | 385.32 | | | |
| Donkey | 3582 | 2.28 | 8166.96 | | | |
| Camel | 400 | 2.28 | 912 | | | |
| Total | 103190 | | 235273.2 | 833531.16 | 598257.96 | 0.00 |

A = Livestock number in the district (TLU), B = Feed requirement of one animal (tDm $yr^{-1}$), AxB =Total feed requirement of the animals (t DM $yr^{-1}$), C = Estimate of the available feed resources in district (t DM/yr), C-(AxB) = Estimated feed balance of the district, D = Deficit (if any)

### 4.7. Major livestock constraints of the district

During the study, 23.3 % of the respondents in the CBFS and 23.8 % in the SBFS ranked livestock theft as the first problem in the farming systems. Regarding their perception about the impact of theft, there is no significant difference between the two types of respondents. From the overall, 33% of the respondents concluded that livestock theft is among the main constraints in the district. During group discussions elders indicated that 90 heads of livestock are stolen at a time and the problem has been escalating from time to time. The ever-increasing livestock theft occurred due to two main reasons. One is because there is free movement across international border. The other is absence of check points for livestock control and their markets.

Livestock diseases (16.7%) and biting insects (13.3%) are the second and third constraints in CBFS and the SBFS, respectively. Livestock disease in SBFS (18.8 %) is slightly higher than livestock disease occurrence in CBFS (16.7 %. The possible reason for this difference might be that agro-climate of the sesame based farming is dominated by a relatively dry-lowland micro climate (agro-ecological digital map of Metema). Again, this micro-climate may have favored the disease causing organisms. In this district, livestock disease is 17.9 % while biting insects is 12.9 %. On the other hand, the encroachment of croplands to the grazing lands is 11.7% in cotton based farming system. This is larger than that in sesame based farming (10.0 %). This could be attributed to increase in human population in the area. The overall proportion of cropland encroachment in is 10.7 %. Cropland encroachment is the fourth major constraints that threats grazing land of the area. The possible causes of the crop land encroachment might be human population pressure which the settlement program by the government.

Conflict with the transhumant (8.3 %) in the cotton based farming system is lower than conflict in the sesame based farming system (10 %). This might be because of the better availability of extensive open access grazing lands in SBFS than in the CBFS. Conflict between transhumant and the local inhabitants for feed resources in the district is 9.3 %. Feed shortage, drought and low availability of crop residues in the district are 5.7 %, 8.6 % and 5 %, respectively (Table 20). It was learned during group discussion that the low availability of crop residues could be because of the two dominantly growing local sorghum varieties, namely, *wodiaker* and z*ole*, from which the major crop residues generated have gradually decreased in production. That is, *Wodiaker* is highly preferred and used by livestock to *zole* sorghum varieties. However, the productivity of *wodiaker* varieties was alarmingly declining than *zole* varieties as the soil fertility declined from time to time while *zole* varieties are tolerated on less fertile and productive soil than the *wodiaker* varieties. This situation could contribute for the shortage of crop residues during the long dry season. Thus, alternative and dual purpose species of sorghum should be looked to minimize this paradox in the area.

Table 18. Percentage of respondents indicating the major constraints in the study district

| *Variables* | *CBFS* | | *SBFS* | | *Over all* | |
|---|---|---|---|---|---|---|
| | HH | % | HH | % | HH | % |
| Feed shortage | 4 | 15.0 | 4 | 5.0 | 8 | 5.7 |
| Biting insects | 8 | 13.3 | 10 | 12.5 | 18 | 12.9 |
| Livestock diseases | 10 | 16.7 | 15 | 18.8 | 25 | 17.9 |
| Labor shortage | 4 | 6.7 | 5 | 6.3 | 9 | 6.4 |
| Drought | 5 | 8.3 | 7 | 8.8 | 12 | 8.6 |
| Livestock theft | 14 | 23.3 | 19 | 23.8 | 33 | 23.6 |
| Conflicts | 5 | 8.3 | 8 | 10.0 | 13 | 9.3 |
| Crop land encroachment | 7 | 11.7 | 8 | 10.0 | 15 | 10.7 |
| Low availability CRs | 3 | 5.0 | 4 | 5.0 | 7 | 5.0 |

(CBFS: N=60) (SBFS: N= 80), HH= Frequency, CBFS= cotton based farming system, SBFS= sesame based farming system

## 4.8. Floristic Composition of the Study District

### 4.8.1. Herbaceous species composition

In the district, a total of 33 herbaceous species were recorded. Of these, 14 were different species of grasses while 19 were different non-grass species. Among the non-grass species, 6 species were legumes whereas 13 species were sedges and others (Appendix Table 6). Of the grass species identified in the study area, 23.07 % were categorized as highly desirable, 38.46 % as desirable and 30.77 % as less desirable. The proportions of desirable and less desirable species of grasses increased when compared to the proportion of the species identified as highly desirable. This might be due to the gradual disappearance of highly desirable species through overuse and disturbance by livestock and human beings. During discussion with the farmers, it was understood that the major factors that caused decline in the abundance of highly desirable species are drought and overgrazing. The finding confirmed the previous finding that excessive and protracted overuse of land paves the way for invaders or undesirable plants to dominate the area. The invader plants were absent in the original vegetation, but through grazing pressure, they have replaced the decreaser and increaser plants (Gartner, 1976). In similar way, Herlocker *et.al* (1999) suggested that overgrazing reduces ground cover, plant height, forage quality and productivity, and changes are induced in the dominant growth forms of herbaceous plants as tall perennial bunch grass species give away to shorter rhizomatous and sotoloniferous perennial grasses which are replaced by annual grass and forbs species. Moreover, overgrazing tends to reduce perennial grassland vegetation types and allow invasion by annual forbs and grasses (Holechek *et. al.,* 2001). Other studies (e.g. Admasu, 2006; Alemayehu, 2006 and Amaha, 2006) also quantified that drought and overgrazing might have been the main factors that caused decline in the composition and diversity of plant species over a long period of time.

Table 19. Common and /or dominant grass species identified in the farming systems and different grazing types

| | | *CBFS* | | | *SBFS* | | |
|---|---|---|---|---|---|---|---|
| *Grasses* | *Cate.* | CG | RS | EN | CG | RS | EN |
| *Cenchrus ciliars* | DS | D | C | C | C | | C |
| *Pennisetum sphacelatum* | DS | C | | C | D | C | C |
| *Setaria pumila* | DS | C | C | C | - | C | C |
| *Brachiaria lata* | DS | C | - | - | - | - | C |
| *Urochloa fatamensis* | LD | - | C | C | - | - | - |
| *Rhamphicarpa fistulosa* | LD | C | C | - | - | C | - |
| *Temeda triandria* | HD | - | - | D | - | - | - |
| *Cynodon dyctlon* | HD | - | - | C | - | - | - |
| *Cyprus spp.* | DS | - | C | - | - | - | C |
| *Eleusine floccifolia* | LD | - | D | - | - | D | C |
| *Hyparrhenia rufa* | HD | - | - | D | - | - | D |
| *Panicum coloratum* | HD | - | - | - | - | - | D |
| *Sporobolus pyramidialis* | DS | - | - | - | - | - | C |

Cate = Categories; HD = highly desirable; DS = Desirable; LD = Less desirable; CG = Communal grazing; RS = Roadside; EN = Enclosed areas; C = Common (>5% and <20% of DM), D = Dominant (>20% of DM)

### 4.8.2. Woody species composition

A total of 20 woody species were identified in the study district (Appendix Table 5). Of the identified woody species, 15 %, 35 %, and 50 % were highly desirable, desirable and less desirable, respectively. The largest proportion of woody vegetation is contributed by different species of *Acacia* (20%) and commbretum (10%). Moreover, species like *Anogeissus leiocarpus, Pterocarpus lucens,* and *Ziziphus spina-Christi* were identified as highly desirable species. They were also dominant in enclosed areas. *Acacia*, *Balanites aegyptica, Boswelia papyrifera, Combretum collinum, and Combretum mole Dichrostachys cinerea, Ficus sycomorus, Feluegea virosa, Gardenia ternifolia, Grewia villosa, Stereospermum kunthianum, Terminalia laxiflora* and *Ximenia Americana* are commonly found woody species in the study district (Table 22). In sesame based farming system, *Acacia polyacantha, Acacia seyal, Balanites aegyptiaca* and *Boswelia papyrifera* are the dominant species but *Acacia tortilis*, *Anogeissus leiocarpus, Acacia Senegal*, *Combretum collinum*. *Combretum mole, Dichrostachys cinerea, Ficus sycomorus, Fluegea virosa, Pterocarpus lucens,* and *Ziziphus spina-christi* are ere common species in communal grazing areas. In roadside grazing areas, *Acacia polyacantha*, and *Dichrostachys cinerea* are dominant, but *Acacia seyal, Balanites aegyptica, Boswelia papyrifera, Terminalia laxiflora, Combretum collinum*. *Combretum mole* and *Ximenia Americana* are common species. From this one can conclude that the grazing lands in the district are characterized as an *acacia* tree dominated woodland. These woody vegetations sever as the most important sources of feed for ruminant animals in the area.

During group discussions the researcher leraned that *Pterocarpus lucens* is one of the most important fodder trees in the district. After the long dry season during the onset of the main rainy season, the communities search for *Pterocarpus lucens* to heal their emaciated animals. Therefore, the communities give more protections for this tree against destruction. This shows the fact that woody plants are of higher significance as sources of livestock feed in the district. The finding strengthens the report that woody species are important source of food, fodder, fuel wood, medicine, fiber and gums (Herlocker *et.al.*, 1999; Alemayehu, 2006).

Table 20. Common and/or dominant woody species and percentage composition in the farming systems and in the different grazing areas in the study district

| | | *CBFS* | | | *SBFS* | | |
|---|---|---|---|---|---|---|---|
| *Woody species* | *Cate.* | CG | RS | EN | CG | RS | EN |
| *Gardenia ternifolia* | LD | C | - | - | - | - | - |
| *Acacia polyacantha* | DS | D | D | C | D | D | - |
| *Terminalia laxiflora* | DS | C | - | C | - | C | - |
| *Acacia tortilis* | DS | C | D | - | C | C | C |
| *Acacia seyal* | DS | D | C | D | D | C | C |
| *Dichrostachys cinerea* | DS | - | D | - | C | D | - |
| *Anogeissus leiocarpus* | DS | C | C | D | C | - | D |
| *Pterocarpus lucens* | HD | C | - | D | C | - | D |
| *Ficus sycomorus* | DS | C | - | | C | - | - |
| *Combretum collinum.* | LD | - | - | - | C | C | C |
| *Ximenia americana* | LD | C | - | - | - | - | - |
| *Stereospermum kunthianum* | DS | C | - | - | - | - | - |
| *Balanites aegyptica* | DS | C | - | C | D | C | C |
| *Grewia villosa* | LD | - | - | - | - | - | C |
| *Ziziphus spina-christi* | HD | C | C | D | C | - | D |
| *Piliostigma toningii* | DS | - | - | - | - | - | - |
| *Fluegea virosa* | LD | C | - | - | C | - | - |
| *Boswelia papyrifera* | UD | C | C | C | D | C | D |
| *Acacia Senegal* | DS | D | - | C | C | - | C |
| *Combretum mole* | LD | - | - | - | C | C | - |

CBFS: cotton based farming system; SBFS: sesame based farming system; Cate. = Category CG: communal grazing; RS: road side; EN: enclosed areas; C: common (> 10 % and < 20 % density); D: dominant (> 20 % density)

#### 4.8.2.1. Height classes of woody vegetation

There is no difference in height class categories of (< 0-1 M) between grazing types found in cotton based farming system and sesame based farming system. The proportion of height classes >1- 3m revealed that the two farming system are comparable. Generally, most height classes of the vegetation could be considered as they are at the browsing height of the animals.

Table 21. The percentage of height class distribution of trees and shrubs in the study district

| Height class | CBFS (%) | | | SBFS (%) | | |
|---|---|---|---|---|---|---|
| | CG | RS | EN | CG | RS | EN |
| < 0-1M | 22.6 | 25 | 21.1 | 20.6 | 23.1 | 20.8 |
| 1- 3 M | 45.2 | 33.3 | 42.1 | 41.2 | 38.5 | 33.3 |
| 3- 4.5 M | 19.4 | 16.7 | 15.8 | 26.5 | 23.1 | 12.5 |
| > 4.5 M | 12.9 | 25 | 21.1 | 11.8 | 15.4 | 33.3 |

CBFS = cotton based farming system; SBFS = sesame based farming system;
CG = communal grazing; RS = road side grazing, EN = enclosed areas

Hence, these reachable heights of different woody browse species situation in the district can make the area more favorable for browsing animals such as camels and goats, and maintain the balance between the woody and herbaceous species. Studies suggested that integrating grazers and browser having different feeding habitats enables more efficient use of vegetations. According to Taylor (1985), when cattle were replaced by goats and/or sheep, individual cattle performance increased because forage demand for the grass component was reduced due to lower grazing pressure. Likewise, it can be assumed that the production of ewe increased when some sheep were replaced by cattle and goats because intensity of grazing pressure on the forbs component declined. Again, diversification of herds through increasing the number of browsers enhances efficient resource utilization and decreases woody plant encroachments (Gemedo, 2004).

### 4.8.3. Vegetation in cotton based farming system

#### 4.8.3.1. Herbaceous species composition

From a total of 24 herbaceous species recorded in CBFS, 50 % are different grass species. On the other hand, 20.83 % and 29.17 % are the legume species and sedges respectively (Table24). Though the proportion of grass species appeared to be high with respect to the legumes and sedges species in the farming system, the desirability of the species by livestock was very low. Therefore, of the total grass species identified in this farming system, 25 % were identified as highly desirable, 33.33 % and 41.67 % as desirable and less desirable, respectively. The ratios of the herbaceous species in the farming system are 12: 5:7 (grasses: legumes: sedges). From the identified grasses, *Bracheria lata, Pennisetum spheslatum, Rhamphicarpa fistulosa* and *Seteria pumila* are the common species. *Cenchurs ciliaris* is the dominant grass species in the communal grazing areas of cotton based farming system of the study district. In contrast, *Cenchurs ciliaris, Cyprus spp, Eurochloa fatamensis fistulosa, Rhamphicarpa* and *Seteria pumila* are amongst the common grass species while *Eleusine flocifolia* is the dominant species found in roadside grazing areas (Table 24). The enclosed areas have a relatively higher percentage of highly desirable grass species than the communal and roadside grazing areas. That is to say, *Cenchurs ciliaris, Cyprus spp, Eurochloa fatamensis, pennisetum spheslatum* and *Seteria pumila,* are the common species. On the other hand, *Themeda teriandra* and *Hyparrhenia rufa* are the dominant species in the enclosed areas. This could be attributed to the results of good management by the communities and due to lesser intensity in the grazing pressure which the livestock can exert in the enclosed areas. This finding supports some of the recent findings that focused on similar issues (e.g. Amaha, 2006; Admasu, 2006; Teshome, 2006).

Table 22. Herbaceous species composition (% DM biomass) and their desirability in the grazing types of CBFS

| *Grazing types* | *Herbaceous species* | *Category* | *% composition* |
|---|---|---|---|
| Communal | *Cenchrus ciliaris* | DS | 21.2 |
| | *Pennisetum sphacelatum* | DS | 5.8 |
| | *Setaria pumila* | DS | 10.4 |
| | *Brachiaria lata* | DS | 6.2 |
| | *Urochloa fatamensis* | LD | 1.4 |
| | *Rhamphicarpa fistulosa* | LD | 16.66 |
| | *Urochloa cf.brchyura* | LD | 1.2 |
| | *Themeda triandria* | HD | 2.6 |
| | *Cynodon dyctlon* | HD | 1.4 |
| | *Ahiya Abish (Local name)* | UD | |
| | *Alysicarpus quartinianus* | LD | |
| | *Vigna membranacea* | LD | |
| | *Chamaecrista mimosoides* (L) | UD | |
| | *Euphhorbia indica* | UD | |
| | *Spermacoce sphaerostima* | UD | 1.3 |
| | *Hygrophilla schulli* | UD | 10.4 |
| | *Kedrostis foetidissima* | LD | 0.63 |
| | *Commelina subula* | UD | 0.5 |
| Road side | *Cynodon dyctlon* | *HD* | 3.4 |
| | *Cyprus spp.* | LD | 6.7 |
| | *Cenchrus ciliaris* | DS | 14.9 |
| | *Setaria pumila* | DS | 17.2 |
| | *Urochloa fatamensis* | LD | 5.3 |
| | *Rhamphicarpa fistulosa* | LD | 5.2 |
| | *Eleusine floccifolia* | LD | 23.6 |

Table 22.Herbaceous species composition (% DM biomass) and their desirability in the grazing types of CBFS *(Continued)*

| *Grazing types* | *Herbaceous species* | *Category* | *% composition* |
|---|---|---|---|
| | *Ahiya abish(Local name)* | UD | 13.2 |
| | *Alysicarpus quartinianus* | LD | 8.0 |
| | *Vigna membranacea* | DS | |
| | *cyanotis barbata* | UD | |
| | *Hygrophilla schulli* | UD | |
| | *Spermacoce sphaerostima* | UD | |
| | *Bidens setigera* | UD | |
| | *Kedrostis foetidissima* | LD | |
| | *Zennia elegans* Jaquin**.** | UD | |
| Enclosed | *Pennisetum sphacelatum* | DS | 6.1 |
| | *Cenchrus ciliaris* | DS | 6.5 |
| | *Setaria pumila* | DS | 5.2 |
| | *Brachiaria lata* | DS | 1.9 |
| | *Urochloa fatamensis* | LD | 5.2 |
| | *Themeda triandra* | HD | 22.6 |
| | *Hyperrahania rufa* | HD | 24.4 |
| | *Cynodon dactylon* | *HD* | 5.8 |
| | *Indigofera spicata* | DS | |
| | *Alysicarpus quartinianus* | LD | |
| | *Dismodium dichotomum* (Klein) | DS | |
| | *Hibiscus articulatus* | HD | |
| | *Cyanotis barbata* | UD | |
| | *Commelina subula* | UD | |
| | *Hibiscus vitifolius* L. | DS | |

Note: HD =Highly Desirable, DS = Desirable, LD = less desirable, CBFS = Cotton Based Farming system

### 4.8.3.2 Woody vegetation

A total of 17 woody species were recorded in the study district (Table 25). Of the identified woody species, 17.65 %, 41.18 %, 35.29 % and 5.88 % were identified as highly desirable, desirable, less desirable and undesirable respectively. *Acacia polyacantha*, *Acacia seyal, Acacia senegal* and *Boswelia papirefera* are dominant species whereas, *Acacia tortolis, Anogeissus leiocarpus,Balanites aegyptica, Ficus sycomorus, Gardenia ternifolia, Pterocarpus lucens, Terminalia laxiflora,* and *Ziziphus spina-Christi* are commonly found species in communal grazing lands in the CBFS. In roadside grazing, *Acacia polyacantha*, *Acacia tortilis* and *Dichrostachys cinerea* are the dominant species while *Acacia seyal, Anogeissus leiocarpus, Acacia senegal, Boswelia papyrifera* and *Ziziphus spina-christi* are the common species. In the enclosed grazing areas, *Anogeissus leiocarpus, Pterocarpus lucens, Acacia syal* and *Ziziphus spina-christi* were identified to be dominant woody plant species while *Acacia polyacantha, Balanites aegyptica, Boswelia papyrifera*, *Acacia senegal,* and *Terminalia laxiflora* were identified to be common species in the enclosed sites of the cotton based farming system. The proportion of desirable species in this farming system is considerably large when compared to the highly desirable and less desirable species. This situation may favor browsing animals in the area than the grazing animals.

Table 23.Woody species and percentage composition in different grazing system at CBFS

| Grazing types | Woody species | Cate. | % composition |
|---|---|---|---|
| Communal | *Terminalia laxiflora* | LD | 0.9 |
| | *Gardenia ternifolia* | LD | 24.8 |
| | *Acacia polyacantha* | DS | 1.5 |
| | *Acacia tortilis* | DS | 12.1 |
| | *Acacia seyal* | DS | 8.5 |
| | *Dichrostachys cinerea* | LD | 5.5 |
| | *Anogeissus liocarpus* | HD | 15.2 |
| | *Pterocarpus lucens* | HD | 7.0 |
| | *Ficus sycomorus* | DS | 2.4 |
| | *Combretum collinum.* | LD | 1.2 |
| | *Stereospermum kunthianum* | DS | 0.6 |
| | *Ximenia americana* | LD | 0.9 |
| | *Blanites aegyptica* | DS | 5.5 |
| | *Ziziphus spina christi* | HD | 1.8 |
| | *Piliostigma toningii* | LD | 5.2 |
| | *Boswellia paperiferra* | UD | 0.6 |
| | *Acacia senegal* | DS | 3.9 |
| Road side | *Gardenia ternifolia* | LD | 21.0 |
| | *Acacia polyacantha* | DS | 1.1 |
| | *Acacia tortilis* | DS | 14.8 |
| | *Acacia seyal* | DS | 2.3 |
| | *Dichrostachys cinerea* | LD | 15.3 |
| | *Anogeissus liocarpus* | HD | 2.8 |
| | *Pterocarpus lucens* | HD | 5.7 |
| | *Ficus sycomorus* | DS | 14.8 |
| | *Combretum collinum.* | LD | 1.1 |
| | *Stereospermum kunthianum* | DS | 1.7 |
| | *Ximenia americana* | LD | 9.1 |
| | *Blanites aegyptica* | DS | 7.5 |
| | *Ziziphus spina christi* | HD | 1.1 |
| | *Piliostigma toningii* | LD | |
| Enclosed areas | *Terminalia laxiflora* | LD | 31.0 |
| | *Anogeissus liocarpus* | HD | 3.4 |
| | *Acacia polyacantha* | DS | 10.3 |
| | *Acacia seyal* | DS | 20.7 |
| | *Pterocarpus lucens* | HD | 6.9 |
| | *Blanites aegyptica* | DS | 13.8 |
| | *Ziziphus spina christi* | HD | 5.7 |
| | *Boswellia paperiferra* | UD | 3.4 |
| | *Acacia senegal* | DS | 2.8 |

Cate, = category; D = Desirable, HD = highly desirable; UD = undesirable; LD = Less desirabl

#### 4.8.4. Vegetation in the sesame based farming system

##### 4.8.4.1. Herbaceous species

Herbaceous species obtained in sesame based farming system and their percentage composition is presented in Table 26. During the study, a total of 25 herbaceous species were recorded in this farming system. Out of this, 56 % were grass, 20 % were legumes and 24 % were sedges species. In communal grazing area, a total of 13 herbaceous species were recorded. Out of this, 6, 3 and 4 were grasses, legumes and sedges/others species, respectively. From the recorded grass species, 16.67 %, 33.33 % and 50 % were highly desirable, desirable, and less desirable respectively. In roadside grazing areas, out of the recorded 5 species of grasses, 20 %, 40 % and 40 % were represented as highly desirable, desirable, and less desirable, respectively. On the other hand, in enclosed grazing areas, 8 species of grasses, 4 species of legumes and 2 species of sedges were recorded. From the identified grass species, 37.5 % highly desirable, 50 % desirable and 12.5 % less desirable, respectively (Table 26).

In roadside grazing areas, the less desirable species of Eleunine flocifolia was 23.1% while 17.4 %, 8.5 % and 9.2 % were the desirable species of Setaria pumila, *Pennisetum spheslatem* and less desirable *Rhamphicarpa fistulosa* species, respectively. In communal grazing areas, 2.9 %, 24.1 %, and 38.5 % were highly desirable, desirable and less desirable species of grasses, respectively (Table 26). In enclosed grazing areas, the highly desirable species of *Hyparrhenia rufa* (25.1%) and Panicum coloratum (20.5 %) were the dominant species. The rest of *Brachiaria lata*, that is, *Eleusine flocifolia*, *Pennisetum sphacelatum*, *Setaria pumila* and *Sporobolus pyramidalis* were 8.3 %, 6.4 %, 5.6 %, 5.2 %, 5.1 and 2.6 % respectively (Table 26). It was identified during the study that there were a relatively high percentage of highly desirable (decreasers) grass species in the enclosed areas. This is followed by communal and the roadside grazing areas. This might suggest that the highly desirable species were replaced by less desirable and unpalatable species as a result of increased grazing pressure (Crawley, 1986).

Table 24. Herbaceous species composition (% DM biomass) and their desirability in the grazing types of SBFS

| *Grazing types* | *Herbaceous species* | *Category* | *% composition* |
|---|---|---|---|
| Communal | *Urochloa fatamensis* | LD | 2.6 |
| | *Pennisetum sphacelatum* | DS | 22.0 |
| | *Urochloa bracyra* | LD | 3.2 |
| | *Themeda triandra* | HD | 2.9 |
| | *Cenchrus ciliaris* | DS | 16.5 |
| | *Eleusine floccifolia* | LD | 18.3 |
| | *Ahiya abish* | UD | |
| | *Alysicarpus quartinianus* | LD | |
| | *Indigofera spicata* | DS | |
| | *cyanotis barbata* | UD | |
| | *Euphhorbia indica* | UD | |
| | *Spermacoce sphaerostima* | UD | |
| | *Commelina subul* | UD | |
| | *Hygrophilla schulli* | UD | |
| Roadside | *Pennisetum sphacelatum* | DS | 8.5 |
| | *Setaria pumila* | DS | 17.4 |
| | *Cynodon dyctlon* | HD | 3.6 |
| | *Rhamphicarpa fistulosa* | LD | 9.2 |
| | *Eleusine floscifolia* | LD | 23.1 |
| | *Ahiya abish* | UD | |
| | *Chamaecrista mimosoides* (L) | UD | |
| | *Euphhorbia indica* | UD | |
| | *Hygrophilla schulli* | UD | |
| | *Spermacoce sphaerostima* | UD | |
| | *Bidens setigera* | UD | |
| | *Zennia elegans* Jaquin. | UD | |
| | *Commelina subula* | UD | |
| Enclosed areas | *Pennisetum sphacelatum* | DS | 6.4 |
| | *Themeda triandra* | HD | 2.6 |
| | *Setaria pumila* | DS | 5.2 |
| | *Brachiaria lata* | DS | 8.3 |
| | *Panicum coloratum* | HD | 20.5 |
| | *Hyparranya rufa* | HD | *25.1* |
| | *Sporobolus pyramidialis* | DS | *5.1* |
| | *Eleusine flocifolia* | LD | *5.6* |
| | *Indigofera spicata* | DS | |
| | *Alysicarpus quartinianus* | LD | |
| | *Hibiscus articulatus* | HD | |

Table 24.Herbaceous species composition (% DM biomass) and their desirability in the grazing types of SBFS *(Continued)*

| *Grazing types* | *Herbaceous species* | *Category* | *% composition* |
|---|---|---|---|
| | *Vigna membranacea* | DS | |
| | Sedges: | | |
| | *Corchorus trilocularis* L | DS | |
| | *Bidens setigera* | UD | |
| | *Cyanotis barbata* | UD | |

Cate, = category; D = Desirable, HD = highly desirable; UD = undesirable; LD = Less desirable

**4.8.4.2. Woody vegetation in sesame based farming system.**

A total of 18 woody species were identified in the SBFS of the district (Table 27).These species comprised of 16.67 %, 38.89 %, and 44.44 % of highly desirable, desirable, and less desirable, respectively. *A. tortolis*, *Anogeissus leiocarpus, Balanites eagyptica, Pterocarpus lucens*, *Terminalia laxiflora*, *Ximenia Americana*, and *Ziziphus spina Christi* were the common species found in communal grazing areas. On the other hand, *A. polyacantha*, *A. syal, A. senegale* and *B. papirefera* were identified as dominant species in communal grazing areas. In roadside grazing areas, *A. polyacantha*, *A. tortolis, Acacia seyal* and *Dichrostachys cinerea* are dominant species but *Acacia senegal*, *Anogeissus leiocarpus*, *Boswelia papyrifera, Ziziphus spina-christi* and were common species. In enclosed areas, on the other hand, the highly desirable species like *Anogeissus leiocarpus, Pterocarpus lucens, Ziziphus spina-christi* and the desirable species of *A. seyal* are found widely. *Balanites egyptica, Bosweelia papirefera*, A*cacial senegal, A. polyacantha,* and *Terminalia laxiflora* were amongst the common species (Table 27).

Table 25. Woody species in the sesame based farming system with different grazing types in the district

| *Woody Species* | *Cate.* | *SBFS* | | |
|---|---|---|---|---|
| | | CG | RS | EN |
| *Acacia polyacantha* | DS | C | D | |
| *Terminalia laxiflora* | LD | P | C | |
| *Acacia tortilis* | DS | C | C | C |
| *Acacia seyal* | DS | D | C | C |
| *Dichrostachys cinerea* | DS | C | D | P |
| *Anogeissus leiocarpus* | DS | C | P | D |
| *Pterocarpus lucens* | HD | C | P | D |
| *Ficus sycomorus* | DS | P | | P |
| *Combretum collinum.* | LD | C | P | C |
| *Ximenia americana* | LD | P | - | - |
| *Balanites aegyptica* | DS | C | C | C |
| *Grewia villosa* | LD | P | - | C |
| *Ziziphus spina-christi* | HD | C | C | D |
| *Piliostigma toningii* | DS | P | P | |
| *Fluegea virosa* | LD | C | | |
| *Boswelia papyrifera* | UD | C | C | D |
| *Acacia Senegal* | DS | C | P | C |
| *Combretum mole* | LD | C | C | |

CBFS: cotton based farming system; SBFS: sesame based farming system; Cate.= CategoryCG: communal grazing; RS: road side; EN: enclosed areas ; P: Present (<10%density); C: common (>10% and <20% density); D: dominant (>20% density)

There is a significant (P<0.05) difference in woody vegetation composition among the communal, roadside and enclosed areas. This may be due to the fact that in communal and roadside grazing areas, the desirable tree species are influenced by human beings and animals. The less desirable species might have occurred due to the dissemination of their seeds though animal dung and as a result of ecological evolvement. The respondents made clear during group discussions that, for instance, before 10 years almost the entire district was covered by Bamboo tree species. The researcher's own observations during field work also confirmed that there were relicts of bamboo trees in the sloppy areas. It was observed that the bamboo trees are still in remote kebeles of Shimele Gara, Kemechela, Zebach Bahir and Lemlem Terara. The respondents made clear that in the past the district was dominated by bamboo trees and that *Acacia polyacantha* had covered only small areas unlike today. Today, it has become the dominant species and is found everywhere in the district. This finding is in agreement with Alemayehu's (2006) recent findings.

### 4.9. Range Condition Assessment

#### 4.9.1. The Effect of farming systems on rangeland condition at different levels of grazing areas

##### 4.9.1.1. Communal grazing areas

In the communal grazing areas of the districts, the composition of the grass species is significantly ($P<0.05$) higher in SBFS than in CBFS (Table 26). The study revealed that basal cover, litter cover, age distribution, seedling count and hedging effect are greater in SBFS than they are in the CBFS. This may be due to increase in the intensity of the grazing pressure and the disturbance that followed. The adverse impact of the intensity of grazing is tougher in cotton based farming system than in sesame based farming system. In similar way, a large body of literatures suggested that the frequency and intensity of grazing influences the rate of live biomass accumulation on a site, there by, disrupting the rate of competitive displacement in a multi-species community (McNaughton1968; Noy-Meir et al. 1989). In addition, intensive grazing affects the amount of plant litter at the soil surface and exerts indirect pressures on the germination and seedling establishment patterns (Heady 1956; Facelli and Pickett 1991, Belaynesh, 2006; Lishan, 2007and Teshome, 2006). The productivity of most rangelands has been reduced by human and livestock pressures, and natural hazards. Because vegetation integrates all environmental factors acting on a site, knowledge of its types may be used to make inference about prevailing environmental patterns (Herlocker *et.a.,* 1999). The m major causes of changes in rangelands are excessive grazing by domestic and/or wildlife animals, cultivating for cropping and intensive collection of resources like firewood, foods and building materials (Tolba, 1992).

Table 26. Range condition score (LSM ± SE) of communal grazing areas found in the different farming systems of the study district

| Parameter | CBFS | SBFS |
|---|---|---|
| Gsc | 4.64± (0.33)[b] | 6.37± (0.33)[a] |
| Bc | 4.95± (0.41) | 5.28± (0.41) |
| Lc | 4.52 ± (0.23)[b] | 5.4± (0.23)[a] |
| Se | 2.99± (0.37) | 2.59± (0.37) |
| Sc | 2.79± (0.37) | 3.08± (0.37) |
| Ag | 2.36± (0.38) | 3.06± (0.38) |
| Sec | 2.91 ± (0.34) | 3.22± (0.34) |
| Wds | 2.25± (0.27) | 1.5± (0.27) |
| Ccs | 8.92± (0.77) | 6.97± (0.77) |
| Hed | 1.9± (0.25) | 2.15± (0.25) |
| Trs | 38.25± (1.46) | 38.18± (1.46) |
| Rc | Fair | Fair |
| Wd | 3354.17± (292.28) | 4137.52± (292.28) |
| Cc | 146.55± (15.98) | 179.1± (15.98) |

GSC = Grass species composition score; BC= Basal cover; Lc = Litter cover; Se = Soil erosion; Sc = Soil compaction; Ag = Age distribution of grasses; Wds = Woody density score; Ccs = Canopy cover score; Hed = hedging; Trs = Total range condition score; RC = Range condition; Wd = Woody density; Cc = Canopy cover; Means with different letter in a row are significantly (P<0.05) different

### 4.9.1.2. Roadside grazing areas

Grass species composition in sesame based farming system is significantly (P<0.05) higher than that in cotton based farming system. Basal cover, litter cover, age distribution, woody density, canopy cover and total range condition scores in SBFS were found to be different from that in CBFS (Table 27). This could possibly be the result of high grazing pressure exerted by the livestock and due to mismanagement of the area, which on its part, caused replacement of the most palatable tall and erect species like *Hyparrhenia rufa, Themeda triandra* and *Panicum coloratum* by creeping, spreading and grazing resistant species like *Cynodon dactylon* and the less palatable grass species like *Eleusine floccifolia* which cover the soil. This result is a further strength to findings made in studies in Borena, Middle Awash, Bena-Tsemay (Ayana, 1999; Amsalu, 2000; Admasu, 2006). In their studies these researchers revealed that the percentage of cover decreased as the conditions of the range declined when the tall and erect species were gradually replaced by with low growing, spreading species.

Table 27. Range condition score (LSM ± SE) roadside grazing areas
Found in different farming system of the study district.

| *Parameters* | *CBFS* | *SBFS* |
|---|---|---|
| Gsc | 3.99±(0.30)$^{b}$ | 4.37±(0.30)$^{a}$ |
| Bc | 3.25(0.26) | 3.82±(0.26) |
| Lc | 3.14±(0.37) | 3.0±(0.37) |
| Se | 1.89±(0.29) | 2.0±(0.29) |
| Sc | 2.15±(0.33) | 1.99±(0.33) |
| Ag | 1.90±(0.38) | 2.71±(0.38) |
| Sed | 1.96±(0.38) | 2.20± (0.38) |
| Wds | 2.75±(0.27) | 2.5±(0.27) |
| Ccs | 3.02±(0.79) | 1.9±(0.79) |
| Hed | 1.25±(0.29) | 2.10± (0.29) |
| Trs | 25.32± (0.93) | 26.12±(0.93) |
| Rc | Poor | Poor |
| Wd | 2678.33±(196.34) | 2795.85±(196.34) |
| Cc | 68.38±(13.04) | 75.40±(13.04) |

Gsc = Grass species composition; Bc = basal cover; Lc = Litter cover; Se = Soil erosion; Sc = Soil compaction; Ag = Age distribution of grasses; Wds = Woody density score; Ccs = Canopy cover score; Hed = Hedging; Trs = Total range condition score; Rc = Range condition; Wd = Woody density; Cc = Canopy cover; Means with different letter in a row are significantly ($P < 0.05$) different

The mean density of woody plants in the grazing lands along the roadsides of the different farming system categories were 2,678.33± (13.04) /ha in cotton based farming system and 2795.85± (13.04) /ha in sesame based farming. Based on density value (plants/ha), the woody species in the roadside grazing areas of the CBFS are *A. tortilis,* (1,600), *A. seyal,* (350); *B. egyptica*, (1,300), *Dichrostachys cinerea* (1,655), *G. ternifolia,* (1,150), *P. toninngii* (300), identified as common and/or dominant. On the other hand, A. *syal* (2,200), *B. egyptica*, (1,350), *B. periphera*, *C. collinum*, (300), *T. laxiflora* (750), (1,660), and *Z. spina-christi* (1,850) were identified as common and/or dominant in SBFS (Table 27). Similar to the communal grazing areas, the roadside grazing areas are bush encroached. Both the density of woody plants and the total range condition scores indicated that the riverside grazing areas of the district are in poor condition. This implies that it is imperative to improve the condition of the rangeland.

### 4.9.1.3. Enclosed areas

Analysis of the range condition in the enclosed areas revealed that there is no significant different between the assessed parameters. However, the grass species composition, basal cover, litter cover, woody density and canopy cover scores in the enclosed areas found in the sesame based farming system were found to be greater in mean values than in cotton based farming system. This could be attributed to variations in land use pattern of the sites and the response of the species to protection from grazing. Other similar studies indicated that knowledge of the land use history of a site is imperative (Fleischner1994). In addition to this, spatial scale (e.g. plant distribution patterns in enclosed sites) may be caused by different processes than in patterns found at the landscape scale, short temporal scales and the pool of species that are present or able to disperse to the protected area Bartolome (1989). There is no significant (P< 0.05) difference in the soil erosion, compaction, age distribution, seedling count, and hedge effects between enclosed grazing areas of the two farming systems (Table 28). Generally, these parameters suggested that the enclosed sites are relatively in good conditions. This could be due to the influence of the management measures taken by the communities. Furthermore, the number of stocks spent in the enclosed areas limited the grazing pressure and positively influenced on the conditions of the rangelands in the district. This is considered as a means to protect and conserve the threatened local resources due to ever-increasing human and livestock population pressures and other forms of devastating interventions.

There is no significant difference ($P<0.05$) between the enclosed areas found in the two farming systems as far as the conditions of the woody vegetation density is concerned (Table 28). The mean density of woody vegetation in the enclosed sites of the two farming system is 1,029.93 plants/ha. Based on density value (plants/ha), the commonly/dominantly observed species in cotton based farming system are *Anogeissus leiocarpus (*300)*, Acacia senegal (*540), *Balanites aegyptiaca (*500*), Boswelia papyrifera (*500*), Pterocarpus lucens (*400*),* and *Ziziphus spina-christi (*1,540*).* In contrast, in sesame based farming system, *A. polyacantha(*650*), Acacia tortilis(*500*), Acacia seyal (*2250*), Anogeissus leiocarpus(*600*), Acacia Senegal(*1550*) Balanites aegyptiaca(*1,480*), Boswelia papyrifera(*3,200*), Grewia villosa(*450*), Combretum mole(*100*), Pterocarpus lucens (*2,200*), Stereospermum kunthianum(*300*)* and *Ziziphus spina-christi(*1,540*)* were identified as the common and/or dominant species (Table 28).

Table 28. Range condition score (LSM ± SE) in enclosed grazing areas of different farming system of the study district

| *Parameter* | *CBFS* | *SBFS* |
|---|---|---|
| Gsc | 7.80(0.61) | 8.11±(0.50) |
| Bc | 6.91±(0.46) | 7.03±(0.37) |
| Lc | 6.0±(0.33) | 7.05±(0.27) |
| Se | 3.88± (0.16)[b] | 4.89± (0.20)[a] |
| Sc | 4.93± (0.38) | 3.64± (0.31) |
| Ag | 3.70±(0.44) | 3.67±(0.35) |
| Sed | 4.0±(0.21) | 4.64± (0.17) |
| Wds | 3.5± (0.28) | 3.0±(0.23) |
| Ccs | 2.75± (0.61) | 3.46±(0.50) |
| Hed | 2.20± (0.41) | 2.43± (0.33) |
| Trs | 46.65± (0.78) | 46.93±(0.63) |
| Rc | Good | Good |
| Wd | 2316.7±(244.68) | 2340.0 ±(199.78) |
| Cc | 64.05±(7.27) | 71.93±(3.44) |

GSC = Grass species composition score; BC = basal cover; Lc = Litter cover; Se = Soil erosion; Sc = Soil compaction; Ag = Age distribution of grasses; Wds = Woody density score; Ccs = Canopy cover score; Hed = Hedging; Trs = Total range condition score; RC = Range condition; WD = Woody density; Cc = Canopy cover; Means with different letter in a row are significantly ($P<0.05$) different

In general, the rangelands in the enclosed areas are in good condition. This implies that the enclosed grazing areas are alternative methods of improving the conditions of rangelands. The finding confirms a similar observation made by other researchers (e.g. Ayana, 1999; Amsalu, 2000; Admasu, 2006; Amaha, 2006; Teshome and 2006; and Lishan, 2007).

### 4.9.2 The effect of grazing areas on range condition at different farming System

#### 4.9.2.1. Range condition in the CBFS

There is a significant difference ($P<0.05$) among the grazing types found in CBFS in species composition, basal cover, litter cover, age distribution and number of grass seedlings. The observed difference in these condition scores among the grazing types could be attributed to the better management and a relatively less opportunity for the communities to access and disturb the enclosed sites, the reality that contrasted to the increased intensity of grazing in the communal and roadside grazing areas. The result of this study supports the findings of other researchers (e.g. Amsalu, 2000; Ayana, 1999; Admasu, 2006; Belaynesh, 2006; Teshome, 2006; and Lishan, 2007). In the current study as well, it became evident that the species composition, basal cover, age distribution and seedlings were affected by factors like the types of gazing management, drought frequency and human and livestock population pressure. This implies that decline in the rangeland condition in roadside and communal grazing areas have a direct negative influence on the livestock production of the inhabitants in the district.

Soil erosion and compaction in the roadside and communal grazing areas are significantly ($P<0.05$) different than that in enclosed area. This relatively higher soil erosion and compaction in roadside and communal grazing types might be attributed to the impact of overgrazing the resources by livestock, mismanagement of the grazing lands by the communities and change in climate. Different studies suggested that increase in soil compaction and soil erosion following deterioration in the conditions of rangelands leads to decline in the productivity of the rangelands and their ability to support a sustainable livestock production system. Again, high livestock grazing pressure has a strong relation with decline in perennial and increase in annual cover, reduced litter cover and increased soil erosion and degradation of surface soil structure. Moreover, other factors that may have attributed to the compaction of soil are high soil erosion, which, in turn, is the compound effect of overstocking, overgrazing and over-utilization of the canopy layers of the rangeland vegetation (Amaha, 2006). Grazing changes soil structure primarily by compaction, this reduces the infiltration of water and air into the soil and hampers the physical and biological growth of the plant roots (Tisdale, et al, 1985).

The mean score of woody species density, canopy cover and hedging showed significant difference ($P<0.05$) among the three grazing areas. The woody species density score of the communal and the riverside grazing areas were found to be significantly lower ($P<0.05$) than that in the enclosed grazing areas. The woody species density scores in communal grazing is significantly higher ($P < 0.05$) than roadside grazing areas. Canopy cover scores, woody vegetation density and canopy cover percentage in communal grazing areas were found to be significantly higher ($P<0.05$) than that in roadside and enclosed grazing areas. This may be because of the over-use of browse plants and/or the roadside grazing areas. Again, the thinning practice of the farmers in the enclosed grazing areas might have contributed to lower canopy cover in the enclosed areas and roadside areas than in communal grazing areas. The large number and high concentration of livestock potentially favors woody plants in numerous ways. Among the major resisting behaviours of the woody species that increase in grazed environments are high seed production, prolonged life in soil, the ability to disperse over long distances, the ability to sprout following top removal, tolerance to low levels of water and nutrients and low palatability (Archer, 1989). The total range score in enclosed areas was found to be higher than other two grazing types (Table 29). The result is in line well with Admasu' (2006) findings. In his study, Admasu (2006) reported that enclosed areas had lower number of woody plants when compared to their corresponding communal and riverside grazing areas. By taking into consideration the overall condition scores, communal, roadside and enclosed grazing areas were classified as fair, poor and good conditions, respectively (Table 29). The finding here strongly confirms the findings of other similar studies (Amsalu, 2000; Admasu, 2006; Amaha, 2006; Belaynesh, 2006; Teshome, 2006 and Lishan, 2007).

Table 29. Range condition score (LSM ± SE) in the different grazing areas of the CBFS of the study district

| Parameters | Communal | Roadside | Enclosed |
|---|---|---|---|
| Gsc | 4.64± (0.33)[b] | 3.99±(0.30)[c] | 7.80(0.61)[a] |
| Bc | 4.95± (0.41)[b] | 3.25(0.26)[c] | 6.91±(0.46)[a] |
| Lc | 4.52 ± (0.23)[b] | 3.14±(0.37)[c] | 6.0±(0.33)[a] |
| Se | 2.99± (0.37)[b] | 1.89±(0.29)c | 4.89± (0.20)[a] |
| Sc | 2.79± (0.37)[b] | 2.15±(0.33)c | 4.93± (0.38)[a] |
| Ag | 2.36± (0.38)[b] | 1.90±(0.38)[b] | 3.70±(0.44)[a] |
| Sed | 2.91 ± (0.34)[b] | 1.96±(0.38)[c] | 4.0±(0.21)[a] |
| Wds | 2.25± (0.27)[a] | 2.75±(0.27)[b] | 3.5± (0.28)[c] |
| Ccs | 8.92± (0.77)[a] | 3.02±(0.79)[b] | 2.75± (0.61)[c] |
| Hed | 1.9± (0.25)[a] | 1.25±(0.29)b | 2.20± (0.41)[a] |
| Trs | 38.25± (1.46)[b] | 25.32± (0.93)[c] | 46.65± (0.78)[a] |
| Rc | Fair | Poor | Good |
| Wd | 3354.17± (292.28)[a] | 2678.33±(196.34)[b] | 2316.7±(244.68)[c] |
| Cc | 146.55± (15.98)[a] | 68.38±(13.04)[b] | 64.05±(7.27)[c] |

GSC = Grass species composition score; BC= Basal cover; Lc= Litter cover; Se = Soil erosion; Sc = Soil compaction; Ag = Age distribution of grasses; Wds = Woody density score; Ccs = Canopy cover score; Hed = Hedging; Trs= Total range condition score; RC = Range condition; Wd = Woody density; Cc = Canopy cover; Sed = seedling distribution, Means with different letter in a row are significantly ($P<0.05$) different

#### 4.9.2.2. Range condition in the SBFS

The communal grazing areas had a significantly higher (P< 0.05) value of grass species composition, basal cover, litter cover, age distribution, and woody species density score than that of roadside grazing areas and lower (P<0.05) density score than that in enclosed grazing areas (Table 30). Canopy cover scores in communal grazing areas showed a significantly higher (P< 0.05) value than that of the enclosed and riverside grazing areas. Canopy cover in roadside grazing areas was found to be higher (P<0.05) than that of the enclosed areas. The better scores in communal than in roadside grazing areas, and lower in the enclosed areas could be difference in the level of the grazing pressure exerted on it. The roadside grazing is more vulnerable for livestock grazing and trampling. Moreover, it is more exposed to forest clearing as largely nobody takes the prime responsibility to control the areas when compared to the other two grazing types. In the same manner, the management of the enclosed grazing areas is better than that of communal grazing and roadside grazing.

Soil erosion and compaction is significantly (P<0.05) greater in roadside grazing than in communal grazing and enclosed areas. In communal grazing areas, soil erosion and compaction were found to be higher (P<0.05) than that in enclosed areas. The age and seedling count obtained in communal grazing areas were found to be higher (P<0.05) than the roadside grazing areas and was significantly (P<0.05) smaller with that of the enclosed areas. On the other hand, the percentage of canopy cover, canopy cover scores and woody density obtained in communal grazing areas were significantly (P<0.05) higher than that of roadside and enclosed areas. This may be due to less grazing pressure, low numbers of browsers in the area than grazers and absence of fire to suppress the bushes in the district

The enclosed area showed a higher (P<0.05) total score for range condition than did the communal and roadside grazing areas. Generally, three grazing types fell in the category of good, fair and poor for enclosed, communal and roadside grazing areas, respectively (Table 30). The study revealed that the productivity of the rangeland decreased as the deterioration of the rangeland increased. This finding supports the findings of Ayana (1999) and Alemayehu (2004).

Table 30. Range condition score (LSM ± SE) in the different grazing areas of the SBFS of the study district

| Parameters | Communal | Road side | Enclosed |
|---|---|---|---|
| Gsc | 6.37± (0.33)[a] | 4.37±(0.30)[c] | 8.11±(0.50)[a] |
| Bc | 5.28± (0.41)[b] | 3.82±(0.26)[c] | 7.03±(0.37)[a] |
| Lc | 5.4± (0.23)[b] | 3.0±(0.37)[c] | 7.05±(0.27)[a] |
| Se | 2.59± (0.37)[ab] | 2.0±(0.29)[b] | 3.88± (0.16)[a] |
| Sc | 3.08± (0.37)[b] | 1.99±(0.33)[c] | 3.64± (0.31)[a] |
| Ag | 3.06± (0.38) | 2.71±(0.38) | 3.67±(0.35) |
| Sed | 3.22± (0.34)[b] | 2.20± (0.38)[c] | 4.64± (0.17)[a] |
| Wds | 1.5± (0.27)[a] | 2.5±(0.27)[b] | 3.0±(0.23)c |
| Ccs | 6.97± (0.77)[a] | 1.9±(0.79)[c] | 3.46±(0.50)[b] |
| Hed | 2.15± (0.25)[b] | 2.10± (0.29)[b] | 2.43± (0.33)[a] |
| Trs | 38.18± (1.46)[b] | 26.12±(0.93)[c] | 46.93±(0.63)[a] |
| Rc | Fair | Poor | Good |
| Wd | 4137.52± (292.28)[a] | 2795.85±(196.34)[b] | 2340.0 ±(199.78)[c] |
| Cc | 179.1± (15.98)[a] | 75.40±(13.04)[b] | 71.93±(3.44)[b] |

GSC = Grass species composition score; BC = Basal cover; Lc = Litter cover; Se = Soil erosion; Sc = Soil compaction; Ag = Age distribution of grasses; Wds = Woody density score; Ccs = Canopy cover score; Hed = Hedging; Trs = Total range condition score; RC = Range condition; WD = Woody density; Cc = canopy cover; Sed = seedling distribution, Means with different letter in a row are significantly (P<0.05) different, Means with different letter in a row are significantly (P<0.05) different

### 4.9.3. Interaction effects of farming system and grazing areas on range condition

The interaction effects between farming system and grazing areas are shown in (Appendix Table 21-27). The analysis revealed that there are a significant (P<0.05) interaction in range condition parameters between grazing areas and farming system. These could be attributed to difference in grazing intensity and human disturbance on the natural vegetations, and other natural factors.

## 4.10. Biomass Production

### 4.10.1. The effect of farming system on dry matter biomass in different grazing types

#### 4.10.1.1. Communal grazing areas

The total dry matter biomass, desirable grasses, less desirable grass, legumes and others biomass in the communal grazing areas located in the SBFS were found to be significantly ($P<0.05$) higher than that in the communal grazing areas of CBFS (Table 31). This variation might be attributed to the grazing intensity and anthropogenic disturbance in cotton based farming system, which is relatively greater than that in the sesame based farming system. The total biomass, total dry-matter biomass of desirable, less desirable grass and legumes biomass, therefore, were influenced by farming system. Previous studies on soil erosion and soil compaction generally revealed exposure to livestock grazing compacts soil and the compaction, in turn, increases with grazing intensity (Fleischner, 1994). Therefore, compaction is directly related to soil productivity. This happens because; it reduces water and air movement into and through soil. It reduces also the amount of water and air that are necessary for the reliable growth of plant roots. Soil compaction restricts root growth because when soils get compacted, only fewer large pores remain. As a result, only small space remains to allow roots to enter (Tisdale *et al*, 1985). Besides, the soil types are the determinant factors that affect biomass production in semi-arid rangelands (Abel *et al* Vol. 1, 1987). As Alemayehu's (2005) revealed, the plant biomass and standing crop are affected by the composition and density of the species.

Table 31. Dry matter biomass (kg/ha) of the communal grazing areas in different Farming systems of the study district

| Parameters | CBFS | SBFS |
|---|---|---|
| | Mean ±SE | Mean ±SE |
| Total Grasses | 2396.59±370.17[b] | 3282.22± 598.77[a] |
| Highly desirable | 143.31± 22.14[a] | 145.07±27.46[a] |
| Desirable | 1562.81± 242.38[b] | 1928.96 ±352.6[a] |
| Less desirable | 690.21± 106.61[b] | 1206.54 ±221.29[a] |
| Legumes | 699.17± 56.69[b] | 923.3 ±213.74[a] |
| Others | 488.67 ±128.09[b] | 802.08 ±163.14[a] |
| Total biomass | 3584.42 ± 403.34[b] | 5007.60± 664.25[a] |

Means with different superscript letter in the rows are significantly ($P < 0.05$) different, CBFS = cotton based farming system, SBFS = Sesame based farming system

#### 4.10.1.2. Road side grazing areas

Dry matter biomass production of total grass, other highly desirable, desirable and less desirable grasses and total biomass production in the roadside grazing areas of sesame based farming system were found to be significantly different ($P<0.05$) than the biomasses production in cotton based farming system grazing types (Table 32). The identified variation in biomass production between the two grazing types could be associated with the increasing grazing intensity and anthropogenic disturbances applied in the grazing types of cotton based farming system. The result shows how the heavy and continuous grazing pressure ultimately decreased biomass production. However, no significant ($P<0.05$) difference was found in the dry matter biomass of legumes in both grazing system of the district. Normally, grasslands are capable of tolerating a moderate degree of grazing intensity before changing into composition, diversity or productivity. However, as the intensity of grazing increases, tall and mid-grasses eventually gives way to short-stature perennial grasses. This, in turn, gives way to annuals and unpalatable perennials with a corresponding decline in primary and secondary productivity and loss of diversity, cover, and soil (Archer *et al*. 1987). Different studies quantified also that decline in perennial grass and increase in unpalatable forbs and annual grass covers were influenced by the types of grazing management, rainfall and livestock population pressure. The studies underscored that overgrazing, high livestock population and prolonged drought together lead to reduction in dry matter biomass production and aggravate rangeland deterioration (see Ayana, 1999; Amsalu, 2000; Gemedo, 2004 and Amaha, 2006).

Table 32. Dry matter biomass (kg/ha) of the road side grazing areas located in different farming systems of the study district

| *Parameters* | *CBFS* | *SBFS* |
|---|---|---|
| | Mean ±SE | Mean ±SE |
| Total Grasses | 1631.63 ±370.17[b] | 1963.67± 598.77[a] |
| Highly desirable | 79.29± 18.99[b] | 114.82± 35.85[a] |
| desirable | 751.85 ±170.60[b] | 822.77± 250.88[a] |
| Less desirable | 798.68± 181.19[b] | 1026.21± 312.92[a] |
| Legumes | 422.13 ±106.45[a] | 497.67± 72.21[a] |
| others | 288.69± 52.98[b] | 712.88 ±225.98[a] |
| Total biomass | 2342.45 ±403.34[b] | 3174.21 ±664.25[a] |

Means with different superscript letters in a row are significantly ($P < 0.05$) different, CBFS = cotton based farming system, SBFS = Sesame based farming system

**4.10.1.3. Enclosed grazing areas**

All parameters found in SBFS were found to be significantly ($P < 0.05$) higher than those in CBFS (Table 33). This may be due to the presence of more dominant herbaceous species in SBFS that contribute for the higher biomass production. A body of literature suggested that the most dominant species contributed the highest amount of biomass (Kamau, 2004).The total dry matter biomass value obtained for the enclosed areas of the district under study was found to be much higher than those reported in the previous studies (e.g. Amsalu, 2000; Amaha, 2006; and Lishan, 2007) conducted in arid and semi-arid rangelands of Middle Awash and Somali regions of Ethiopia. The general observation is that the productivity of grazing land in the study district was better than the productivity of the above mentioned rangelands to support livestock population provided that there are good rangeland management practices.

Table 33.Dry biomass (kg/ha) of the enclosed grazing areas in different farming systems of study area

| Parameters | CBFS | SBFS |
|---|---|---|
| | Mean ±SE | Mean ±SE |
| Total Grasses | 4814.86 ±453.36[b] | 8438.56 ±598.77[a] |
| Highly desirable | 3342.95± 259[b] | 5161.02 ±367.21[a] |
| Desirable | 1165.19± 15.55[b] | 2676.71 ±198.9[a] |
| Less desirable | 305.74 ±23.51[b] | 599.13 ±42.51[a] |
| Legumes | 697.13± 164.73[b] | 1071.25± 116.27[a] |
| Others | 375.63± 116.27[b] | 1185.96± 203.98[a] |
| Total biomass | 5887.61 ±493.9[b] | 10695.77± 664.2[a] |

Means with different letter in a row are significantly (P < 0.05) different
CBFS = cotton based farming system, Sesame based farming system

### 4.10.2. Biomass at different farming system

#### 4.10.2.1. Biomass in CBFS

The total grass biomass, highly desirable grass and total biomass in enclosed areas were found to be significantly (P<0.05) higher than that of the total grass biomass, highly desirable and total biomass obtained in communal grazing and roadside grazing areas. Similarly, the total grass, highly desirable grass, desirable grass, total biomass and other biomasses in communal grazing areas were found to be significantly (P<0.05) higher than that of roadside grazing. On the other hand, legumes biomass and desirable biomass in communal grazing were found to be significantly (P<0.05) different from the legumes biomass and desirable biomass obtained in enclosed and roadside grazing areas. Similarly, legumes and desirable biomass were found to be significantly (P<0.05) higher than that of roadside grazing areas. In contrast, the less desirable grass biomass in roadside grazing was found to be significantly (P<0.05) higher than that in the less desirable grass biomass in enclosed grazing areas (Table 34). This could be attributed to the low grazing intensity and better management in enclosed grazing areas than in the communal and roadside grazing areas. In the district, roadside grazing is more exposed to grazing and trampling than the communal and enclosed grazing areas. This finding strongly agrees with that of Amsalu (2000) in which the researcher reported that the high pressure on roadside and communal grazing areas favored the invasion of forbs while discouraging the growth of the highly desirable species.

Table 34. Dry matter biomass (kg/ha) of the different grazing types in CBFS in the study district

| *Parameters* | *CG* | *RS* | *En* |
|---|---|---|---|
| | Mean ±SE | Mean ±SE | Mean ±SE |
| Total Grasses | 2396.59±370.17$^{b}$ | 1631.63 ±370.17$^{c}$ | 4814.86 ±453.36$^{a}$ |
| Highly desirable | 143.31± 22.14$^{b}$ | 79.29± 18.99$^{c}$ | 3342.95± 259$^{a}$ |
| Desirable | 1562.81± 242.38$^{a}$ | 751.85 ±170.60$^{c}$ | 1165.19± 15.55$^{b}$ |
| Less desirable | 690.21 ±106.61$^{a}$ | 798.68± 181.19$^{a}$ | 305.74 ±23.51$^{b}$ |
| Legumes | 699.17± 56.69$^{a}$ | 422.13 ±106.45$^{b}$ | 697.13± 164.73$^{a}$ |
| Others | 488.67 ±128.09$^{a}$ | 288.69± 52.98a$^{b}$ | 375.63± 116.27$^{b}$ |
| Total biomass | 3584.42 ± 403.34$^{b}$ | 2342.45 ±403.34$^{c}$ | 5887.61 ±493.9$^{a}$ |

CG = communal grazing, RS = road side grazing, EN = enclosed areas Means with different superscript letter in a row are significantly (P<0.05) different

#### 4.10.2.2. Biomass in SBFS

The total dry matter biomass, dry matter biomass of total grass and highly desirable grass, others and legumes found in the enclosed areas were found to be significantly (P<0.05) higher than the total dry matter biomass of communal grazing areas found in SBFS. On the other hand, the total dry matter biomasses in communal grazing areas were found to be significantly (P<0.05) greater than those of roadside grazing areas. In addition, the less desirable grasses found in communal grazing areas were found to be significantly (P<0.05) higher than those in enclosed and roadside grazing areas. In contrast, the legumes and other biomasses in communal grazing were found to be comparable (P>0.05) with the roadside grazing (Table 35). The impact of management factors may be the main reasons for the significant differences in the herbaceous biomass production of the different grazing areas in the district. Moreover, this variation could be associated with the conditions of the rangelands i.e., poor condition situation in the roadside, fair condition in communal and good condition class in enclosed areas. These conditions were identified as influential in the findings of Amsalu (2000) and Amaha (2006) as well. The researchers reported that good condition class produces higher dry matter biomass than poor condition class.

Table 35. Dry matter biomass (kg/ha) of the different grazing types in SBFS the study district

| *Parameters* | *CG* | *RS* | *En* |
|---|---|---|---|
| | Mean ±SE | Mean ±SE | Mean ±SE |
| Total Grasses | 3282.22± 598.77$^{b}$ | 1963.67± 598.77$^{c}$ | 8438.56 ±598.77$^{a}$ |
| Highly desirable | 145.07±27.46$^{ab}$ | 114.82± 35.85a$^{b}$ | 5161.02 ±367.21$^{a}$ |
| Desirable | 1928.96 ±352.6$^{b}$ | 822.77± 250.88$^{c}$ | 2676.71 ±198.9$^{a}$ |
| Less desirable | 1206.54± 221.29$^{a}$ | 1026.21± 312.92$^{b}$ | 599.13 ±42.51$^{c}$ |
| Legumes | 923.3 ±213.74$^{b}$ | 497.67± 72.21$^{c}$ | 1071.25± 116.27$^{a}$ |
| Others | 802.08 ±163.14a$^{b}$ | 712.88 ±225.98a$^{b}$ | 1185.96± 203.98$^{a}$ |
| Total biomass | 5007.60 ± 664.25$^{b}$ | 3174.21 ±664.25$^{c}$ | 10695.77± 664.2$^{a}$ |

CG = communal grazing, RS = road side grazing, EN = enclosed areas
Means with different superscript letters in a row are significantly (P < 0.05) different

### 4.11. The effect of farming system on biomass

The total biomass, desirable grass, less desirable grass, legume and other biomasses were estimated from the grazing lands of cotton based farming. They were found to be lower than the above mentioned biomass in grazing areas of sesame based farming system (Fig. 2). This variation might be due to the impacts of edaphic conditions, livestock grazing intensity and population impact on cotton based farming. The impacts of these variables were found to be greater than the sesame based farming. The finding implicates that climatic and grazing variables can limit biomass production in arid and semi-arid rangelands of Africa (Behanke *et al.*, 1993; Amsalu, 2000).

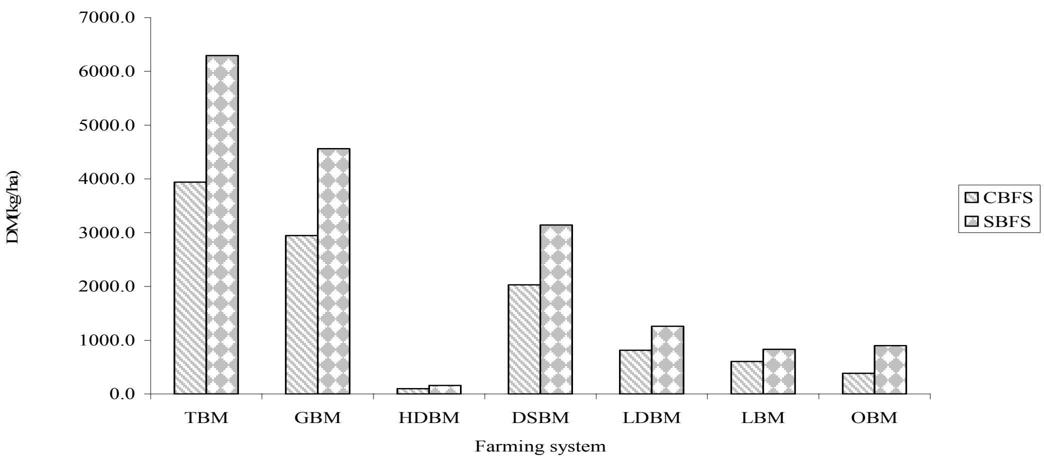


Figure 2. Effects of farming system on biomass

**4. 12. The effect of grazing on dry matter biomass**

As the grazing intensity increased, the legume biomass, total grasses biomass, palatable grasses biomass and total biomass were reduced while the unpalatable forbs, sedges and other unwanted species increased (Figure 3). In similar way, Jones and Mott (1980) argued that proper grazing management aids recruitment and persistence of desired species whereas poor management hastens the demise of preferred species and ultimately leads to their replacement by other species. Ahmed (2006) also cited Pluhar *et al*. (1987, who argued that heavy grazing generally causes change in the species composition, reduced productivity and increased erosion. Similarly, Wolter *et al* (1990) and Amsalu (2000) reported that high grazing pressure caused loss of high yielding forage species and loss of ground cover.

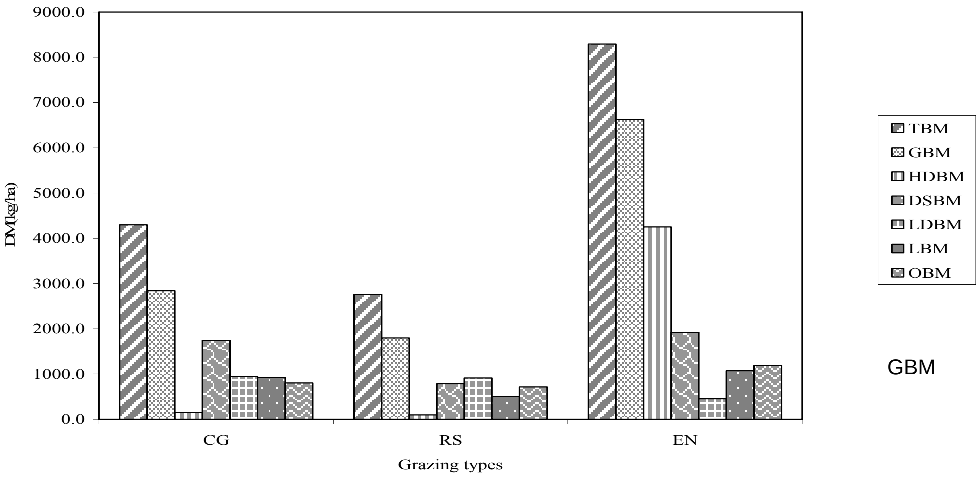


Figure 3. The effect of grazing on biomass production

### 4.13. Correlation among Variables Studied in Range Condition Assessment

Among the different variables correlated, only the most important ones were presented (Appendix Table7-12). Correlation analysis of the variables in grazing areas of CBFS indicated that basal cover, soil compaction, seedling count, litter cover, soil erosion, age distribution, and hedge effect were found to be positively correlated significantly (P<0.01) with the composition of grass species and within each other, while the total range condition score was found to be negatively correlated with the composition of the grass species. On its part, woody density total range score were found to be negatively correlated with basal cover, litter cover, soil erosion, soil compaction, age distribution and woody density scores. Similarly, there was a significantly (P <0.01) positive correlation in different range condition factors of the grazing areas in SBFS between the composition of grass species, basal cover, litter cover, soil compaction, soil erosion, age distribution, seedling count and total range condition score. The woody density scores and canopy cover scores were positively correlated with grass species, basal cover, soil erosion, soil compaction, age and seedling count. However, woody vegetation was negatively correlated with basal cover, litter cover, soil erosion, and seedling count (Appendix table 11).

#### 4.14. Relationship between Dry matter Biomass production and Range Condition

The linear regression analysis revealed a significant positive linear relationship between herbaceous dry-matter biomass and rangeland condition scores (Figure.4). The $R^2 = 0.4509$ of the variation in total biomass production was explained using variation in rangeland condition. Other studies indicated that rangelands in better conditions produced more forages than those in poor conditions (Amsalu, 2000; Gemedo, 2004; Amaha, 2006).

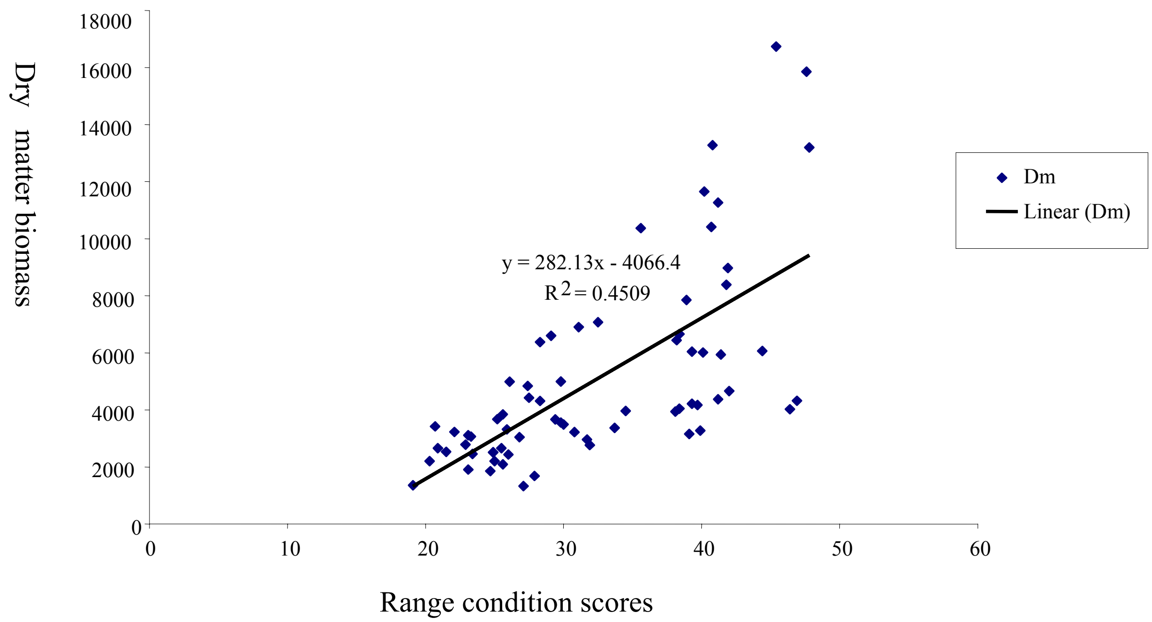


Figure 4. Regression graph of dry matter biomass and range condition

# 5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This final chapter of the thesis is devoted to summarize the study, draw conclusions on the basis of the major findings and suggest some working recommendations to improve the future conditions of rangeland management in the Metema District and to remind the direction of research that should follow.

## 5.1. Summary

This study was conducted in Metema District, North Gondar Zone, Amhara National Regional State. The aims of the study were to describe the socio-economic conditions of the district, assess the major livestock feed resources in the area, analyze the chemical composition and biomass yields of the available livestock feed resources and finally to characterize the range condition based on herbaceous, woody and soil layers. Descriptions of the socio-economic conditions and assessments of the major livestock feed resources in the study area were carried out. The study involved 140 households. The researcher used a semi-structured interview questionnaire, group discussions and personal observations as methods of data collection. The assessment made on the rangeland condition of the district was stratified into two different farming systems (CBFS and SBFS) and three grazing types (communal, enclosed and roadside grazing areas). For data collection, the composition of grass species, basal and litter covers, age distribution, seedling count, soil erosion, soil compaction, woody species density, canopy cover and hedging effect were considered as parameters.

The youngest and child age categories (50 % and 30.12 %) of the households in the district are dominant. The mean family size of the district is 5.31 ± (0.20) persons per family .The majority of the households in CBFS (43.3 %), in SBFS (50. 0 %) and in aggregate (47.14 %) possessed 1-5 hectares of land. On the other hand, 23.4 % of households in CBFS, 21.25 % of them in SBFS and 22.16 % of them in the district possessed 5.1-10 hectares of land (Table 6). Large ruminants (cattle) are the dominant livestock species raised in the district, followed by small ruminants (goats) and male donkeys, respectively. The mean livestock holding per household of cattle, goat, sheep, donkey and camel in the district are 12.52± (6.23), 0.80± (0.40), 0.13± (0.07), 0.65± (0.32) and 0.07± (0.04), TLU, respectively. Regarding livestock herd structures, the study revealed that females dominated in both farming systems when compared to males. The main reason is that male stocks are preferred sale whereas females and calves are retained as breeding stock. In the district, milk cows are symbols of wealth and prestige. The main livestock feed resources in the district are natural pasture, crop residues, crop aftermath and hay, respectively. Among these, the natural pasture was the major sources of livestock feed that support animal productivity in the rainy season. However, in the dry season, these pastures can hardly maintain the animals as most of the feed resources at this time of the year are low in quantity. Free grazing, tethering and cut-and-carry feeding systems are the commonly practiced feeding systems in both farming systems. Animals are allowed to graze in communal grazing land, forest land and fallow lands (privately owned land) during wet season, from the month of October. There are no proper practice in collecting, handling and utilizing crop residues in the district. The total mean utilization of crop residues as livestock feed in tones are 22.23± (2.98), 14.71± (2.67), 14.96± (2.98) and 0.28± (0.18) for sorghum, maize, teff, and peanut. Generally, the study suggested that the feed balance estimate of the district in DM basis is sufficient to support the maintenance requirement of livestock per household despite the quality of the feed. The chemical composition of *Pennisetum spheselatum*, *Cenchrus sciliaris* and *Pterocarpus lucens* were found to be significantly (P<0.05) different and are influenced by season and types of species.

In the floristic composition, a total of 32 herbaceous and 20 woody species were recorded in the district. Among the herbaceous species, 41.94 % species were of different grasses while 58.06 % were non-grass species. The non-grass species comprised of 5 species legumes, 7 species of sedges, and 6 species of forbs. Of the grass species, 23.07 % were identified as highly desirable, 38.46 % desirable and 30.77% less desirable. From the identified woody species in the district, 15%, 35%, and 50% were identified as highly desirable, desirable and less desirable species respectively. The largest proportion of woody vegetation in the district is constituted from *Acacia* (20%) and commbretum (10%). *Pterocarpus lucens (*charia) is an important fodder and is used as a main livestock feed in the district during the onset of the main rain season. Most of height classes of the vegetation are at the browsing height of the animals (that is >1- 3 m).

The assessments made on the conditions of the range in the communal grazing areas of both farming systems, basal cover, litter cover and grass species composition in SBFS were found to be significantly ($P<0.05$) larger than that in CBFS. The woody vegetation density in sesame based farming system was significantly ($P<0.05$) larger than cotton based farming system. The composition of the grass species, basal cover and litter cover of road side grazing were found to be significantly ($P<0.05$) larger in sesame based farming system than in cotton based farming system. On the other hand, the communal grazing areas had a significantly higher ($P< 0.05$) value of grass species composition, basal cover, litter cover, age distribution, and woody species density score than the roadside grazing areas and lower values ($P<0.05$) than the enclosed grazing areas. The amount of total dry matter biomass were found to be significantly ($P < 0.05$) higher in enclosed areas. This is followed by communal areas, which is significantly ($P \leq 0.05$) higher than that in roadside grazing areas.

**5.2. Conclusions**

On the basis of the entire study and the summary made above, the researcher tries to draw some important conclusions. In Metema District, cattle, goats, donkeys, sheep and camels are raised. Among these livestock species, cattle and goats are the most dominant animal species reared in the district. The study indicated that the resources used in the area to feed these livestock species are natural pasture, crop residue, crop aftermath and hay. The study revealed that more than 50 % of dry season feed resources and all wet season livestock feeds come from natural pasture. Cattle species are critically faced by the shortage of dry season feed resources while in wet season a surplus amount of feed resources are available. Making hay is not properly done and well practiced. These abundant feed resources are wasted in the wet season. The study showed also that the remaining dry grasses are turned to ash by wild and man-made fire (forest honey harvesters and crop land cleaning) throughout the dry season. To overcome this problem, little amount of supplementation of embaze (sesame cake), wheat bran, noug cake, hay and crop residues are given during peak season for highly affected animals. The nutrient content of grass species during haymaking time is very low. The study implicated that the district should embark on sustainable feed conservation practices and effective management of grazing areas. The other key finding of the study is that population pressure and the corresponding increase in livestock number exerted greater pressure on natural grazing lands of the district. In addition, the perpetuations of livestock movements to the area have also been aggravating the intensity of grazing and its debilitating impacts on the rangelands. By and large, the study suggested the rangeland, species composition and biomass production of the district have been adversely affected by miss-management, disturbances and intensity of livestock grazing.

### 5.3. Recommendations

On the basis of the summary and conclusions made above, the following recommendations are suggested:

- The study revealed that the rangeland condition of the area is declining. Therefore, should be reversed through rangeland rehabilitation, proper management and delineation of the natural grazing lands.
- Provision of integrated extension services regarding feed resources management and training on basic principles of feed collection, storage, proper feeding systems and amounts of supplementation of the feed resources should be made.
- A due attention should be given to chemical treatment of crop residues and balancing legume and grass mixtures in the district through introducing legume species that are appropriate to the area and through putting in place effective grazing management.
- Balancing the grazing and browsing species in the area is of paramount importance to keep ecological balance and to increase the productivity of livestock.
- Attention should be given for conservation and development of the fodder species like *Pterocarpus lucens* and mechanism should be devised as to how to introduce dual purpose sorghum species in the area.

**The scope for the future study in the district should be given due attention for the following areas**;

- Detailed studies should be made on important browse woody vegetation species production based on different seasons and on their contribution to livestock in the area.
- Studies should be conducted on the influence of different sub-habitats of woody plants on herbaceous species composition and on diversity, biomass production and livestock productivity.
- The potential use of sesame oil by-product (*Embaz*) as an animal feed supplements should be investigated and analyzed.

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# 7. APPENDIX

Appendix Table 1. Criteria for the scoring of the different factors determining Range conditions (Herbaceous vegetation & soil condition)

| *Score* | *Grasses spp composition* | *Basal cover* | *Number of seedlings* | *Litter cover* | *Soil erosion* | *Soil compaction* | *Age distribution* |
|---|---|---|---|---|---|---|---|
| 10 | 91-100% decreaser | > 12%, no bare areas | | > 12%, no bare areas | | | |
| 9 | 81-90% decreaser | - | | - | | | |
| 8 | 71-80% decreaser | >9% evenly distributed | | >9% evenly distributed | | | |
| 7 | 61-70% decreaser | >9% occasional bare spots | | >9% occasional bare spots | | | |
| 6 | 51-60% decreaser | >6% evenly distributed | | >6% evenly distributed | | | |
| 5 | 41-50%decreaser | >6%, bare spots | >4 seedlings on A4 paper | >6%, bare spots | No sign of soil erosion | No compaction | Young, medium ,old |
| 4 | 10-40%decreaser & ≥30% increaser | >3%, mainly perennials | 4 seedlings on A4 paper | >3%, mainly perennials | Slight sand mulch | Isolated capping | two size categories |
| 3 | 10-40%decreaser& <30% increaser | >3%, mainly annuals | 3 seedlings on A4 paper | >3%, mainly annuals | Weak-side pedestals | >50% capping | Only old |
| 2 | < 10%decreaser & ≥ 50% increaser | 1-3% | 2 seedlings on A4 paper | 1-3% | Steep-sided pedestals | >75% capping | Only medium |
| 1 | <10% decreaser & <50%incr. | <1% | 1 seedling on A4 paper | <1% | Pavement | Almost 100% capping | Only young |
| **0** | | 0% | No seedlings | 0% | Gullies | | |

*Sources: Baars et al., 1997.*

Appendix Table 2. Criteria for the scoring of the different factors determining range conditions

| *Parameters* | *Value* | *Total point* | *Descriptions* |
|---|---|---|---|
| Hedging | 3 | 5 | Highly palatable and palatable shrubs share dominance<br>Most hedge able plants are lightly to moderately hedged<br>Few or no decadent plants. |
| | *2* | 3 | Palatable plants dominant. Hedgeable plants moderately to heavily hedged.<br>Some shrubs decadent due to hedging. |
| | *1* | 2 | Palatable and less palatable plants dominant.<br>Hedge able plants heavily to very heavily hedged.<br>Considerable numbers of decadents' shrubs present.<br>Some may be dead due to hedging. |
| | *0* | 1 | Less palatable and unpalatable shrubs dominant.<br>Some normally un hedge able shrubs are hedged.<br>Hedge able shrubs very heavily hedged the crowns often reduced to |
| Canopy cover | 3 | 5 | >45%cover |
| | 2 | 4 | 36-45%cover |
| | 1.5 | 3 | 26-35% |
| | 1 | 2 | 15-25% |
| | 0 | 1 | <15%cover |
| Density | | 5 | 0-1000/ha |
| | | 4 | >1000-2000/ha |
| | | 3 | >2000-3000/ha |
| | | 2 | >3000- 4000/ha, |
| | | 1 | >4000/ha |

Source: Kuchar (1995)

Appendix Table 3. ANOVA test on total family size of inhabitants

| *Sources of variation* | *Sum of Squares* | *df* | *Mean Square* | *F* | *Sig.* |
|---|---|---|---|---|---|
| Between Groups | 0.372 | 1 | 0.372 | 0.70 | 0.792 |
| Within Groups | 737.421 | 139 | 5.344 | | |
| Total | 737.793 | 139 | | | |

Appendix Table 4. ANOVA test of the land holding the house holds in the district

| Sources of Variation | Sum of Square | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 54.445 | 1 | 54.445 | 2.912 | .090 |
| With in groups | 2336.932 | 125 | 18.695 | | |
| Total | 2391.377 | 126 | | | |

Appendix Table 5. Common and /or dominant woody species and their percentage composition in the farming system of different grazing areas

| *Woody species* | *Cate* | *CBFS* | | | *SBFS* | | |
|---|---|---|---|---|---|---|---|
| | | CG | RS | EN | CG | RS | EN |
| *Gardenia ternifolia* | LD | C | - | P | - | - | - |
| *Acacia polyacantha* | DS | D | D | C | C | D | |
| *Terminalia laxiflora* | | C | P | C | P | C | |
| *Acacia tortilis* | DS | C | D | - | C | C | C |
| *Acacia seyal* | DS | D | C | D | D | C | C |
| *Dichrostachys cinerea* | DS | | D | - | C | D | P |
| *Anogeissus leiocarpus* | DS | C | C | D | C | P | D |
| *Pterocarpus lucens* | HD | C | P | D | C | P | D |
| *Ficus sycomorus* | DS | C | P | - | P | | P |
| *Combretum collinum* | LD | P | - | - | C | P | C |
| *Ximenia americana* | LD | C | | - | P | - | - |
| *Stereospermum kunthianum* | DS | C | P | - | - | P | |
| *Balanites aegyptica* | DS | C | P | C | C | C | C |
| *Grewia villosa* | LD | - | - | - | | - | C |
| *Ziziphus spina-christi* | HD | C | C | D | C | C | D |
| *Piliostigma toningii* | DS | P | | | P | P | |
| *Fluegea virosa* | LD | C | - | - | C | | |
| *Boswelia papyrifera* | UD | C | P | C | C | C | D |
| *Acacia senegal* | DS | D | P | C | - | P | C |
| ***Combretum mole*** | LD | - | | | C | C | |

CBFS: cotton based farming system; SBFS: sesame based farming system; Cate.= Category CG: communal grazing; RS: road side; EN: enclosed ; P: Present (< 10%density); C: common (> 10% and < 20% density); D: dominant (> 20% density)

Appendix Table 6. Herbaceous species identified in different farming systems and grazing types of the district

| Botanical Name | Local name | Cate | CBFS | | | SBFS | | |
|---|---|---|---|---|---|---|---|---|
| **Grasses:** | | | CG | RS | EN | CG | RS | EN |
| *Eriochloa fatamensis* (Hochst. & steud.) | *Metruqe* | LD | P | C | C | P | | |
| *Pennisetum sphacelatum* (Nees) | *Jingra* | DS | C | C | C | D | C | C |
| *Urochloa cf. brachyura* (Hack.) stapf | *Metruq* | LD | P | | | P | | |
| *Themeda triandra* | *Chechewa* | HD | P | | D | P | | P |
| *Cenchrus ciliaris* | *Zemen* | DS | D | C | C | C | | |
| *Eleusine floccifolia* | *Ahya Dagusa* | LD | | D | | C | D | C |
| *Setaria pumila* (Poir.) R. & S. | *Dimemo* | DS | C | | C | | C | C |
| *Cynodon dayctlon* | *Serdo* | HD | P | P | C | | P | |
| *Rhamphicarpa fistulosa* (Hochst.) Benth. | *Ejargew* | LD | C | C | | | C | |
| *Brachiaria lata* (Schumach.) C. E. Hub | *Mashilo* | DS | C | | P | | | C |
| *Panicum coloratum* L. | *kok sar* | HD | | | D | | | D |
| *Hyparrhania rufa* | *Topas* | HD | | | | | | D |
| *Sporobolus pyramidilis* | *NA* | DS | | | | | | C |
| *Cyprrus Spp.* | *Gicha* | LD | | C | | | | |
| Legumes: | | | | | | | | |
| *Iindigofera spicata* Forsk | *Kola maget* | DS | | C | | C | | C |
| *Alysicarpus quartinianus* A. Rich | *Adoye* | DS | C | | C | C | | D |
| *Chamaecrista mimosoides* (L) Greene) | *Koina* | UD | P | C | | | p | |
| | *Yeahiya abish* | UD | C | D | | D | D | |
| *Vigna membranacea* | *Yeayit Guaya* | DS | C | P | C | | | C |
| *Dismodium dichotomum* (Klein ex W) | *Aborida* | | P | | D | | | |
| **Sedges and others:** | | | | | | | | |
| *Cyanotis barbata* | *Mech mesel* | UD | | P | | P | | C |
| *Euphhorbia indica* | *Na* | UD | C | C | | C | D | |
| *Spermacoce sphaerostima* | *wuha ankur* | UD | C | P | | | C | |
| *Hygrophilla schulli* | *Amakela* | LD | P | | | | | |
| *Kedrostis foetidissima* | *Hareg ressa* | UD | P | P | | | | |
| *Commelina subula* | *Yekola mech* | UD | D | D | C | C | P | |
| *Hibiscus articulatus* Hoccht. | *Abo hareg* | HD | *P* | | D | | | C |
| *Bidens setigera* **(**Sch. Bip.) Sherff | *Yebereha adey* | UD | C | C | | | C | C |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Phyllanthus rotundifolius* Willd. | | UD | p | p | | | | |
| *Corchorus trilocularis* L | *Amirra* | DS | | | | | | p |
| *Hibiscus vitifolius* L. | *Gimel waika* | DS | p | | P | p | | |
| *Zennia elegans* Jaquin. | *adey abeba* | UD | C | C | | C | C | |

Appendix Table 7. Correlation matrix among variables studied in the communal grazing areas of CBFS

| | *fs* | *spc* | *bc* | *lc* | *se* | *sc* | *ag* | *sed* | *wds* | *ccs* | *heg* | *tor* | *wd* | *cc* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fs | | | | | | | | | | | | | | |
| Spc | 0.767** | | | | | | | | | | | | | |
| Bc | 0.758** | 0.540** | | | | | | | | | | | | |
| C | 0.526** | 0.383 | 0.548** | | | | | | | | | | | |
| Se | 0.571** | 0.315 | 0.744** | 0.576** | | | | | | | | | | |
| Sc | 0.388 | 0.387 | 0.335 | 0.126 | 0.135 | | | | | | | | | |
| Ag | 0.462* | 0.575** | 0.243 | 0.017 | -0.14 | 0.132 | | | | | | | | |
| Sed | 0.234 | -0.023 | 0.179 | 0.338 | 0.118 | 0.228 | -0.087 | | | | | | | |
| Wds | -0.203 | -0.323 | -0.056 | -0.314 | 0.491 | -.691 | -0.240 | -.612 | | | | | | |
| Ccs | 0.664 | 0.728* | 0.312 | -0.103 | 0.121 | 0.188 | 0.383 | -.046 | 0.172 | | | | | |
| Heg | 0.887** | .737** | 0.856** | 0.383 | 0.353 | 0.555 | 0.716* | 0.118 | -.058 | 0.616 | | | | |
| Tor | .666** | .593** | 590** | .468* | .497 | .383 | .196 | .345 | -.169 | .649 | .902** | | | |
| Wd | .612 | .859** | .490 | .511 | .033 | .807* | .515 | .219 | -.611 | .410 | .489 | .731* | | |
| Cc | .507 | .351 | .303 | .254 | .374 | -.180 | .088 | -.196 | .237 | .576 | .304 | .417 | .170 | 1 |

** Correlation is significant at 0.01 levels;* Correlation is significant at 0.05 levels

Appendix Table 8. Correlation matrixes among variables studied in the roadside grazing areas of CBFS

| | *fs* | *spc* | *bc* | *lc* | *se* | *sc* | *ag* | *sed* | *wds* | *ccs* | *heg* | *tor* | *wd* | *cc* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fs | | | | | | | | | | | | | | |
| Spc | 0.707** | | | | | | | | | | | | | |
| Bc | 0.497* | 0.226 | | | | | | | | | | | | |
| Lc | 0.406* | 0.288 | 0.040 | | | | | | | | | | | |
| Se | -0.073 | -0.058 | -0.057 | 0.321 | | | | | | | | | | |
| Sc | 0.080 | 0.108 | -0.240 | 0.021 | 0.014 | | | | | | | | | |
| Ag | 0.132 | 0.138 | -0.070 | 0.507** | 0.128 | 0.197 | | | | | | | | |
| Sed | 0.330 | 0.060 | 0.426* | 0.137 | -0.070 | -0.154 | -0.248 | | | | | | | |
| Wds | 0.460 | 0.246 | 0.127 | -0.038 | 0.060 | 0.185 | -0.183 | 0.395 | | | | | | |
| Ccs | -0.220 | -0.196 | 0.488 | 0.025 | 0.017 | 0.334 | -0.201 | 0.141 | -0.003 | | | | | |
| Heg | 0.482 | 0.306 | -0.083 | -0.073 | 0.119 | 0.030 | -0.200 | 0.198 | 0.792* | -0.275 | | | | |
| Tor | 0.462* | 0.523** | 0.222 | 0.418* | 0.167 | 0.271 | 0.434* | 0.235 | 0.380 | 0.457 | 0.199 | | | |
| wd | 0.142 | 0.036 | 0.156 | 0.150 | 0.453 | -0.295 | 0.149 | 0.240 | 0.392 | -0.446 | 0.374 | 0.138 | | |
| Cc | -0.071 | -0.331 | 0.472 | 0.445 | 0.331 | 0.111 | 0.061 | 0.753* | -0.002 | 0.298 | -0.310 | 0.469 | -.203 | |

**= correlation is significant at 0.01 levels,*= correlation is significant at 0.05 levels, Fs: arming system; Spc: species composition; Bc: basal cover; Lc: litter cover; Se: soil erosion; Sc: soil compaction; Ag: age distribution; Sed: seedling count; Wds: woody density score; Ccs : canopy cover score; Heg : hedging effect; Tor : total range condition score; Wd : woody density; Cc : canopy cover

Appendix Table 9. Correlation matrixes among variables studied in the enclosed areas of CBFS

| | *fs* | *spc* | *bc* | *lc* | *se* | *sc* | *ag* | *sed* | *wds* | *ccs* | *heg* | *Tor* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fs | | | | | | | | | | | | |
| Spc | 0.339 | | | | | | | | | | | |
| Bc | 0.439 | 0.595** | | | | | | | | | | |
| Lc | 0.302 | -0.229 | 0.027 | | | | | | | | | |
| Se | 0.202 | 0.342 | 0.089 | -0.294 | | | | | | | | |
| Sc | 0.013 | 0.411 | -0.050 | -0.034 | 0.197 | | | | | | | |
| Ag | -0.258 | -0.494* | -0.323 | 0.235 | -0.548* | -0.213 | | | | | | |
| Sed | -0.146 | -0.347 | -0.066 | 0.467* | -0.115 | -0.261 | 0.214 | | | | | |
| Wds | -.968** | -0.289 | 0.009 | -0.639 | -0.045 | -0.069 | -0.163 | -0.362 | | | | |
| Ccs | -449 | -219 | 0.747 | -0.575 | -0.349 | -0.170 | -0.265 | 0.180 | 0.509 | | | |
| Heg | -425 | 0.509 | -0.071 | -0.702 | 0.730 | 0.697 | 0.041 | -0.886* | 0.360 | 0.304 | | |
| Tor | -0.241 | 0.198 | -0.022 | -0.621 | 0.250 | 0.155 | -0.193 | 0.105 | 0.896* | 0.360 | 0.304 | 1 |

** = correlation is significant at 0.01 levels ;* = correlation is significant at 0.05 levels Fs: farming system; Spc: species composition; Bc: basal cover; Lc: litter cover; Se: soil erosion; Sc: soil compaction; Ag: age distribution; Sed: seedling count; Wds: woody density score; Ccs : canopy cover score; Heg : hedging effect; Tor : total range condition score; Wd : woody density; Cc : canopy cover

Appendix Table 10. Correlation matrix among variables studied in the grazing areas of CBFS

| | *Grt* | *spc* | *bc* | *lc* | *se* | *sc* | *ag* | *sed* | *wds* | *ccs* | *heg* | *Tor* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grt | 1 | | | | | | | | | | | |
| Spc | 0.665** | 1 | | | | | | | | | | |
| Bc | 0.611** | 0.671** | 1 | | | | | | | | | |
| Lc | 0.583** | 0.697** | 0.714** | 1 | | | | | | | | |
| Se | 0.642** | 0.644** | 0.582** | 0.586** | 1 | | | | | | | |
| Sc | 0.592** | 0.600** | 0.626** | 0.386** | 0.521** | 1 | | | | | | |
| Ag | 0.579** | 0.689** | 0.802** | 0.654** | 0.620** | 0.648** | 1 | | | | | |
| Sed | 0.790** | 0.720** | 0.477 | 0.715* | 0.820** | 0.701* | 0.669* | 1 | | | | |
| Wds | 0.124 | 0.048 | -0.087 | -0.235 | -0.056 | 0.092 | -0.139 | 0.147 | 1 | | | |
| Ccs | 769** | 0.693** | 0.426 | 0.788** | 0.866** | 0.503 | 0.669* | 0.902** | -0.159 | 1 | | |
| Heg | 0.757** | 0.790** | 0.747** | 0.764** | 0.723** | 0.660** | 0.801** | 0.878** | 0.043 | 0.826** | 1 | |
| Tor | -0.281 | -0.140 | 0.112 | -0.068 | -0.406 | -0.096 | -0.056 | -0.540 | 0.151 | -0.309 | -0.233* | 1 |

**= correlation is significant at 0.01 levels ;*= correlation is significant at 0.05 levels, Fs: farming system; Spc: species composition; Bc: basal cover; Lc: litter cover; Se: soil erosion; Sc: soil compaction; Ag: age distribution; Sed: seedling count; Wds: woody density score; Ccs : canopy cover score; Heg : hedging effect; Tor : total range condition score; Wd : woody density; Cc : canopy cover

Appendix Table 11. Correlation matrixes among variables studied in the grazing areas of SBFS

| | *spc* | *bc* | *lc* | *se* | *sc* | *ag* | *sed* | *wds* | *ccs* | *heg* | *tor* | *wd* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Spc | 1 | | | | | | | | | | | |
| Bc | 0.631** | 1 | | | | | | | | | | |
| Lc | 0.718** | 0.718** | 1 | | | | | | | | | |
| Se | 0.652** | 0.615** | 0.728** | 1 | | | | | | | | |
| Sc | 0.833** | 0.602** | 0.807** | 0.641** | 1 | | | | | | | |
| Ag | 0.689** | 0.0.470** | 0.734** | 0.617** | 0.732** | 1 | | | | | | |
| Sed | 0.568** | 0.784** | 0.714** | 0.458** | 0.699** | 0.437** | 1 | | | | | |
| Wds | 0.247 | 0.484 | 0.516 | 0.545 | 0.291 | 0.052 | 0.395 | 1 | | | | |
| Ccs | 0.143 | 0.219 | -0.019 | 0.182 | 0.049 | 0.125 | 0.023 | -0.624* | 1 | | | |
| Heg | 0.633* | 0.574 | 0.563 | 0.718* | 0.572 | 0.401 | 0.582 | 0.556 | -0.240 | 1 | | |
| Tor | 0.846** | 0.634** | 0.811** | 0.672** | 0.819** | 0.685** | 0.663** | 0.307 | 0.336 | 0.591 | 1 | |
| wd | 0.162 | -0.114 | -0.147 | -0.054 | 0.038 | 0.124 | -0.168 | -.835** | 0.828** | -0.271 | 0.117 | 1 |

**= correlation is significant at 0.01 levels ,*= correlation is significant at 0.05 levels Fs: farming system; Spc: species composition; Bc: basal cover; Lc: litter cover; Se: soil erosion; Sc: soil compaction; Ag: age distribution; Sed: seedling count; Wds: woody density score; Ccs : canopy cover score; Heg : hedging effect; Tor : total range condition score; Wd : woody density; Cc : canopy cover

Appendix Table 12. Correlation matrix among of variables studied and their interaction effects in the range condition assessment in the district

| | *Fs* | *Grt* | *spc* | *bc* | *lc* | *se* | *sc* | *ag* | *sed* | *wds* | *ccs* | *heg* | *tor* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FS | 1 | | | | | | | | | | | | |
| Grt | 0.078 | 1 | | | | | | | | | | | |
| Spc | 0.509** | 0.345** | 1 | | | | | | | | | | |
| Bc | 0.443** | 0.473** | 0.726** | 1 | | | | | | | | | |
| Lc | 0.306** | 0.451** | 0.690** | 0.727** | 1 | | | | | | | | |
| Se | 0.247* | 0.323** | 0.630** | 0.677** | 0.739** | 1 | | | | | | | |
| Sc | 0.192 | 0.454** | 0.704** | 0.634** | 0.703** | 0.603** | 1 | | | | | | |
| Ag | 0.157 | 0.328** | 0.615** | 0.549** | 0.682** | 0.513** | 0.628** | 1 | | | | | |
| Sed | 0.207 | 0.576** | 0.588** | 0.733** | 0.772** | 0.577** | 0.669** | 0.571** | 1 | | | | |
| Wds | -0.086 | 0.799** | 0.418 | 0.556** | 0.406 | 0.590** | 0.520* | 0.411 | 0.523* | 1 | | | |
| Ccs | 0.117 | -0.678** | 0.173 | 0.169 | 0.005 | 0.041 | 0.040 | 0.060 | -0.024 | -.359 | 1 | | |
| Heg | 0.285 | 0.536* | 0.719** | 0.677** | 0.529* | 0.702** | 0.734** | 0.515* | 0.633** | 0.737** | -.142 | 1 | |
| Tor | 0.282* | 0.440** | 0.797** | 0.745** | 0.732** | 0.773** | 0.765** | 0.679** | 0.756** | 0.634** | 0.205 | 0.770** | 1 |

** = correlation is significant at 0.01 levels';*= correlation is significant at 0.05 levels, Fs: farming system; Spc: species composition; Bc: basal cover; Lc: litter cover; Se: soil erosion; Sc: soil compaction; Ag: age distribution; Sed: seedling count; Wds: woody density score; Ccs : canopy cover score; Heg : hedging effect; Tor : total range condition score; Wd : woody density; Cc : canopy cover

Appendix Table 13. ANOVA for interaction effect of season and species type on DM composition feeds

| Sources | DF | Type III SS | Mean square | F value | P>F |
|---|---|---|---|---|---|
| | 5 | 16.945 | 3.389 | 27.975 | 0.000 |
| SS | 1 | 144747.108 | 144747.108 | 1194831 | 0.000 |
| SSxSpT | 5 | 16.945 | 3.389 | 27.975 | 0.000 |

R squared = 0.921(Adjusted R squared = 0.888) ;DM =Dry matter; SS= season; SpT = species type

Appendix Table 14. ANOVA for interaction effect of season and species type on ASH composition of the feeds

| Sources | DF | Type III SS | Mean square | F value | P>F |
|---|---|---|---|---|---|
| | 5 | 1052.147 | 210.429 | 5.421 | 0.008 |
| SS | 1 | 3713.496 | 3713.496 | 95.669 | 0.000 |
| SSxSpT | 5 | 1052.147 | 210.429 | 5.421 | 0.008 |

R square =0.693 (Adjusted R squared = 0.565), SS= season; SpT = species type; ASH = Ash

Appendix Table 15. ANOVA for interaction effect of season and species type on OM composition of the feeds

| Sources | DF | Type III SS | Mean square | F value | P>F |
|---|---|---|---|---|---|
| | 5 | 1052.147 | 210.429 | 5.421 | 0.008 |
| SS | 1 | 132005.496 | 132005.439 | 3400.807 | 0.000 |
| SSxSpT | 5 | 1052.147 | 210.429 | 5.421 | 0.008 |

R square =0.693 (Adjusted R squared = 0.565); SS= season; SpT = species type; OM= organic matter

Appendix Table 16. ANOVA for interaction effect of season and species type on CP composition of the feeds

| Sources | DF | Type III SS | Mean square | F value | P>F |
|---|---|---|---|---|---|
| | 5 | 401.438 | 80.288 | 72.370 | 0.000 |
| SS | 1 | 1635.157 | 1635.157 | 1473.912 | 0.000 |
| SSxSpT | 5 | 401.438 | 80.288 | 72.370 | 0.000 |

R square =0.968 (Adjusted R squared = 0.955); SS= season; SpT = species type; CP= crude protein

Appendix Table 17. ANOVA for interaction effect of season and species type on NDF composition of the feeds

| Sources | DF | Type III SS | Mean square | F value | P>F |
|---|---|---|---|---|---|
| | 5 | 1896.053 | 379.211 | 154.524 | 0.000 |
| SS | 1 | 81640.323 | 81640.323 | 33267.512 | 0.000 |
| SSxSpT | 5 | 1896.053 | 379.211 | 154.524 | 0.000 |

R square =0.985 (Adjusted R squared = 0.978), SS= season; SpT = species type; NDF; Neutral detergent fiber

Appendix Table 18. ANOVA for interaction effect of season and species type on ADF composition of the feeds

| Sources | DF | Type III SS | Mean square | F value | P>F |
|---|---|---|---|---|---|
| | 5 | 550.769 | 110.154 | 59.829 | 0.000 |
| SS | 1 | 36374.439 | 36374.439 | 19756.548 | 0.000 |
| SSxSpT | 5 | 550.769 | 110.154 | 59.829 | 0.000 |

R square =0.961 (Adjusted R squared = 0.945); SS= season; SpT = species type; ADF = Acid detergent fiber

Appendix Table 19. ANOVA for interaction effect of season and species type on ADL composition of the feeds

| Sources | DF | Type III SS | Mean square | F value | P>F |
|---|---|---|---|---|---|
| | 5 | 930.415 | 186.883 | 56.451 | 0.000 |
| SS | 1 | 2495.476 | 2495.476 | 757.034 | 0.000 |
| SSxSpT | 5 | 930.415 | 186.083 | 56.451 | 0.000 |

R square =0.959 (Adjusted R squared = 0.942); SS= season; SpT = species type; ADL = Acid detergent lignin

Appendix Table 20. ANOVA for interaction effect of season and species type on IVDMD composition of the feeds

| Sources | DF | Type III SS | Mean square | F value | P>F |
|---|---|---|---|---|---|
| | 5 | 1133.193 | 226.639 | 26.887 | 0.000 |
| SS | 1 | 35363.815 | 35363.815 | 4195.352 | 0.000 |
| SSxSpT | 5 | 1133.193 | 226.639 | 26.887 | 0.000 |

R square =0.918 (Adjusted R squared = 0.884); SS= season; Spt = species type; IVDMD = Ivitro dry matter digestibility

Appendix Table 21. ANOVA for interaction effect of farming system and grazing types on species composition

| *Sources* | *DF* | *Type III SS* | *Mean square* | *F value* | *P>F* |
|---|---|---|---|---|---|
| Fsys | 1 | 6.606 | 6.606 | 16.949 | 0.001 |
| GrT | 2 | 26.846 | 13.423 | 34.442 | 0.000 |
| Fsys*GrT | 2 | 2.133 | 1.066 | 2.736 | 0.097 |

R square= o.870 (Adjusted R squared= 0.826) , Fsys= farming system; GrT= Grazing types

Appendix Table 22. ANOVA for interaction effect of farming system and grazing types on basal cover

| *Sources* | *DF* | *Type III SS* | *Mean square* | *F value* | *P>F* |
|---|---|---|---|---|---|
| Fsys | 1 | 0.318 | 0.318 | 0.507 | 0.487 |
| GrT | 2 | 24.533 | 12.266 | 19.586 | 0.000 |
| Fsys*GrT | 2 | 0.060 | 0.30 | 0.048 | 0.954 |

R squared= 0.734 (Adjusted R squared = 0.645) , Fsys= farming system; GrT= Grazing types

Appendix Table 23. ANOVA for interaction effect of farming system and grazing types on litter cover

| *Sources* | *DF* | *Type III SS* | *Mean square* | *F value* | *P>F* |
|---|---|---|---|---|---|
| Fsys | 1 | 4.720 | 4.720 | 9.077 | 0.009 |
| GrT | 2 | 16.497 | 8.249 | 15.862 | 0.000 |
| Fsys*GrT | 2 | 0.709 | 0.355 | 0.682 | 0.521 |

R squared= 0.756 (Adjusted R squared= 0.675),Fsys= farming system; GrT= Grazing types;

Appendix Table 24. ANOVA for interaction effect of farming system and grazing types on soil erosion

| *Sources* | *DF* | *Type III SS* | *Mean square* | *F value* | *P>F* |
|---|---|---|---|---|---|
| Fsys | 1 | 1.674 | 1.674 | 6.022 | 0.027 |
| GrT | 2 | 14.339 | 7.169 | 25.797 | 0.000 |
| Fsys*GrT | 2 | 0.375 | 0.188 | 0.675 | 0.521 |

R squared= 0.784 (Adjusted R squared=0.712); Fsys= farming system; GrT= Grazing types

Appendix Table 25. ANOVA for interaction effect of farming system and grazing types on soil compaction

| *Sources* | *DF* | *Type III SS* | *Mean square* | *F value* | *P>F* |
|---|---|---|---|---|---|
| Fsys | 1 | 0.183 | 0.183 | 0.589 | 0.455 |
| GrT | 2 | 10.634 | 5.317 | 17.127 | 0.000 |
| Fsys*GrT | 2 | 2.638 | 1.319 | 4.249 | 0.035 |

R squared=0.722(Adjusted R squared=0.629) ,Fsys= farming system; GrT= Grazing types

Appendix Table 26. ANOVA for interaction effect of farming system and grazing types on age distribution

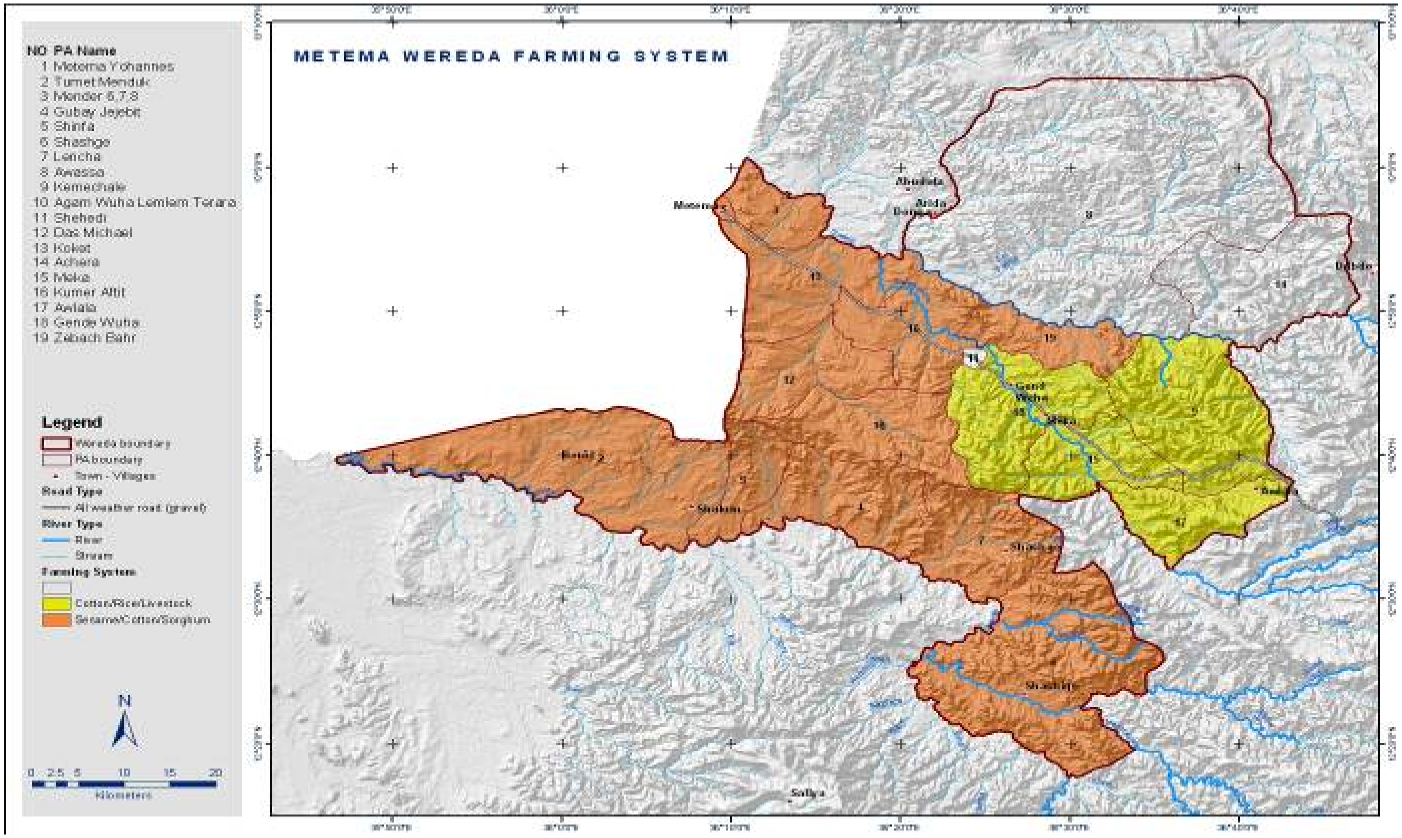
| *Sources* | *DF* | *Type III SS* | *Mean square* | *F value* | *P>F* |
|---|---|---|---|---|---|
| Fsys | 1 | 0.952 | 0.952 | 2.602 | 0.128 |
| GrT | 2 | 4.427 | 2.214 | 6.052 | 0.012 |
| Fsys*GrT | 2 | 0.627 | 0.314 | 0.857 | 0.444 |

R squared=0.543Adjusted R squared=0.391) ,Fsys= farming system; GrT= Grazing types

Appendix Table 27. ANOVA for interaction effect of farming system and grazing types on Seedling count

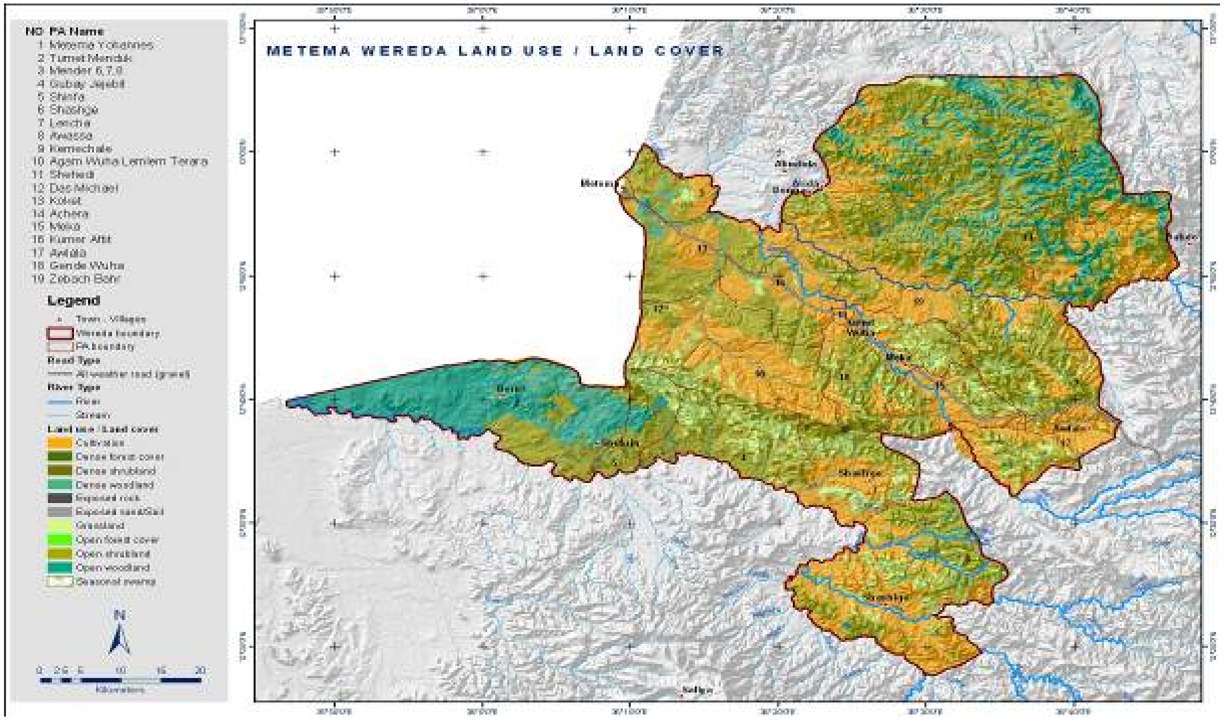
| *Sources* | *DF* | *Type III SS* | *Mean square* | *F value* | *P>F* |
|---|---|---|---|---|---|
| Fsys | 1 | 0.753 | 0.753 | 1.685 | 0.214 |
| GrT | 2 | 15.255 | 7.628 | 17.070 | 0.000 |
| Fsys*GrT | 2 | 0.134 | 0.067 | 0.150 | 0.862 |

R squared=0.720(Adjusted R squared=0.627) ,Fsys= farming system; GrT= Grazing types




Source: ILRI, 2005

Appendix Figure 1. Metema district farming systems




Source: ILRI, 2005

Appendix Figure 2. Land Use and Land cover of Metema district

Appendix Figure 3. The view of communal grazing lands at the dry season prior to flash burning

Appendix Figure 4.The view of communal grazing lands at peak dry season

Appendix Figure 5. Partial view of communal grazing lands Sesame based farming

Appendix Figure 6. Hay storage mechanism of the farmers in open field

Appendix Figure 7. *Pennisetum spheslatum* grass dominated communal grazing land at SBFS

Appendix Figure 8. Parts of the Enclosed  site at Sesame based farming (Agam wuha)

Appendix Figure 9. Communal grazing land after unpericribed burning

Appendix Figure 10. Hyparrhenia *rufa grass* dominated woodland (Guange river side areas)