



ASSESSMENT OF GRAZING LAND CONDITION, HERBACEOUS BIOMASS SPECIES
AND CHEMICAL COMPOSITION IN ADAMI-TULLU JIDO-KOMBOLCHA AND ARSI-
NEGELLE WOREDAS, SOUTHERN ETHIOPIA

MSc THESIS

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HAWASSA, ETHIOPIA

MARCH, 2016

ASSESSMENT OF GRAZING LAND CONDITION, HERBACEOUS BIOMASS SPECIES
AND CHEMICAL COMPOSITION IN ADAMI-TULLU JIDO-KOMBOLCHA AND ARSI-
NEGELLE WOREDAS, SOUTHERN ETHIOPIA

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OF SCIENCE IN ANIMAL AND RANGE SCIENCES (SPECIALIZATION: ANIMAL
PRODUCTION)

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MARCH, 2016

APPROVAL SHEET 1
SCHOOL OF GRADUATE STUDIES
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This is to certify that thesis entitled “Assessment of grazing land condition, herbaceous biomass species and chemical composition in Adami-Tullu Jido-Kombolcha and Arsi-Negelle woredas, southern Ethiopia” toward in partial fulfillment of the requirements for the degree of Master of Science in Animal and Range Sciences with specialization in Animal Production of the graduate program of the School of Animal and Range Sciences, College of Agriculture, and is a record of original research carried out by **Mulugeta Gudisa Goro** ID No. SGS/061/05 under our supervision and we confirm that the thesis is ready for submission of thesis defense. Therefore, we recommend that it be accepted as fulfilling the thesis requirements.

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As members of the Board of Examiners of the final open defense by **Mulugeta Gudisa Goro**, we have read and evaluated his/her thesis entitled “Assessment of grazing land condition, herbaceous biomass species and chemical composition in Adami-Tullu Jido-Kombolcha and Arsi-Negelle woredas, southern Ethiopia” and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science in Animal production.

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DEDICATION

This piece of work is dedicated to the memory of the late **Tirunesh Hailu**, my mother who lifeless without seeing my success.

STATEMENT OF THE AUTHOR

I declare that this thesis is my genuine work and that all sources of materials used for this Thesis have been duly acknowledged. This Thesis has been submitted in partial fulfillment of the requirements for MSc. degree at Hawassa University and is reserved at the University Library to be made available to borrowers under rules and regulations of the Library. I solemnly again 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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LIST OF ABBREVAITIONS

°C	Degree Celsius
ADF	Acid Detergent Fiber
ADL	Acid Detergent Lignin
CP	Crude Protein
DM	Dry Matter
EARO	Ethiopia Agriculture Research Organization
GLM	General linear model
Ha	Hactare
ILCA	International Livestock Center for Africa
IUCN	International Union for the Conservation of Nature and Natural Resources
Masl	Meter above sea level
MOA	Ministry of Agriculture
NDF	Neutral Detergent Fiber
RISC	Range Inventory Standardization Committee
SE	Standard error
SEPR	Socio-Economic Profile of Rayitu
SPSS	Statistical Package for Social Sciences
UNEP	United Nations Environmental Program
OESPO	Oromia Economic Study Project Office
LSM	Least Square Mean

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ABSTRACT

*This study was conducted in Adami-Tullu Jido-Kombolcha and Arsi Negelle woredas, Southern Ethiopia. The objectives of the study were: (1) To assess the effects of grazing pressure and altitude on range condition, herbaceous biomass and species composition in the study areas and (2) To evaluate the effects of grazing pressure and altitude on chemical composition of herbaceous plants in the study areas. In the assessment of rangeland condition: grass species composition, basal cover, litter cover, number of seedlings, age distribution of dominant grasses, soil erosion and compaction were considered. The data were analyzed using GLM procedure in SPSS 16.0 version, which was used for mean comparisons using post-hoc t-test that can be employed to compare mean differences for enclosure and open grazed areas. To test the effect of management and altitude on rangeland condition, biomass production, chemical composition of herbaceous species, mixed model analysis was used where site was used as a random variable while management and altitude were fixed variables. The rangeland condition assessment factors showed that grass species composition, basal cover, litter cover, age distribution, number of seedlings, soil erosion and compaction, and total range condition scores in the enclosed areas were significantly ($p < 0.05$) higher than in the open grazed areas. A total of 28 herbaceous species were identified. Of the identified herbaceous species, 20 were grasses, 2 were legumes while 6 species were forbs. Among the recorded grass species, some were highly desirable, while others were in the category of intermediate in terms of desirability and less desirable. The total biomass production of grasses, forbs and legumes in the enclosure areas were significantly ($p < 0.05$) higher than that of the open-grazed areas across the study sites. The dominant and common grass species included: *Arstida adscensionis*, *Cenchrus ciliaris*, *Chloris gayana*, *Chloris roxburghiana*, *Bothriochloa insculpta*, *Entropogon*, *Eragrostis papposa*, *Heteropogon contorus*, *Panicum maximum*, *Bides pilos sida ovate*, *Indigofer spinosa*, *Tephrosia pumila*, *Sporobolus pyramidalis*, *Themeda triandra*, *B. nigropedata*, *Ocimum basilicum*, *Amaranthus dubis*, *Tribulos terrestris* and *Achyranthes aspera*. The chemical composition of herbaceous plants were evaluated for DM, CP, NDF, ADF, ADL and Ash between the two management systems and among three site of different altitude for grazing land condition. The average CP content in the open-grazed area was significantly ($p < 0.05$) higher than that of enclosure grazing areas. This suggests that proper management of grazing lands in the study areas is required as part of the grassland monitoring activities and restoration programs. It is also suggested that the herbaceous forages were utilized at early stage of maturity to provide optimum nutrients for animals in the study area.*

Key words: grazing rangeland condition, Biomass production and chemical composition of herbaceous biomass

1. INTRODUCTION

Rangelands are defined as uncultivated land that provides native forage for grazing and browsing animals in arid and semi-arid environments (Holechek et al., 2001). In Africa, rangelands are the major sources of native forage for grazing and browsing animals that constitute about 65% of the total land area of the region, which supports 59% of all ruminant livestock (Friedel et al., 2000).

In Ethiopia, rangelands are located around the margin of the country and most of these areas are found below 1500 meter above sea level (Coppock, 1994). They cover about 61 to 65% of the total area of the country (Beruk and Tafesse, 2000) and are characterized by arid and semi-arid agro-ecologies; experience a relatively harsh climate with low, unreliable, and erratic rainfall, regularly high temperature and low human population density (Beruk, 2003a; Alemayehu, 2004). The lowlands are home to 12 -15% of the human population, 26% of the total livestock population (Coppock, 1994). Pastoralism and agro-pastoralism are the dominant types of land use systems in these areas (Teshome, 2007). Although the lowlands have lower number of livestock than the highlands, the lowland livestock play significant role in the national economy (Teshome, 2007). Lowland breeds of cattle and sheep make up over 90% of the legal export of live animal and lowland cattle provide around 20% of the draught animals for the highlands (Coppock, 1994). The rangelands are not only known for livestock rearing, but there are many wildlife parks, sanctuaries, and reserves (MOA, 2000; EARO, 2001).

In the lowlands of Ethiopia, more than 90% of the livestock are kept on rangeland, which vary in composition depending on altitude, rainfall and soil (Alemayehu, 2004). Many of these

rangelands and rangeland based life style at present, are shrinking and degrading due to natural and manmade causes such as increase in human population growth, bush encroachments and crop, settlement, conflicts, and recurrent drought (Tafesse, 2000 and Beruk, 2003a; Alemayehu, 2004). Studies on indigenous knowledge of rangeland management have shown that pastoralists consider rangeland conservation in their management strategies (Oba, 1998; Solomon, 2000; Ayana and Fekadu, 2003; Mapinduzi et al., 2003). Pastoralists have their own traditional ecological knowledge to classify rangelands and assess range condition and trend (Oba and Kotile, 2001). According to Oba (1998), the managerial skills and compress environmental knowledge is crucial feature of the pastoral land use to cope up with rainfall variability. Similarly, several authors (Ayana, 1999; Solomon, 2000; Alemayehu, 2004; Gemedo, 2004) suggested that traditional knowledge of natural resource management, utilization and grazing management system are important coping strategies for pastoralists.

Rangeland management practices developed largely as a result of detailed ecological studies on the composition of natural vegetation could help in improving and monitoring rangelands, in locating development programs as well as conserving rangeland biodiversity (Tainton, 1999; Alemayehu, 2005). Hence, it is essential to have basic information on vegetation composition coupled with information on traditional grazing land utilization practices of the pastoralists as these may facilitate the efficient utilization of rangeland resources. So far, some research and development works on rangelands were conducted in the South and Southeast rangelands (Beruk and Tafesse, 2000; Dawit, 2000), studies on rangeland conditions are limited in relation to grazing pressure and altitudinal variation. For example, rangeland condition assessments were conducted in Borana (Ayana, 1999; Oba, 2001; Gemedo, 2004), part of the Middle Awash by Abule (2003), part of the Somali region by Ahmed (2003), Belaynesh (2006) and Amaha (2006) and Hamer-and Benna-Tsemy districts by Admasu (2006).

Adami-Tullu Jido-kombolch and Arsi-Negelle are among the districts found in the lowlands of East Showa and West Arsi where pastoralism and agro-pastoralism are the main land use systems and livestock are the main assets of the community. It has been a custom for the owner to aim at keeping as many animals as possible, irrespective of the condition of the animal or availability of the pasture (Teshome, 2007). This is partly because livestock are regarded as wealth, a man's social position and prestige value in the study areas (Phaulos et al., 1999). Feed shortage particularly during the dry season has been the main constraint to livestock production in the study sites.

Crop cultivation is a recently introduced practice because of settlements and the need to diversify income (Phaulos et al., 1999) for the local inhabitants. There has been rather limited research undertaken on assessment of grazing land condition, herbaceous biomass and chemical composition in Adami-Tullu Jido-Kombolcha and Arsi-Negelle woredas. Accordingly, for successful livestock production and sustainable resource management, knowledge of grazing land conditions, herbaceous biomass species and chemical composition is essential in these districts. Therefore, this study was initiated with the following objectives:

- ❖ To assess the effects of grazing pressure and altitude on rangeland condition, herbaceous biomass and species composition in the study areas in the study areas.
- ❖ To evaluate the effects of grazing pressure and altitude on chemical composition of herbaceous plants in the study areas.

2. LITERATURE REVIEW

2.1. Rangelands of Ethiopia

Rangelands in Ethiopia are in danger of becoming seriously degrading owing to natural and human-induced factors (Coppock, 1994; Amaha et al., 2006). This implies that rehabilitation is a matter of priorities and should follow by a detailed assessment of the state of health of the rangelands. The rangelands of Ethiopia consist of mainly native pastures (grass, forbs and woody plant species); they are main feed sources of grazers and browser (Gemedo et al., 2006). Rangeland plants usually are consumed by domestic and wildlife animals. Therefore, assessing the condition of vegetation utilized by grazing and browsing herbivores are essential for sustainable utilization of rangeland ecosystem. The concept of rangeland condition is encompassing to indicate the state of health of the rangeland in terms of its ecological status, resistance to soil erosion and potential for producing forage for sustained optimum livestock production (Tainton, 1999).

2.2. Livestock Production in Middle Rift Valley of study district

Pastoral and agro-pastoral way of land use is the dominant production system in Adami-Tullu Jido-Kombolcha and Arsi-Negelle woredas and also crop farming occupies in some areas (Abule, 2003). The primary purpose of keeping cattle in the area is provision of milk followed by draft power, prestige, and accumulation of wealth and income generation for both economic and social values (Abule, 2003). The milk is a major product in the pastoral system and the main purpose of livestock rearing is subsistence (Ahmed, 2003; Leshan, 2007). The cattle production

have also used for other social significances such as slaughter at wedding, funerals and presenting as gift for relatives (Nigussie, 2008).

2.3. Indigenous rangeland assessment

Pastoralists have elaborated system of assessing rangeland condition and trends (Oba, 1998). According to Alemayehu (1998) and Ayana (1999), the Borana pastoralists conduct seasonal assessments of range condition and trends. These assessments were based on the type of vegetation, water, soil, absence of tick, topography and livestock performance. Furthermore, the Borana pastoralists categorized landscape suitability for different livestock species, seasons of use and grazing capacity (Oba et al., 2000). However, according to Ayana and Fekadu (2003), the traditional grazing systems of Borana pastoralists was under pressure due to drought, ban of fire, conflict between clans, overgrazing, increase in human and livestock populations, decrease in grazing lands which have eroded the effectiveness of the traditional management.

2.4. The Importance of Rangeland Condition Assessment

Range condition is the state and health of the range (Tainton; 1999). In a more complete sense, it includes the direct and indirect changes in vegetation composition, land productivity and land stability overtime under various regimes of livestock production due to inventory and monitoring activities is essential feature of range management. Plant for natural vegetation is sufficiently conserved if it would be used as a broad guide to ensure more natural, more complex and more stable flora and fauna (Tewoldeberhan, 1991). The dry lands of Ethiopia are reportedly biodiversity rich and any vegetation change may result in species decline or loss (Tewoldeberhan, 1991). Dry land monitoring and assessments activities are essential for planning and implementation of conservation measures (Tewoldeberhan, 1991). Vegetation is an

essential component of an ecosystem and needs careful study and analysis since such study is used as a means of revealing useful information about vegetation of an area and ecosystem Goldsmith *et al.* (1994).

2.5. Methods of Range Condition Assessment

Range condition is perhaps the most important concepts in the management of renewable natural resources in arid and semi-arid lands (Snyman, 1998). There are three objectives in rangeland condition assessment namely; evaluation of rangeland condition relative to its potential in that ecological zone (Tainton, 1999); evaluation of the effects of current management on rangeland condition and monitoring changes over time (Tainton, 1999) and classification of the different vegetation types on the farm and quantification of their condition (Tainton, 1999). There are two basic approaches to range condition rating for an ecological site. One is ecological based method, and the other is agronomic based method.

2.5.1. Ecological based method

There are many methods under ecologically based methods such as the benchmark, ecological index method, the key species, weighted key species and the degradation gradient techniques (Tainton, 1999). A benchmark is an example of vegetation that is considered to provide the highest possible sustainable animal production for the rangeland type under consideration (Holechek *et al.*, 2001). Benchmarks provide a baseline against which the benefits and harmful effects of domestic grazing can be evaluated and a standard against which the effects of man's intervention in the natural environment can be assessed. All range sites within the same ecological zone can be rated against such benchmark site. A benchmark will not necessarily be the climax vegetation for an area and is often some form of sub-climax. However, limitations to the benchmark method have been suggested by Holechek *et al.* (2001). Benchmarks may be in a

typically favored location, they may experience different rainfall or have a different fire history, or they may simply not exist and must be theoretically constructed. Differences due to variability within a site may be inappropriately attributed to management. Multiple benchmarks have been proposed (Holechek et al., 2001) to represent the variability within a rangeland site or land unit.

2.5.2. Agronomic based method

The agronomic approach measures range condition in terms of current productivity level of the resources for defined land use (RISC, 1983) and it is important to obtain measures of rangeland composition, at least in terms of palatability classes, which are representative of the rangeland being, grazed (Tainton, 1999). Species are allocated palatability ratings, which signify their forage production potential. The main objective of management based on this is to maintain and improve the suitability of the ecological site for the given use (Tainton, 1999).

2.6. Factors Affecting Vegetation Composition.

Vegetation is usually used to quantify range condition since it is a more sensitive indicator of ecosystem change. Vegetation attributes can be used as an indicator of environmental condition. Vegetation composition of rangeland can be changed because of many factors, including soil, altitude, grazing practices, burning, drought, temperature, pest and disease and human activities. Depending on the nature of this change, the productivity of the rangelands may change (Tainton, 1999).

2.7. Effect of Grazing on Range Condition

Livestock grazing can have a profound effect on vegetation and the general pattern of grazing induced vegetation change is well documented (Illius and O'Connor, 1999). It is known that undesirable species is increasing at the expense of desirable species. Several studies showed that as grazing intensity is increased, herbaceous composition change from highly palatable to less

palatable (Amsalu; 2000; Abule et al., 2005). As grazing is continued palatable plants (decreasers) die and with the death of decreasers less palatable plants (increasers) become abundant. As the pressure further increases, the climax plants may disappear and invasion of new species occur (Illius and O'Connor, 1999) and this causes a reduction in vigor and reproductive potential. It is widely believed that overgrazing reduces the dry matter yield of grasses (Amsalu and Barrs, 2002; Abule et al., 2005), causes changes in vegetation composition (Amsalu and Barrs, 2002), causes soil compaction and erosion (Snyman, 1998) and the spread of woody vegetation and resulted in the reduction of grasses (Ayana and Barrs, 2000). In general, overgrazing is the most common cause of rangeland degradation (Baars and Said, 1999) and this can have a major economic implication (Van der Westhuizen et al., 1999). Therefore, the determination of rangeland condition and trend is essential to ensure sustainable utilization and production of the grassland ecosystem.

2.8. Rangeland Vegetation of Ethiopia

As described by Zerihun Woldu (1999), the vegetation of Ethiopia is extremely complex. The complexity arises from the great variations in altitude implying equally great spatial differences in moisture regimes as well as temperatures within very short horizontal distances. The rangeland vegetation of the tropical zone contains a variety of native plant species that have developed special strategies to cope with the low and sporadic rainfall, and extreme variability in temperatures that prevail in these ecosystems. The vegetation type is characterized by low plant density and coverage, little variation and plant productivity per unit area. Rangeland vegetation patterns are classified mainly based on the height and density of the principal growth forms and species composition. These vegetation types include bushes, shrubs, succulent and scrub

vegetation. The native vegetation is represented by a variety of species, such as grasses, forbs, shrubs and trees (UNEP, 1992; IUCN, 1999).

2.9. Causes of rangeland degradation

The causes of rangeland degradation and land deterioration vary from altitude to altitude with difference in opinion as to the cause of reduced land productivity, however the effect was clear. Recurrent drought was the main cause of rangeland degradation followed by shortage of rainfall, mismanagement, soil erosion, expansion of cultivated land, overgrazing and bush encroachment (Coppock, 1994). The increase in human population necessitates the increase in livestock population, following this overstocking on limited pasture resources resulted in overgrazing that triggered rangeland degradation (Coppock, 1994). According to Belaynesh (2006), communal ownership of land and individual ownership of livestock and free access to grazing land without community control over the utilization of grazing resources and subsequent disruption of their traditional institution for resource management also contributed to degradation of the rangelands of the study district.

The superficial causes of rangeland degradation and the relative contribution of each and every causal factor vary from one rangeland environment to the other. In a study by Ayana (1999), the Borana elders ranked drought, prohibition of fire, population pressure, and ranch expansion as the major factors leading to rangeland degradation.

3. MATERIALS AND METHODS

3.1. Description of the study area

The study was carried out in Adami-Tullu Jido-Kombolcha and Arsi-Negelle woredas, Southern Ethiopia, Oromia Regional State. Adami-Tulu Jido-Kombolcha is located between $38^{\circ}37'12''$ - $38^{\circ}40'4''$ E and $7^{\circ}45'36''$ - $7^{\circ}49'48''$ N and Arsi-Negelle is located $38^{\circ}38'24''$ - $38^{\circ}42'36''$ E and $7^{\circ}26'24''$ - $7^{\circ}34'12''$ N. The average annual rainfall distribution and temperature are ranged from 700 mm to 900 mm and 23°C - 26°C , respectively (Adami-Tulu Jido-Kombolcha (OESPO), 2003)). In Arsi-Negelle woreda, the annual rainfall and temperature are within the range of 900 mm to 1100 mm and 28°C - 30°C , respectively (Arsi- Negelle Agricultural office). The soil types of both woredas are mostly sandy and clay soils with altitude of 1500 m – 2300 m in Adami-Tulu Jido-Kombolcha woreda (OESPO), 2003)). The altitude in Arsi-Negelle woreda ranges from 1500 m – 2300 m above sea level.

The total human population of Arsi-Negelle woreda is about 1, 362,881, out of which 674,626 (49.5%) are males and 688,255 (50.5%) of females, respectively. The total population of Adami-Tullu Jido-Kobolcha woreda 1,324,866, out of which 664,987 (50.2%) are males and 659,879 (49.8%) are females.

3.2. Site selection

Before the actual field study, reconnaissance site were selected throughout the study kebeles for a general overview of the nature and distribution of the open grazed and enclosure areas of lands. The study kebeles were stratified into three altitude ranges for the purpose of rangeland condition assessment, since altitude is considered as one of the most important variable affecting

vegetation distribution. The altitude categories of vegetation samples were stratified into three altitude zones: bottom (1550-1558 m), medium (1560-1575 m) and top-land (1578-1595 m).

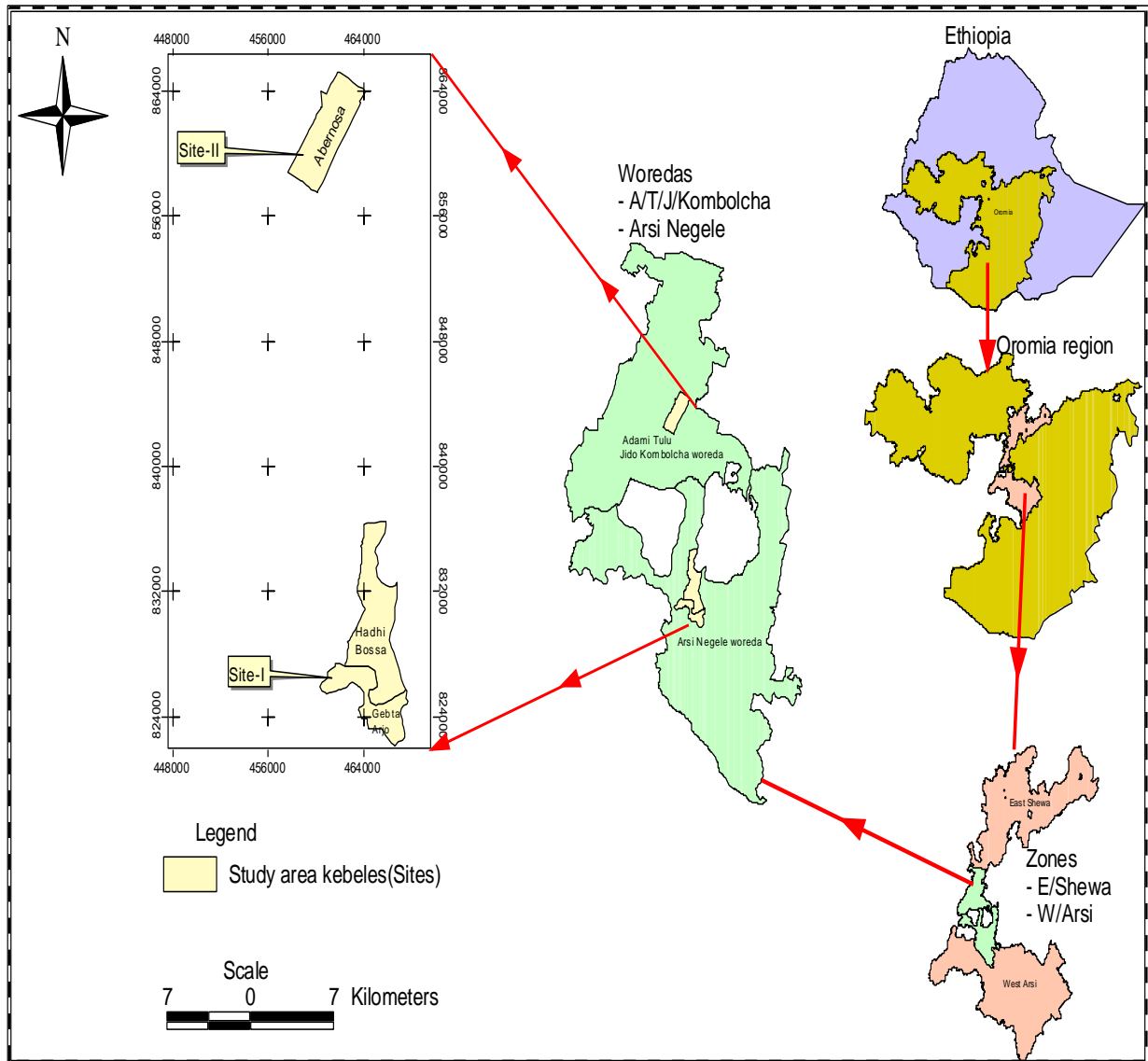


Figure 1: Map of Study site

Table 1: Selected rangeland sites and experimental design used for range condition assessments in Adami-Tullu Jido-Kombolcha and Arsi-Negelle woredas.

Grazing type	Location of Rangeland Site (Kebele)			Sub-total	Quadrant
	Abernosa	Hadha-Bossa	Gubeta-Arjo		
Enclosed areas	1	1	1	3	54
Open-grazed areas	1	1	1	3	54
Total	2	2	2	6	108

3.2.1. Sampling procedure

The sampling method used was 'Systematic Stratified Random Sampling Technique' (ILCA, 1990). Each study area or site was stratified into Bottomland, medium altitude and top-land. Then, each altitude range was stratified into two categories of grazing pressure (enclosure vs. open grazed areas). A total of 108 samples were randomly collected using 1 m x 1 m quadrant across three study sites. (i.e., four samples per altitude at each site). At each sample site, herbaceous biomass were assessed by harvesting samples at ground level in 1 m × 1 m quadrant along transect at an interval of 30 m. The samples were weighed immediately using digital balance and transferred into properly labeled paper bag and fastened at the top. Samples were kept under shade until sampling for the day was completed. Subsequently, samples were sun dried until the work was completed. Finally, the dry matter of herbaceous biomass was determined in an oven dried at 65⁰c for 48 h at Hawassa University in the Animal Nutrition Laboratory. Sampling was done between June and July 2014 when most of the pasture plants were fully-grown to their flowering stage.

3.3. Assessment of Rangeland Condition Indicator

The factors considered and the criteria for scoring rangeland conditions were based on Tainton, (1981) and Baars, (1997). The maximum possible score was 50 points. The rating were interpreted as excellent (41 to 50 points), good (31 to 40), fair (21 to 30), poor (11 to 20) or very poor (3 to 10).

3.3.1. Grass species composition

At each sample site, the grass species composition was studied in the month of June based on visual observation. For grass composition, a score of one to ten points were considered according to the methods shown in Table 2. Then, the grass species was divided into desirable species likely to decline with heavy grazing pressure (decreasers), intermediate species likely to increase with heavy grazing pressure (increasers), and undesirable species likely to invade with heavy grazing pressure (invaders), according to the succession theory (Tainton, 1981). Classification of grasses into decreasers, increasers and invaders was done by conducting detailed interview with experienced persons about the palatability and distribution of each identified grass species in relation to the intensity of grazing.

3.3.2. Basal and litter cover

Basal cover and litter cover were assessed on a scale of 0-10 points (Table 2). A representative sample area of 1 m² was selected for detailed assessments of basal and litter covers. In both cases, the 1 m² was divided into eight. All plants in the selected 1 m² were removed and their basal/litter cover transferred to the eight in order to facilitate visual estimations. The rating of basal cover for tufted species was considered excellent if the eighth was completely filled (12.5 per cent) with the transferred grass basal cover (Baars et al., 1997 and Dahlberg, 2000). Basal

cover was considered very poor at < 3 percent cover. The rating for litter covers within the same 1 m² was considered excellent when it exceeded 40 per cent and poor at < 10 per cent litter cover (Table 2).

3.3.3. Number of seedlings and age distribution

The number of seedling per unit area indicates the intensity of grazing pressure (Baars et al., 1997; Friedel, 1991). For the assessment of number of seedlings, the score was counted using three areas, each equal to the size of an A4 sheet of paper (30 cm x 21 cm) sample at random. For the number of seedlings, 0-5 points were considered. For the category "no seedlings", a score of 0 point was given and maximum score of 5 point was given when encountered more than 4 seedlings. For the age distribution, 1-5 points were considered. When all age categories, young, medium aged and old plants of the dominant species were present, a maximum score of 5 point was given. When there was only old, medium aged or young plants, the scores 3, 2 or 1 point was given, respectively. The most useful factor indicating pasture condition and trend assessment is reproduction of the desirable species. The absence of young plants indicates that plants are dying and the trend is downward (Hardy, 1989). If all age categories, young, medium and old plants of the dominant species were present, a maximum score of 5 point was given. If there were only young plants then, a minimum score of one (1) point was given.

3.3.5. Soil erosion and soil compaction

The extent of soil erosion in each of the quadrants of 1 m x 1 m was evaluated subjectively by visual observations. Soil erosion assessment was done based on 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, 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.

In each quadrant of the study areas, the extent of soil erosion and compaction were evaluated by visual observations and a corresponding score was assigned in each case. A scale of 0-5 points was considered. Soil erosion was rated based on the amount of pedestals (high parts of soil held together by plant roots with eroded soil around tuft), and in severe cases pavements (terraces of flat soil, normally without basal cover with a line of tufts between pavement). Soil compaction was assessed based on the amount of capping (crust forming). Five reading per sample site were taken and a range of points (1-5) were given as 5, 4, 3, 2 and 1 points for soil surface with no capping, isolated or scattered capping, > 50% capping, >75% capping and almost 100% capping, respectively (Angassa,2014).

Table 2: Methods for range condition assessment and scoring in arid to semi-arid rangelands

GC	BC	LC	NS	AD	SC	SE	Score
91-100 percent decreaser	>12 per cent no bare spot	>40 per cent					10
81-90 percent decreasers	>12 per cent slightly bare spots						9
71-80 percent decreasers	>9 percent evenly distributed	11-40 per cent and evenly distributed					8
61-70 percent decreasers	>9 percent occasional bare spots						7
51-60 percent decreasers	>6percent evenly distributed	11-40 per cent and unevenly distributed					6
41-50 percent decreasers	>6 percent bare spots		>4 seedlings	All age categories	No sign of erosion	No sign of compaction	5
10-40percent decreasers and \geq 30 percent increasers	>3percent mainly perennials	3-10 percent mainly of grasses	4 seedling	Two size category present	Slight sand mulch	Isolated capping	4
10-40 percent decreasers and <30 per cent increasers	>3percent mainly of Annuals		3 Seedlings	Present only	Slope side pedestals (>50 per cent capping)	>50 per cent capping	3
<10 per cent decreasers and \geq 50percent increasers	1-3 percent basal cover	3-10 percent weeds or tree leaves	2 Seedling	Only Medium	Steep-sided pedestals(>75 per cent capping)	>75 per cent capping	2
<10percent decreasers and<50percent increasers	<1 percent basal cover		1 Seedling	Only young	Pedestals (almost 100 capping)	Almost 100 per cent capping	1
Bare ground	0 percent	<3 per cent cover	No seedling		Gullies		0

GC, grass composition; BC, basal cover; LC, litter cover; NS, number of seedlings; AD, age distribution; and SC, soil condition.
Source: (Baars et al., 1997)

3.4. Determination of chemical composition of herbaceous biomass

The oven dried samples were ground in a Willey mill to pass through 1 mm sieve for the determination of chemical composition. Samples of herbaceous biomass were analyzed for DM and ash using the method of AOAC (2000). Nitrogen was determined using the micro-Kjeldahl method (AOAC, 2000). Crude protein (CP) was calculated as $N \times 6.25$. The neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed according to Van Soest and Robertson (1985).

3.5. Data Analysis

Grass composition, basal cover, litter cover, age distribution of dominant grasses, numbers of seedlings and soil condition, as well as herbaceous biomass were considered as numerical response variables. Descriptive statistics were used to describe the herbaceous species composition. The data generated from this study was stratified into study sites and grazing pressure (enclosure versus open grazed) and analyzed using the General Linear Model (GLM) in statistical Package for social science (SPSS version 16.0) procedure. Post-hoc t-test was employed to compare mean differences for enclosure and open grazed areas. To test the effect of management and altitude on rangeland condition, biomass production, chemical composition of herbaceous sample, by using mixed model analysis as site is random variable while management and altitude were fixed. To identify the effect of management within the different attitudes on rangeland condition, herbaceous biomass and chemical composition of herbaceous samples were carried out using analysis of variance with the following model.

$$Y_{ijk} = \mu + A_i + L_j + A(L)_{ik} + \tau L_{ij} + e_{ijk}$$

Where

Y_{ijk} = measurement of response variable

μ = over all mean

A_i = effect of area enclosure ($i=2$ enclosure or open grazing)

L_j = is the random location effect

$A(L)_{ik}$ = is altitude within location

τ_{Lij} = is treatment by location effect

e_{ijk} = the random error

4. RESULTS

4.1. Effect of Grazing Pressure on Herbaceous Biomass and Species Composition

Herbaceous species composition in the study sites each categorized by three altitude ranges is presented in Table 3. A total of 28 herbaceous species were recorded both in the enclosure and open grazed areas across the three altitude ranges. Out of the total herbaceous species, 20 (71.4%) grass species, 6 (21.4%) forbs and 2 (7.1%) herbaceous legumes were recorded (Table3). Of the grass species, 28.5% were highly desirable, 35.7% desirable, 17.8% less desirable and 7.1 % undesirable (Table3). At the time of sampling, the following grass species were identified by their local and scientific names with the help of an experienced person. These includes *Aristida adoensis*, *Aristida adscensionis*, *Cenchrus ciliaris*, *Chloris gayana*, *Chloris pycnothrix*, *Cynodon dactylon*, *Bothriochola insculpta*, *Sida ovate*, *Panicum maximum*, *Heteropogon contortus*, *Eragrostis papposa*, *Sporobolus pyramidalis*, *Themeda triandra*, *Tetrapogon teneullus*, *Dactyloctenium aegypticum*, *Indigofera spinosa*, *Tephrosia pumila*, *Bides pilosa*, *Amaranthus dubis*, *Chrysopogon plumulosus*, *Tribulus terrestris*, *Achyranthes aspera*, *Cenchrus setigures* and *Ocimum basilicum*. The results showed that the proportion of herbaceous legumes and forbs in the sampled sites was very low. Herbaceous species composition across the studied rangeland sites was similar regardless of management (enclosure vs open-grazed areas) and altitude ranges.

4.1.1. Herbaceous Species Composition in the Bottomland Altitude (1550m-1558m)

A total of 16, 2 and 4 species of grasses, legumes, and other herbaceous plants were identified in the bottomland altitude range, respectively (Table3). Of the total herbaceous species identified in the bottomland altitude, 51.6% were grasses of different species, 6.4% legumes

species and 12.9% forbs species. Of the grass species, 43.7% were highly desirable, 50% desirable and 31.2% less desirable species.

4.1.2. Herbaceous Species Composition in the Medium Altitude (1560 m-1575 m)

A total of 14, 2, and 6 species of grasses, legumes and forbs were identified in the medium altitude of the study sites, respectively (Table3). Of the total herbaceous species identified in the medium altitude, 45.1% were grasses of different species, which included highly desirable, desirable and less desirable species. The grasses *Bothriochola insculpta*, *Brachiaria humidicola*, *Bothriochola nigropedata*, *Indigofer spinosa*, *Tephrosia pumila*, *Eragrostis papposa* and *Sporobolus pyramidalis* were common and/or dominant in the open-grazed areas, where as species like *Heteropogon contortus* and *Chloris pycnothrix* were common and/or dominant species in the enclosure areas (Table3). There was a relatively high amount of highly desirable (decreasers) grass species in the enclosure followed by open-grazing areas.

4.1.3. Herbaceous Species Composition in the Top Altitude (1578m-1595m)

A total of 15 species of grasses, 1 legume and 6 species of other herbaceous plants were identified (Table3). The grass species in the top land altitude consisted of 48.38% of the total herbaceous species composition and of these categories 53.3% were highly desirable, 60% desirable and 33.3% less desirable species. The most common and dominant plant species both in the enclosure and open-grazed areas of the top land altitude included: *Cynodon dactylon*, *Entropogon*, *Panicum maximum*, *Heteropogon contortus*, *Chrysopogon plumulosus*, *Tetrapogon teneullus*, *Sida ovate*, *Cenchrus ciliaris*, *Chloris roxburghiana*, *Indigofer spinosa*, *Amaranthus dubis*, *bides pilosa*, *Themeda triandra*, *Ocimum basilicum*, *Achyranthes aspera* and *Tribulos terrestris* (Table3).

Table 3: Distribution of common grass, legumes and forbs species in the enclosures vs open grazed areas by three altitude ranges in the study areas.

Enclosure grazed areas versus open grazed areas								
Altitude categories								
Site	Grass Species	Category	Bottomland (1550m-1558m)		Medium (1560m-1575m)		Top-land (1578m-1595m)	
			Enclosure	Open-grazed	Enclosure	Open-grazed	Enclosure	Open-grazed
Abernosa	<i>Aristida adoensis</i>	LD	P	-	-	P	-	-
	<i>Aristida adscensionis</i>	LD	P	C	P	-	P	P
	<i>Cenchrus ciliaris</i>	HD	C	-	P	-	P	
	<i>Cenchrus setigures</i>	D	-	P	D	-	P	-
	<i>Chloris gayana</i>	HD	D	D	C	C	P	P
	<i>Chloris pycnothrix</i>	D	C	-	-	P	-	-
	<i>Chloris roxburghiana</i>	D	C	-	P		-	C
	<i>Cynodon dactylon</i>	D	-	P	-	P	C	-
	<i>Dact.aegypticum</i>	HD	P	P	-	P	-	P
	<i>Bothriochola insculpta</i>	D	P	D	-	C	P	-
	<i>Entropogon</i>	LD	-	P	P	-	C	-
	<i>Eragrostis papposa</i>	D	P	-	-	D	P	-
	<i>Heteropogon contortus</i>	D	P	-	D	C	-	-
<i>Microchloa kunthii</i>	LD	-	-	C	-	P	P	

<i>Bothriochola nigropedata</i>	HD	P	-	D	-	-	P
<i>Panicum maximum</i>	HD	-	P	P	P	C	P
<i>Chrysopogon plumulosus</i>	HD	P	-	p	P	C	D
<i>Brachiaria humidicola</i>	HD	-	P	C	D	P	-
<i>Themeda triandra</i>	LD	P	P	-	-	D	-
<i>Sporobolus pyramidalis</i>	LD	P	-	C	-	P	P
<i>Tetrapogon teneullus</i>	HD	P	-	-	P	-	-
Legumes							
<i>Indigofera spinosa</i>	D	C	C	D	-	C	C
<i>Tephrosia pumila</i>	HD	-	C	C	D	-	P
Forbs/Other/							
<i>Sida ovate</i>	D	C	C	D	D	D	C
<i>Bides pilosa</i>	UD	P	P	C	C	C	P
<i>Amaranthus dubis</i>	UD	C	C	C	C	C	C
<i>Tribulus terrestris</i>	D	C	C	D	D	D	P
<i>Achyranthes aspera</i>	D	D	D	C	C	C	C
<i>Ocimum basilicum</i>	HD	P	P	C	C	C	P

HD=highly desirable, D=Desirable, LD=Less desirable, UD=Undesirable; P=present, C=Common, D=Dominant

Table 3: Continue...

Enclosure grazed areas versus Open grazed areas								
Site	Altitude categories		Bottomland(1550m-1558m)		Medium (1560m-1575m)		Top-land(1578m-1595m)	
	Grass Species	Category	Enclosure	Open-grazed	Enclosure	Open-grazed	Enclosure	Open-grazed
Hadha-Bossa	<i>Aristida adoensis</i>	LD	P	-	-	P	-	-
	<i>Aristida adscensionis</i>	LD	-	C	P	-	P	P
	<i>Cenchrus ciliaris</i>	HD	C	-	P		P	C
	<i>Cenchrus setigerus</i>	D	-	P	D	-	P	-
	<i>Chloris gayana</i>	HD	D	D	C		P	P
	<i>Chloris pycnothrix</i>	D	C	P	-	P	-	P
	<i>Chloris roxburghiana</i>	D	C	-	P		-	C
	<i>Cynodon dactylon</i>	D	-	P	-	P	C	-
	<i>Dact.aegypticum</i>	HD	P	P	-	P	-	P
	<i>Bothriochola insculpta,</i>	D	P	D	-	C	P	-
	<i>Entropogon</i>	LD	-	P	P	-	C	-
	<i>Eragrostis papposa</i>	D	P	-	P	D	P	-
	<i>Heteropogon contortus</i>	D	P	P	D	C	-	-
<i>Microchloa kunthii</i>	LD	P	-	C	-	P	P	

<i>Bothriochola nigropedata</i>	HD	P	P	D	P	-	P
<i>Panicum maximum</i>	HD	-	P	P	-	C	-
<i>Themeda triandra</i>	LD	P	-	P	P	D	P
<i>Sporobolus pyramidalis</i>	LD	P	-	C	P	P	-
<i>Tetrapogon teneullus</i>	HD	P	P	-	P	-	-
Legumes							
<i>Indigofera spinosa</i>	D	C	C	D	-	C	C
<i>Tephrosia pumila</i>	HD	-	C	C	D	-	P
Forbs/Other/							
<i>Sida ovate</i>	D	C	C	D	D	C	C
<i>Bides pilosa</i>	UD	P	P	C	C	P	P
<i>Amaranthus dubis</i>	UD	C	C	C	C	C	C
<i>Tribulos terrestris</i>	D	C	C	D	D	P	P
<i>Achyranthes Aspera</i>	D	D	D	C	C	C	C
<i>Ocimum basilicum</i>	HD	P	P	C	C	P	P

HD = highly desirable, D = Desirable, LD = Less desirable, UD = Undesirable; P = present C = Common, D = Dominant

Table 3: Continue...

Enclosure grazed areas versus open grazed areas

Altitude categories

Site	Grass Species	Category	Bottomland (1550m-1558m)		Medium (1560m-1575m)		Top-land (1578m-1595m)	
			Enclosure	Open-grazed	Enclosure	Open-grazed	Enclosure	Open-grazed
Gubeta-Arjo	<i>Aristida adoensis</i>	LD	P	-	-	P	-	-
	<i>Aristida adscensionis</i>	LD	-	C	P	-	P	P
	<i>Cenchrus ciliaris</i>	HD	C	-	P	-	P	C
	<i>Cenchrus setigerus</i>	D	-	P	D	-	P	-
	<i>Chloris gayana</i>	HD	D	D	C	-	P	P
	<i>Chloris pycnothrix</i>	D	C	-	-	P	-	-
	<i>Chloris roxburghiana</i>	D	C	-	P	P	-	C
	<i>Cynodon dactylon</i>	D	-	P	-	P	C	-
	<i>Dact.aegypticum</i>	HD	P	P	-	P	-	P
	<i>Bothriochola insculpta</i>	D	P	D	-	C	P	-
	<i>Eragrostis papposa</i>	D	P	-	-	D	P	-
	<i>Heteropogon contortus</i>	D	P	25	-	D	C	-
<i>Microchloa kunthii</i>	LD	-	-	C	-	P	P	

<i>Bothriochola nigropedata</i>	HD	P	P	D	P	-	P
<i>Panicum maximum</i>	HD	-	P	P	-	C	-
<i>Themeda triandra</i>	LD	P	-	-	P	D	P
<i>Sporobolus pyramidalis</i>	LD	P	-	C	P	P	-
<i>Tetrapogon tenellus</i>	HD	P	P	-	P	-	-
Legumes							
<i>Indigofera spinosa</i>	D	C	C	D	-	C	C
<i>Tephrosia pumila</i>	HD	-	C	C	D	-	P
Forbs/Other/							
<i>Sida ovate</i>	D	C	P	D	-	C	D
<i>Bides pilosa</i>	UD	P	D	C	P	P	P
<i>Amaranthus dubis</i>	UD	C	P	C	-	C	-
<i>Tribulus terrestris</i>	D	C	C	D	C	P	P
<i>Achyranthes aspera</i>	D	D	D	C	P	C	-
<i>Ocimum basilicum</i>	HD	P	-	C	-	P	D

HD = highly desirable, D = Desirable, LD = Less desirable, UD = Undesirable; P = present C = Common; D = Dominant

4.2. The Effect of Enclosure on Rangeland Condition

The effect of enclosure on rangeland condition parameters is presented in Table 4. Grass species composition did not show any significant ($P>0.05$) difference between enclosures and open-grazed areas in Abernosa site while it was significantly ($P<0.05$) different at Hadha-Bossa and Gubeta-Arjo sites. The score values for basal cover, litter cover and age distribution of dominant grasses were significantly ($P<0.05$) higher in enclosures than in the open-grazed areas across the three study sites. The number of seedlings for herbaceous plants did not show significant ($P>0.05$) difference between enclosure and open-grazed areas across the three study sites. Age distribution of dominant grasses did not show any significant ($P>0.05$) difference between enclosure and open-grazed areas at Hadha-Bossa site while Gubeta-Arjo and Abernosa sites were significantly ($P<0.05$) varied.

Soil erosion and soil compaction were significantly ($P<0.05$) higher in the open-grazed areas than in the enclosure areas across the three study sites. The overall range condition score was in the range of 18.09 (in poor condition) to 34.13 (in good condition) and the difference was significantly ($P<0.05$) varied.

Table 4: Range condition score (LSM+SE) of enclosures versus open grazed areas found in three different Sites

Parameters	Abernosa		Hadha-Bossa		Gubeta-Arjo	
	Enclosed	Open-grazed	Enclosed	Open-grazed	Enclosed	Open-grazed
Grass composition	6.90±0.33 ^a	6.16±0.33 ^a	6.65±0.33 ^a	5.71±0.33 ^b	7.74±0.33 ^a	5.58±0.33 ^b
Basal cover	7.12±0.21 ^a	2.25±0.21 ^b	7.16±0.21 ^a	2.53±0.21 ^b	7.75±0.21 ^a	1.95±0.21 ^b
Litter cover	6.83±0.30 ^a	4.16±0.30 ^b	6.75±0.52 ^a	3.28±0.35 ^b	7.28±0.28 ^a	3.57±0.20 ^b
Number of seedling	0.00+0.00 ^a	0.00+0.00 ^a	0.00+0.00 ^a	0.00+0.00 ^a	0.00+0.00 ^a	0.00+0.00 ^a
Age distribution	4.45±0.17 ^a	2.94±0.17 ^b	3.34±0.17 ^a	3.35±0.17 ^a	4.20±0.17 ^a	2.49±0.17 ^b
Soil erosion	3.29±0.13 ^a	1.89±0.13 ^b	3.66±0.13 ^a	1.85±0.13 ^b	3.55±0.13 ^a	2.40±0.13 ^b
Soil compaction	3.08±0.13 ^a	1.75±0.13 ^b	3.54±0.13 ^a	1.70±0.13 ^b	3.61±0.13 ^a	2.10±0.13 ^b
Total range score	31.67±1.27^a	19.15±1.27^b	31.1±1.27^a	21.95±1.27^b	34.13±1.27^a	18.09±1.27^b

Means with different letter in a row are significantly different ($P < 0.05$), The Range Score was interpreted as excellent (41-50 points), good (31-40 points), fair (21-30 points), poor (11-20 points), or very poor (3-10 points).

4.3. The Effect of Altitude at Different Levels of Grazing on Rangeland Condition

4.3.1. Effect of Grazing Pressure on Rangeland Condition in the Bottomland Altitude

(1550 m-1558 m)

The effect of grazing pressure on rangeland condition parameters in the bottomland altitude is shown in Table 5. The number of seedlings in Abernosa, Hadha-Bossa and Gubeta-Arjo sites in the bottomland altitude did not show any significant ($P>0.05$) difference between enclosure and open-grazed areas (Table 5). The range condition scores for grass composition, basal cover, litter cover and age distribution of dominant grass species were significantly ($P<0.05$) different between enclosure areas and open-grazed sites in the bottom lands.

Grass composition in the categories of bottomland altitude did not show any significant ($P>0.05$) difference between enclosures and open-grazed areas at Hadha-Bossa site while Abernosa and Gubeta-Arjo sites were significantly ($P<0.05$) differed. Soil erosion and soil compaction in bottomland altitude was significantly ($P<0.05$) higher in the open-grazed areas than in enclosures. The total score for the range condition status in the bottomland altitude ranged from 17.5 (in poor condition) to 33.6 (in good condition) and the difference was significant ($P<0.05$).

4.3.2. Effect of Grazing Pressure on Rangeland Condition in the Medium Altitude

(1560 m-1575 m)

The effect of grazing pressure on range condition score in the medium altitude is presented in Table 5. The score for grass composition did not show any significant ($P>0.05$) difference between enclosures and open-grazed areas in the medium altitude of the study sites at Hadha-Bossa while this was significant ($P<0.05$) at Abernosa and Gubeta-Arjo sites.

The range condition scores for basal cover, litter cover and age distribution of dominant grass species were significantly ($P < 0.05$) differed between enclosures and open-grazed areas of the medium altitude. In the medium altitude, the extent of range condition score values were in the range of 17.4 (in poor condition) to 33.1 (in good condition) and the difference was significant ($P < 0.05$). The score values for soil erosion and soil compaction were significantly ($P < 0.05$) higher in enclosure areas than in the open-grazed areas of the medium altitude.

4.3.3. Effect of Grazing pressure on Rangeland Condition in the Top land Altitude

(1578m-1595m)

The effect of grazing pressure on range condition in the top land altitude for the different range condition rating factors is presented in Table 5. The score for grass composition showed a significant ($P < 0.05$) difference between enclosures and open-grazed areas in the top land altitude across the three studied sites (Table 5). Soil erosion did not show any significant ($P > 0.05$) difference between enclosure areas and open-grazed areas at the Abernosa site while significantly ($P < 0.05$) difference at Gubeta-Arjo and Hadha-Bossa sites.

The score for basal cover, litter cover and age distribution of dominant grass species was significantly ($P < 0.05$) higher in the enclosure areas than in the open-grazed areas in the top land altitude. The litter cover, basal cover and age distribution of grasses was significantly ($P < 0.05$) higher in the enclosure areas than open-grazed areas. The magnitudes of range condition mark standards in the range of 18.1 (in poor condition) to 36.6 (in good condition) and the difference was significant ($P < 0.05$). The score for soil erosion and soil compaction was significantly ($P < 0.05$) higher in the open-grazed areas than in the enclosures in the top altitude site.

Table 5: Range condition score (LSM+SE) of enclosed versus open grazed areas in three different altitude Sites

Site	Parameters	Altitude					
		Top (1578 m-1595 m)		Medium (1560 m-1575 m)		Bottom(1550 m-1558 m)	
		Enclosed	Open-grazed	Enclosed	Open-grazed	Enclosed	Open-grazed
Abernosa	Grass composition	7.86±0.56 ^a	5.29±0.56 ^b	6.86±0.56 ^a	5.86±0.56 ^b	7.00±0.56 ^a	6.33±0.56 ^b
	Basal cover	6.57±0.35 ^a	2.14±0.35 ^b	7.14±0.35 ^a	2.29±0.35 ^b	7.67±0.35 ^a	2.33±0.38 ^b
	Litter cover	6.83±0.30 ^a	4.16±0.30 ^b	7.00±0.30 ^a	3.57±0.36 ^b	7.14±0.34 ^a	4.00±0.18 ^b
	Number of seedling	0.00+0.00 ^a	0.00+0.00 ^a	0.00+0.00 ^a	0.00+0.00 ^a	0.00±0.00 ^a	0.00±0.00 ^a
	Age distribution	4.43±0.29 ^a	2.85±0.29 ^b	4.23±0.29 ^a	3.14±0.29 ^b	4.50±0.29 ^a	2.83±0.29 ^b
	Soil erosion	3.67±0.23 ^a	2.00±0.23 ^a	3.29±0.23 ^a	2.00±0.23 ^b	3.00±0.24 ^a	1.67±0.23 ^b
	Soil compaction	3.14±0.23 ^a	1.74±0.23 ^b	3.29±0.23 ^a	1.86±0.23 ^b	2.86±0.24 ^a	1.67±0.24 ^b
	Total range score	31.4±1.96	18.18±1.96	32.01±1.96	19.72±2.02	32.17±2.02	18.83±1.65
Hadha-Bossa	Grass composition	6.57±0.56 ^a	5.00±0.61 ^b	6.71±0.56 ^a	6.14±0.56 ^a	6.67±0.56 ^a	6.00±0.56 ^a
	Basal cover	6.71±0.35 ^a	2.86±0.35 ^b	7.29±0.35 ^a	2.43±0.35 ^b	7.50±0.38 ^a	2.33±0.38 ^b
	Litter cover	6.75±0.52 ^a	3.28±0.35 ^b	6.83±0.30 ^a	2.33±0.21 ^b	7.33±0.49 ^a	3.00±0.30 ^b
	Number of seedling	0.00±0.00 ^a	0.00±0.00 ^a	0.00±0.00 ^a	0.00±0.00 ^a	0.00±0.00 ^a	0.00±0.00 ^a
	Age distribution	4.43±0.29 ^a	3.57±0.29 ^b	4.57±0.29 ^a	3.15±0.29 ^b	4.17±0.31 ^a	3.33±0.31 ^b

	Soil erosion	3.42±0.23 ^a	1.86±0.23 ^b	3.57±0.23 ^a	1.86±0.23 ^b	4.00±0.23 ^a	1.83±0.24 ^b
	Soil compaction	3.97±0.23 ^{a+}	1.57±0.23 ^b	3.37±0.23 ^a	1.86±0.23 ^b	3.50±0.24 ^a	1.67±0.24 ^b
	Total range score	31.45±2.4	18.14±2.06	32.54±1.96	17.77±2.27	33.2±2.77	18.2±1.29
Gubeta-Arjo	Grass composition	8.86±0.61 ^a	5.57±0.61 ^b	7.86±0.56 ^a	6.00±0.56 ^b	7.50±0.56 ^a	5.17±0.56 ^b
	Basal cover	8.29±0.35 ^a	2.00±0.35 ^b	7.14±0.35 ^a	1.86±0.35 ^b	7.83±0.38 ^a	2.00±0.38 ^b
	Litter cover	7.28±0.28 ^a	3.57±0.20 ^b	7.00±0.36 ^a	2.83±0.30 ^b	6.85±0.40 ^a	3.00±0.21 ^b
	Number of seedling	0.00±0.00 ^a	0.00±0.00 ^a	0.00±0.00 ^a	0.00±0.00 ^a	0.00±0.00 ^a	0.00±0.00 ^a
	Age distribution	4.74±0.29 ^a	3.29±0.29 ^b	4.29±0.29 ^a	2.71±0.29 ^b	4.17±0.31 ^a	2.83±0.31 ^b
	Soil erosion	3.97±0.23 ^a	2.71±0.23 ^b	3.27±0.23 ^a	2.00±0.23 ^b	3.50±0.24 ^a	2.50±0.24 ^b
	Soil compaction	3.71±0.23 ^a	2.29±0.23 ^b	3.29±0.23 ^a	2.00±0.24 ^b	3.83±0.24 ^a	2.00±0.23 ^b
	Total range score	34.66±1.99	19.43±1.19	33.15±2.02	17.4±1.97	33.68±2.13	17.5±1.93

Means within different letter in a row across altitude are significantly different (P<0.05)

4.3. The Effect of Enclosure on Biomass Production

The harvested samples from each quadrant (1 m²) were separated into sub-samples of grasses, legumes and forbs in the field to determine the biomass production of different herbaceous plants (Table 6). The score values of grass biomass production was significantly ($P<0.05$) higher in enclosures than in the open-grazed areas across all study sites. The biomass production of legumes did not show any significant ($P>0.05$) difference between enclosures and open-grazed areas at Abernosa site, while significantly ($P<0.05$) different in Gubeta-Arjo and Hadha-Bossa sites.

Likewise, the biomass production of legumes and forbs in the study sites was significantly ($P<0.05$) higher in enclosures than in the open-grazed areas across the three sites. The overall total grass biomass production, forbs and legumes across the study sites were increased considerably from 32.4 kg/ha to 42.5 kg/ha with the declining status of range condition. Generally, enclosures had significantly ($P<0.05$) higher biomass production than that of open-grazed areas across the three study sites.

Table 6: Biomass production (kg/ha) of herbaceous species in enclosures versus open-grazed areas in three sites

Parameters	Abernosa		Hadha-Bossa		Gubeta-Arjo	
	Enclosed	Open-grazed	Enclosed	Open-grazed	Enclosed	Open-grazed
Grass	146.90±29.0 ^a	93.16±29.96 ^b	218.26±29.96 ^a	131.10±29.96 ^b	186.70±29.96 ^a	107.20±29.96 ^b
Forbs	62.70±9.07 ^a	32.05±9.07 ^b	76.12±9.07 ^a	34.88±9.07 ^b	64.14±9.07 ^a	32.99±9.07 ^b
Legumes	18.06±3.52 ^a	13.98±3.52 ^b	26.02±3.52 ^a	15.82±3.52 ^b	24.92±3.52 ^a	12.05±3.52 ^b
Total biomass	227.66±32.43	139.19±42.55	320.4±42.55	181.8±42.55	275.76±42.55	152.24±42.55

Means with different letter in a row across sites are significantly different (P<0.05)

4.4. Biomass Production at Different Altitude Zones

4.4.1. Biomass production in Bottom land Altitude (1550 m-1558 m)

Grass biomass production in the bottomland altitude did not show any significant ($P>0.05$) difference between enclosures and open-grazed areas at Abernosa and Hadha-Bossa (Table7). However, grass biomass production in the Bottom land altitude was significantly varied between enclosures and open-grazed areas at Gubeta-Arjo site. Biomass production of forbs in the bottomland altitude showed significant ($P<0.05$) differences between enclosure areas and open-grazed areas at Abernosa and Gubata-Arjo while Hadha-Bossa site did not show any significant ($P>0.05$) differences.

The biomass production of grasses and forbs in the bottom land altitude did not show any significant ($P>0.05$) difference between enclosure areas and open-grazed areas at Hadha-Bossa and Abernosa sites. The Biomass production of legumes in the bottom land altitude showed a significant ($P<0.05$) difference between enclosures and open-grazed areas in all study sites. The total average biomass production of grasses, forbs and legumes was significantly ($P<0.05$) higher in enclosures than in the open-grazed areas. The overall biomass production score values are considerably varied from 115.4 kg/ha to 32.2 kg/ha as the range condition deteriorate from good within enclosures to poor condition along the open-grazed areas for different altitude sites.

4.4.2. Biomass Production in the Medium Altitude (1560 m-1575 m)

The effect of medium altitude on biomass production of grasses showed significant ($p<0.05$) difference between enclosures and open-grazed areas in all the three study sites. The biomass production of forbs and legumes in the medium altitude across the three study sites was

significantly ($P < 0.05$) different between enclosure areas and open-grazed areas. Grass, forbs and legumes biomass production in the medium altitude was significantly ($P < 0.05$) higher in enclosure areas than in the open-grazed areas along the three altitude categories across the study sites.

The total biomass production of grass, forbs and legumes in the medium altitude was significantly ($P < 0.05$) higher in enclosures than in the open-grazed areas across the three study sites. Biomass production varied from 249.8 kg/ha to 54.6 kg/ha as the range condition declines from good within enclosures to poor condition in the open-grazed areas across the three altitude ranges.

4.4.3. Biomass Production in the Top Altitude (1578 m-1595 m)

The Biomass production of grass and forbs in the top altitude showed a significant ($P < 0.05$) difference between enclosure areas and open-grazed areas in Abernosa and Gubata-Arjo sites while biomass production of grass and forbs in the top altitude in Hadha-Bossa site did not show any significant ($P > 0.05$) difference.

The biomass production of legumes in the top land altitude was significantly ($P < 0.05$) higher in enclosures than in the open-grazed areas at Badha-Bosa and Gurbeta-Arjo sites. The biomass production of grass and forbs scores was significantly ($P < 0.05$) higher in enclosures than in the open-grazed areas along the three sites. The total biomass production score values in the top land altitude was considerably varied from 449.2 kg/ha to 102.2 kg/ha as the range condition deteriorates from good condition to poor condition along study sites.

Table 7: Biomass production (kg/ha) of herbaceous species in enclosures versus open-grazed areas in three site

Site	Parameters	Altitude					
		Top (1578m-1595m)		Medium (1560m-1575m)		Bottom(1550m-1560m)	
		Enclosed	Open-grazed	Enclosed	Open-grazed	Enclosed	Open-grazed
Abernos	Grass	159.90±29.0 ^a	98.16±29.96 ^b	150.80±29.0 ^a	93.16±29.96 ^b	46.88±29.0 ^a	36.88±29.0 ^a
	Forbs	62.70±9.07 ^a	32.05±9.07 ^b	51.75±14.68 ^a	34.57±5.95 ^b	72.92±8.12 ^a	20.85±4.57 ^b
	Legumes	18.06±3.52 ^a	13.98±3.52 ^a	45.27±1.17 ^a	18.88±2.99 ^b	23.57±1.93 ^a	11.58±2.82 ^b
	Total biomass	240.66±32.43	144.19±42.55	247.82±3.19	146.61±1.56	143.37±2.46	69.31±1.02
Hadha-Bossa	Grass	291.56±14.30 ^a	144.97±11.18 ^a	180.70±6.46 ^a	81.50±15.65 ^b	75.24±15.53 ^a	40.01±13.71 ^a
	Forbs	114.42±7.47 ^a	37.82±6.31 ^a	46.02±5.78 ^a	23.74±2.20 ^b	26.71±5.58 ^a	12.82±0.98 ^a
	Legumes	38.53±5.69 ^a	13.51±1.51 ^b	22.60±4.29 ^a	9.04±1.34 ^b	13.52±1.76 ^a	6.71±1.2 ^b
	Total biomass	444.51±27.46	196.3±19	249.32±16.53	114.28±19.19	115.47±22.87	59.54±15.96
Gubeta-Arjo	Grass	309.60±80.87 ^a	63.80±7.32 ^b	181.90±42.30 ^a	32.50±3.34 ^b	93.17±33.34 ^a	18.77±1.93 ^b
	Forbs	102.41±7.68 ^a	25.87±4.91 ^b	49.98±2.62 ^a	16.00±3.73 ^b	28.01±2.97 ^a	9.58±1.92 ^b
	Legumes	37.27±6.87 ^a	12.57±0.94 ^b	17.93±2.55 ^a	6.17±0.62 ^b	12.54±2.02 ^a	3.94±0.81 ^b
	Total biomass	449.28±95.42	102.24±13.17	249.81±44.47	54.67±7.69	133.72±38.33	32.29±4.66

Means with in different letter in a row across altitude are significantly different (P<0.05)

4.5. Chemical Composition of herbaceous Species Biomass

Table 8 presents the chemical composition of herbaceous biomass in the study areas. The dry matter of herbaceous biomass did not show any significant ($P>0.05$) difference between enclosure and open-grazed areas at Gubeta-Arjo site, while Hadha-Bossa and Abernosa sites were showed significant ($P<0.05$) difference.

The ash contents of herbaceous biomass was significantly ($P<0.05$) higher in enclosures than in the open-grazed areas across the study sites. The CP content of herbaceous biomass was significantly ($P<0.05$) higher in open grazed areas than in the enclosure sites. The structural constituents (i.e., NDF, ADF and ADL) of herbaceous biomass were significantly ($P<0.05$) higher in enclosures than in the open-grazed areas.

Table 8: Chemical composition (Mean \pm SE) of herbaceous biomass at different Site and management of range land in the study sites.

Parameter	Abernosa		Hadha-Bossa		Gubeta-Arjo	
	Enclosure	Open-grazed	Enclosure	Open-grazed	Enclosure	Open-grazed
DM (%)	91.35 \pm 0.74 ^a	88.91 \pm 0.74 ^b	93.28 \pm 0.74 ^a	92.45 \pm 0.74 ^b	93.65 \pm 0.74 ^a	92.92 \pm 0.74 ^a
Ash	11.1 \pm 0.77 ^a	7.88 \pm 0.77 ^b	7.51 \pm 0.77 ^b	6.95 \pm 0.77 ^a	7.31 \pm 0.77 ^b	5.18 \pm 0.77 ^a
NDF	59.8 \pm 0.76 ^a	57.58 \pm 0.76 ^b	63.01 \pm 0.76 ^a	61.21 \pm 0.76 ^b	67.77 \pm 0.76 ^a	52.97 \pm 0.76 ^b
ADF	32.5 \pm 14.72 ^a	30.7 \pm 14.72 ^b	39.97 \pm 14.72 ^a	33.5 \pm 14.72 ^b	41.31 \pm 14.72 ^a	29.15 \pm 14.72 ^b
ADL	8.63 \pm 0.49 ^a	7.37 \pm 0.49 ^b	9.00 \pm 0.49 ^a	8.38 \pm 0.49 ^b	8.20 \pm 0.49 ^a	7.80 \pm 0.49 ^b
CP	10.25 \pm 0.41 ^b	11.59 \pm 0.41 ^a	9.71 \pm 0.41 ^b	10.76 \pm 0.41 ^a	7.31 \pm 0.41 ^b	14.60 \pm 0.41 ^a

Mean in the same row for each parameter with different superscripts are significantly different (P<0.05)

Note: DM, dry matter; Ash, CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; ADL, acid detergent lignin

4.8. Chemical Composition of Herbaceous Biomass at Different Altitude Zones

4.8.1. Chemical Composition of Herbaceous Biomass in the Bottomland Altitude

(1550 m-1558 m)

The chemical composition of herbaceous biomass in the bottomland altitude was presented in Table 9. The dry matter and ash contents of herbaceous biomass in the bottom land altitude were significantly ($P<0.05$) different between enclosures and open-grazed areas. The dry matter of herbaceous biomass in the bottom land altitude was significantly ($P<0.05$) higher in enclosures than in the open-grazed areas at Hadha-Bossa and Gubeta-Arjo sites. The ash contents of herbaceous biomass in the bottom land altitude were significantly ($P<0.05$) higher in enclosures than in the open-grazed areas at Abernosa and Hadha- Bossa sites.

The CP contents of herbaceous biomass in the bottom land altitude was significantly ($P<0.05$) lower in enclosure areas than in the open grazed areas in all of the studied sites. The CP content of herbaceous plant in the bottom land altitude was significantly ($P<0.05$) higher in open-grazed areas than enclosure areas at Gubeta-Arjo site while the CP content of herbaceous biomass at Hadha-Bossa and Abernosa sites in bottom land altitude was significantly ($P<0.05$) lower in enclosure than in the open-grazed areas. The structural constituents (i.e., NDF, ADF, and AD) of herbaceous biomass in bottomland altitude was significantly ($P<0.05$) higher in enclosures than in the open-grazed areas.

4.8.2. The Chemical Composition of Herbaceous Biomass in the Medium Altitude

(1560 m-1575 m)

Table 9 presents the chemical composition of herbaceous biomass. The dry matter yield of herbaceous plants was significantly ($P<0.05$) difference between enclosure areas and open-grazed

areas. The dry matter and ash contents of herbaceous plants in medium altitude across the study sites were significantly ($P < 0.05$) higher in enclosure areas than in the open-grazed areas.

The CP content of herbaceous biomass was significantly ($P < 0.05$) lower in enclosures than in the open-grazed areas in all the study sites. The CP content of herbaceous biomass in the medium altitude was significantly ($P < 0.05$) higher in the open-grazed areas than in enclosures at Gubeta-Arjo site. The NDF, ADF and ADL content of herbaceous biomass was significantly ($P < 0.05$) higher in enclosure areas than in the open-grazed areas across the study sites. The fundamental constituents of NDF in the medium altitude for herbaceous plants were significantly ($P < 0.05$) higher in enclosure areas than in the open-grazed areas at Gubeta-Arjo and Abernosa.

4.8.3. The Chemical Composition of Herbaceous Biomass in the Top Altitude

(1578 m-1595 m)

The chemical composition of herbaceous biomass in the top altitude was presented in Table 9. The dry matter contents of herbaceous biomass in the top altitude was significantly ($P < 0.05$) higher in enclosures than in the open-grazed areas at Gubeta-Arjo and Hadha-Bossa sites. The ash content of herbaceous biomass in the top altitude was significantly ($P < 0.05$) higher in enclosure areas than in the open-grazed areas at Abernosa.

The CP content of herbaceous biomass in the top altitude was significantly ($P < 0.05$) lower in enclosures than in the open-grazed areas. The CP content of herbaceous biomass in the top altitude was significantly ($P < 0.05$) higher in open-grazed areas than enclosures at Gubeta-Arjo. The NDF, ADF and ADL content of herbaceous biomass in the top altitude were significantly ($P < 0.05$) higher in enclosures than in the open-grazed areas.

Table 9: Chemical composition (Mean \pm SE) of herbaceous biomass at different Site and management of range land in the study sites.

Site	Parameter	Altitude					
		Top (1578 m-1595 m)		Medium (1560 m-1575 m)		Bottom (1550 m-1558 m)	
		Enclosure	Open-grazed	Enclosure	Open-grazed	Enclosure	Open-grazed
Abernosa	DM (%)	92.91 \pm 4.6 ^a	87.87 \pm 4.6 ^b	91.67 \pm 4.6 ^a	89.81 \pm 4.6 ^b	90.01 \pm 4.6 ^a	88.24 \pm 4.6 ^b
	Ash	11.09 \pm 1.35 ^a	7.3 \pm 1.35 ^b	9.05 \pm 1.35 ^a	7.32 \pm 1.35 ^b	8.14 \pm 1.35 ^a	7.04 \pm 1.35 ^b
	NDF	60.32 \pm 1.32 ^a	57.04 \pm 1.32 ^b	59.32 \pm 1.32 ^a	53.32 \pm 1.32 ^b	59.232 \pm 1.3 ^a	56.12 \pm 1.32 ^b
	ADF	32.54 \pm 3.27 ^a	29.95 \pm 3.27 ^b	31.49 \pm 3.27 ^a	30.59 \pm 3.27 ^b	29.49 \pm 3.27 ^a	27.59 \pm 3.27 ^b
	ADL	8.22 \pm 0.41 ^b	7.56 \pm 0.41 ^a	7.98 \pm 0.41 ^a	6.96 \pm 0.41 ^b	7.68 \pm 0.41 ^a	6.26 \pm 0.41 ^b
	CP	10.63 \pm 0.72 ^b	11.20 \pm 0.72 ^a	9.28 \pm 0.72 ^b	10.88 \pm 0.72 ^a	8.28 \pm 0.72 ^b	10.23 \pm 0.72 ^a

Mean in the same row for each parameter with different superscripts are significantly different (P<0.05)

Note: DM, dry matter; Ash, CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; ADL, acid detergent lignin

Table 9: Continue...

		Altitude					
Site	Parameter	Top (1578 m-1595 m)		Medium (1560 m-1575 m)		Bottom (1550 m-1558 m)	
		Enclosure	Open-grazed	Enclosure	Open- grazed	Enclosure	Open-grazed
Hadha-Bossa	DM (%)	94.47 \pm 4.6 ^a	92.01 \pm 4.6 ^b	93.26 \pm 4.6 ^a	92.33 \pm 4.6 ^b	93.12 \pm 4.6 ^a	91.02 \pm 4.6 ^b
	Ash	8.78 \pm 1.35 ^a	6.69 \pm 1.35 ^b	7.70 \pm 1.35 ^a	6.53 \pm 1.35 ^b	7.40 \pm 1.35 ^a	5.31 \pm 1.35 ^b
	NDF	61.55 \pm 1.32 ^a	59.81 \pm 1.32 ^b	60.02 \pm 1.32 ^a	58.08 \pm 1.32 ^b	57.46 \pm 1.32 ^a	55.75 \pm 1.32 ^b
	ADF	40.76 \pm 3.27 ^a	33.85 \pm 3.27 ^b	39.39 \pm 3.27 ^a	32.57 \pm 3.27 ^b	38.29 \pm 3.27 ^a	30.09 \pm 3.27 ^b
	ADL	9.34 \pm 0.41 ^a	8.92 \pm 0.41 ^b	9.01 \pm 0.41 ^a	8.52 \pm 0.41 ^b	8.09 \pm 0.41 ^a	7.21 \pm 0.41.3 ^b
	CP	10.60 \pm 0.72 ^b	12.46 \pm 0.72 ^a	9.93 \pm 0.72 ^b	10.95 \pm 0.72 ^a	9.75 \pm 0.72 ^b	10.76 \pm 0.72 ^a

Mean in the same row for each parameter with different superscripts are significantly different (P<0.05)

Note: DM, dry matter; Ash, CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; ADL, acid detergent lignin

Table 9: Continue...

		Altitude					
Site	Parameter	Top (1578 m-1595 m)		Medium (1560 m-1575 m)		Bottom (1550 m-1558 m)	
		Enclosure	Open-grazed	Enclosure	Open-grazed	Enclosure	Open-grazed
Gubeta-Arjo	DM (%)	94.58±4.5 ^a	92.56±4.6 ^b	93.38±4.6 ^a	91.94±4.6 ^b	93.0±4.6 ^a	90.28±4.6 ^b
	Ash	7.41±1.35 ^a	5.28±1.35 ^b	6.27±1.35 ^a	5.13±1.35 ^b	5.26±1.35 ^a	4.16±1.35 ^b
	NDF	68.25±1.32 ^a	53.16±1.32 ^b	67.19±1.32 ^a	52.07±1.32 ^b	61.88±1.32 ^a	50.70±1.32 ^b
	ADF	41.47±3.27 ^a	30.52±3.27 ^b	40.03±3.27 ^a	29.57±3.27 ^b	39.43±3.27 ^a	28.37±3.27 ^b
	ADL	8.33±0.41 ^a	7.99±0.41 ^b	8.19±0.41 ^a	6.88±0.41 ^b	7.08±0.41 ^a	6.56±0.41 ^b
	CP	7.36±0.72 ^b	15.06±0.72 ^a	7.22±0.72 ^b	14.57±0.72 ^a	6.29±0.72 ^b	11.19±0.72 ^a

Mean in the same row for each parameter with different superscripts are significantly different (P<0.05)

Note: DM, dry matter; Ash, CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; ADL, acid detergent lignin

5. DISCUSSION

5.1. The Effect of Enclosure on Herbaceous Biomass and Species Composition

The outcome of this study indicates that grazing had a significant effect on herbaceous biomass, species composition and rangeland condition, which is also in agreement with the report of Amsalu (2000). The findings of the present study reflect that open-grazed sites had fewer herbaceous biomass and species composition. Similarly, previous studies (Teshome, 2007; Amsalu, 2000) have indicated the impact of increased grazing pressure on herbaceous biomass species composition in the middle rift valley of Ethiopia and south-eastern part of Ethiopia.

More herbaceous biomass and species composition were accumulated in enclosure sites and the status of rangeland was in good condition than in the open-grazed sites. In contrast, some herbaceous plant species were grazing tolerant under increased pressure and become more dominant and common in the open-grazed areas (Teshome, 2007). The present finding shows that the higher herbaceous biomass species that was observed in the enclosure areas is almost certainly correlated to fewer disturbances by livestock and wild life grazing which is also in line with the report by Angassa and Oba (2008). Moreover, the relationship between grazing pressure and herbaceous biomass production and/or species composition suggests more herbaceous biomass under light to moderate reflecting that herbaceous biomass production and species composition could be greatly affected with increased disturbance. The present findings in references to herbaceous biomass production, species composition and rangeland condition are consistent with previous reports (Amsalu, 2000; Teshome, 2007). Herbaceous biomass production and species composition, as well as the frequency of highly palatable species were

highly diminished with increased grazing pressure, which is in agreement with the work of Amsalu, (2000) and Amaha (2006). Similarly, the impact of continuous and increased grazing pressure may greatly affect more palatable plant species (decreasers) allowing less palatable or unpalatable plant species (increasers) to dominant (Oba, 1998).

5.2. Herbaceous Species Composition in the Bottom land Altitude (1550 m-1558 m)

The occurrence of fewer highly desirable grass species both in frequency and density could be a good evidence for the downward trend in rangeland condition in the bottom land altitude and this finding is in agreement with previous reports (Ayana, 1999; Amsalu and Baars, 2002; Gemedo, 2004). In the open-grazed areas of the bottom land altitude in the study sites, species like *Aristida adscensionis*, *Cenchrus ciliaris*, *Indigofer spinos*, *Sida ovate*, *Amaranthus*, *Tribulus terrestris* and *Chloris pycnothrix* were among the dominant and/or common grass species. In the enclosure areas of the bottom land altitude, species like *Chloris roxburghiana*, *Bothriochola insculpta*, *Indigofer spinos*, *Cenchrus ciliaris*, *Entropogon* and *Sporobolus pyramidalis* were some of the dominant and/or common grass species (Table3).

Enclosures had relatively higher percentage of highly desirable grass species than the open-grazed areas. This is probably due to the influence of improved management inside enclosures where livestock impact is minimal to induce damage to desirable grass species. The result is in agreement with the reports of others (Abule, 2003; Gemedo, 2004; Amaha, 2006).

5.3. Herbaceous Species Composition in the Medium Altitude (1560 m-1575 m)

The results of the present study indicate that in the medium altitude it seems that desirable plant species were replaced by less desirable and unpalatable species as the effect of grazing pressure

increases (Crawley, 1986). Moreover, overgrazing by domestic livestock has been considered as a major factor for the decline in desirable and highly palatable species suggesting that grazing influences vegetation structure and composition as a result of which some species increase in abundance while others decrease (Yates et al., 2000; Gemedo, 2004).

5.4. Herbaceous Species Composition in the Top Altitude (1578 m-1595 m)

According to Pratt and Gwynne (1977) prolonged heavy grazing certainly contributes to the disappearance of palatable plant species and the subsequent dominance by other less palatable herbaceous plants or bushes. Furthermore, studies (Fynn and O'Connor, 2000; Yates et al., 2000; Gemedo, 2004) have shown that heavy grazing and low rainfall promote the growth of annual grasses.

In the present study in the open-grazed areas of the top land altitude, plant species such as *Bothriochola nigropedata*, *Indigofer spinos*, *Tephrosia pumila*, *Ocimum basilicum*, *Sida ovata* and *Eragrostis papposa* were among the dominant and/or common grass species recorded. In the enclosure areas of the higher altitude, species like *Cynadon dactylon*, *Panicum maximum*, *Tetrapogon teneullus*, *Indigofer spinos*, *Achyranthes*, *Amaranthus*, *Sida ovate*, *Bides pilosa* and *Themeda triandra* were some of the common and/or dominant grass species (Table 3).

5.5. The Effect of Enclosure on Rangeland Condition

Grass composition does not illustrate any significant ($P>0.05$) difference between enclosures and open-grazed areas at Abernosa site. This may be due to the impact of grazing related disturbance in both sites. This is in agreement with the report of Amsalu (2000). In the current study, the values for range condition score in enclosures were higher than the values recorded in the open-

grazed areas. The lower range condition scores for basal cover, litter cover and age distribution of dominant grasses in the open-grazed areas may be due to the impact of continuous grazing and repeated drought. This is in agreement with the work of Vander Westhuizen et al., (2001) that suggested that in arid and semi-arid rangelands the range condition rating parameters are greatly influenced by the effects of grazing pressure and rainfall variability.

Permanent grazing and frequent drought might lead to a reduction in herbaceous species composition and diversity, which may accelerate decline in rangeland condition (Bezuayehu et al., 2002). According to Angassa (2014), heavy grazing pressure may reduce plant species composition and basal cover. The main factors for the low basal cover in the open-grazed areas could possibly be associated with relatively high grazing pressure accompanied by frequent drought. Furthermore, the lack of organic matter and a high percentage of very fine sandy and silt soils are some of the factors contributing to surface sealing (Bezuayehu et al., 2002).

The low score for soil condition in some sampling plots could be attributed to continuous grazing for a longer period of time and loss of herbaceous species. Amsalu (2000) reported that overstocking aggravates the hoof effect, which increases the soil bulk density resulting in reduced infiltration.

5.6. The Effect of Altitude at Different Levels of Grazing on Rangeland Condition

5.6.1. Effect of Grazing pressure on Rangeland Condition in the Bottomland Altitude

(1550 m-1558 m)

Grass composition did not show any significant effect on rangeland condition between enclosures and open-grazed areas both in the bottom land and medium altitudes at Hadha-Bossa

site. This could be due to the presence of different types of animals with different feeding habits and feed selectivity that might also minimize damage to certain species of forage plants. The results of the present study are in agreement with the work of others (Amsalu and Baars 2002; Gemedo, 2004). The values for the range condition scores within enclosures in the bottom land and medium altitudes at Hadha-Bossa and Gubeta-Arjo sites were higher than the values recorded in the open-grazed areas. This variation in turn influences the distribution, growth and development of range plants in their various localized habitats and varied elevation. This is in accordance with the results of previous studies (Ayana, 1999 and Admasu, 2006).

The results of the current study shows that reduced scores for basal cover, litter cover and age distribution of dominant grasses in the open-grazed areas might be attributed to the impact of continuous grazing. Similarly, the effects of variation in altitude could be the most important environmental variable that contributes to the significance difference in the spatial distribution of herbaceous species in the rangelands. Similarly, Pratt and Gwynne (1977) indicate that areas with lower elevation ranges typically produce much less vegetation than higher elevation as precipitation generally increases with altitude. Gemedo (2004) has also reported a similar finding in the Borana rangelands of southern Ethiopia. Overall, range condition scores were significantly higher in enclosures than in the open grazed areas in the top altitude at Gubeta- Arjo site.

In general, the state of the rangeland within enclosures was in good condition implying that establishing enclosures might be an alternative method for improving the condition of the rangelands. This is in accordance with others work (Ayana, 1999; Amsalu, 2000) who reported that improved range condition inside enclosures as compared to open-grazed areas both in Borana rangelands and in the middle Rift valley of Ethiopia. The number of seedlings had no

significant difference between bottomland, medium and top altitude of the study sites. This may be due to the influence of rainfall variability and changes in temperature.

The soil is more eroded and compacted in the open-grazed areas especially in the bottom land altitude than those located in the medium and top altitude categories. Soil erosion and compaction depend on a number of manmade and natural factors including vegetation cover, soil type, intensity and pattern of rainfall, degree of wind erosion, high percentage value of bare ground and grazing management systems of a particular area. Bezuayehu *et al.* (2002) reported a similar effect regarding the problems associated with soil erosion and loss.

5.6.2. Effect of Grazing Pressure on Rangeland Condition in the Medium Altitude

(1560 m-1575 m)

The present results on grass composition did not confirm any significant effect between grazing pressure (enclosure vs. open-grazed areas) in the medium altitude at Hadha-Bossa site while the results were significant both at Abernosa and Gubeta-Arjo sites. In some cases, lower range condition scores were recorded inside enclosures which could be attributed to many factors like altitude, grazing practices and burning, bush encroachment. This is in agreement with the work of previous scholars (Balaynesh, 2006; Bekele, 2007).

Basal cover was significantly higher in the open-grazed areas found in the top and medium altitudes than those found in the bottom land altitude category. Due to the replacement of most palatable species (e.g. *Cenchrus ciliaris*) by creeping, spreading and grazing resistant species such as *Cynodon dactylon* which cover the soil (Ayana, 1999; Amsalu, 2000).

The results of soil erosion and soil compaction in the open-grazed areas are lower than the values recorded inside enclosures in all the three altitude ranges. Soil is more eroded and compacted in the open-grazed areas of bottom land altitude than in the medium and top altitude categories. The decline in the physical characteristics of the soil surface is the most serious manifestation of a decline in grazing land condition because of its long lasting and progressive impact on plant production attributes (Bezuayehu *et al.*, 2002).

5.5.3. Effect of Grazing pressure on Rangeland Condition in the top Altitude

(1578 m-1595 m)

Grass composition among the study sites across the three altitude ranges indicates a significantly higher in the medium and top altitudes than in the bottom land altitude except at Hadha-Bossa site. The probably explanation could be due to the fact that grazing pressure is lower in the medium and top altitudes than in the bottom land altitude. Studies (Amsalu, 2000), have shown that the impact of heavy grazing causes a shift in grass composition. This is in agreement with the work of Gemedo (2004), suggesting that increased grazing pressure reduces grass species composition in Borana rangelands. Furthermore, basal cover and litter cover were significant higher in enclosures than in the open-grazed areas in the medium and bottom land altitudes both at Abernosa and Hadha-Bossa sites.

The age distribution of dominant grass species was significantly higher in enclosures than in the open-grazed areas in the top and medium altitudes at Hadha-Bossa and Gubeta-Arjo sites. This is in agreement with the work of others (Lishan, 2007; Teshome, 2007). Soil erosion and compaction was significantly higher in the open-grazed areas than enclosures as range condition deteriorates may be due to increased grazing pressure and trampling effects, which may further reduce the productivity of the rangelands and its ability to support a sustainable pastoral

livestock production system. Such results are also in agreement with work of Amaha (2006) in Somali Region of Ethiopia.

5.5.4. Chemical Composition of herbaceous Species

The results of the present finding indicate that the potentiality of sites significantly influenced the nutritive value of herbaceous species among the different land management in study woredas. This is in agreement with the work of Teka *et al.* (2012) who studied the nutritional quality of grass species in Borana rangelands and Mittal *et al.* (2012) in hill area of India. The effect of this study showed that differences in land use management can greatly influence the nutritive value of herbaceous plants in arid and semi-arid environments. The possible explanations for the experiential variation among sites may be due to differences in soil nutrient status and intensity of grazing, where most palatable species may be affected by unnecessary grazing. This is regarding as the higher content of CP in open-grazed areas of rangeland sites. The possible explanation for the highest CP content in the open-grazed areas of rangeland sites may be attributed to the frequent removal of old pastures by grazers and deposition of manure to improve the soil fertility and plant nutrient content indirectly also as reported by Teka *et al.* (2012).

Furthermore, the results indicate that the NDF, ADF and ADL contents within enclosures were higher across the study sites. The possible reasons for the highest content of fibers in the studied herbaceous plant samples could be due to lack of timely harvesting the plants at proper stage of maturity where the structural fibers get more accumulated as the plant matures. This is in agreement with previous researchers (Teka *et al.*, 2012; Shankute *et al.*, 2011). The low accumulation of CP and increased level of fibers are an indication of the poor quality of a forage.

Overall, the nutritive values of herbaceous species were significantly varied and influenced the feeding value of forage by animals.

5.5.5. Chemical Composition of Herbaceous species at Different Altitude Zones

5.5.1. Chemical Composition of Herbaceous species in Bottomland Altitude

(1550 m-1558 m)

The results of the present study showed a significantly higher dry matter content of herbaceous species in the enclosures than in the open-grazed areas in the medium and top altitudes at Hadha-Bossa and Gubeta-Arjo sites. This could be due to differences in physiological, morphological and anatomical differences among herbaceous species and grass yield may increase with increase in growth and development of the plant and longer harvesting period. This is in agreement with the previous scholar Ahmed (2006) and Sisay (2006). The ash contents of the present findings were significantly higher in the enclosure areas than in the open-grazed areas in the top and medium altitudes than in the bottom land altitude across the study sites.

The average ash content of samples taken from different grazing types in the different altitude zones, which implies that the ash content of herbaceous species decreased as the stage of harvesting of the plant advances. This is in agreement with the work of Yihalem (2004). Herbaceous biomass and species differences by altitude are known to be the major factors in affecting the nutritive value of native pasture (Mahala *et al.*, 2009; Sub-halakshmi *et al.*, 2011). Tekla *et al.* (2012) reported that the variation in the nutritive value of herbaceous species might also be attributed to site potential in terms of differences and temperature condition. Most grasses and tree leaves in arid environments are low in nutritive values, due to high contents of lignin and relatively indigestible. This is in agreement with the work of Yihalem (2004).

The maximum NDF, ADF and ADL content was significantly higher in enclosure grazing areas than in the open-grazed areas across the study sites. Due to the result of altitude differences and high NDF content in herbaceous plants which would limit the DM intake and digestibility. This is in agreement with work of Alemu (1982). Those herbaceous species with high NDF, ADF and ADL were low in nutritional value and digestibility. This study is indicated that the nutritive value of herbaceous species was greatly influenced by the plant species. This study also confirmed that, the CP content of most herbaceous biomass in open grazed areas of top and medium altitude was significantly higher than in the enclosures areas across the study sites, due to species at late stage of maturity is very low with seasonal variation. This is in agreement with work of Ammar (2004).

5.5.2. The Chemical Composition of Herbaceous Biomass in Medium Altitude

(1560 m-1575 m)

The study confirms that, the dry matter production in the study sites across the three altitudes was above 90% in the enclosure versus open-grazed areas with the exception of open-grazed areas at Abernosa. This implies that, grass increased with an increase in growth and development of plants and longer harvesting period may be reason. This is in agreement with work of Tesema (2000).

The dry matter content of herbaceous biomass species was significantly higher in the enclosures than in the open-grazed areas in medium and top altitude than in the bottom land altitude of study sites in Hadha-Bossa and Gubeta-Arjo. The ash content of present finding was significantly higher in the enclosures than in the open-grazed areas in the top and medium

altitude than in the bottom land altitude of the study sites. Due to the ash content of herbaceous species decreased as stage of harvesting of the plant advanced may be reason for them. This is in agreement with the report of Yihalem (2004).

The CP content of herbaceous species biomass in the study sites was significantly higher in open-grazed areas than in the enclosures across the study sites. Due to frequent removal of old pasture by grazers and deposition of manure improve the soil fertility and plant nutrient content indirectly reported by (Teka et al., 2012). Similarly, the results of this findings in terms of NDF and ADF in enclosure areas across all altitude ranges were high in the woredas. This is due to mismanagement (time of grazing/harvesting could be one of the possible reasons for the highest content of fibers of herbaceous plants as these get accumulated as the plant matures. This is in agreement with previous scholar (Teka et al., 2012; Shankute *et al.*, 2011). The low accumulation of CP and increased level of fibers are an indication of poor quality of forage. It seems that the chemical composition of herbaceous forage is more influenced by the stage of maturity than any other factors.

5.5.3. The Chemical Composition of Herbaceous Biomass in the Top Altitude

(1578 m-1595 m)

The study shows that the dry matter production of herbaceous plants was higher in enclosures than in the open-grazed areas particularly in the top and medium altitudes at Hadha-Bossa and Gubeta-Arjo. Various levels of grazing intensity and development of plants with longer harvesting period that might be reason. This is in agreement with work of Tesema (2000).

The ash contents were significantly higher in the enclosures than in the open-grazed areas in the top and medium altitude than in the bottom land altitude at Abernosa and Hadha-Bossa sites. Due to herbaceous species decreased as stage of harvesting of the plant advanced. This is in agreement with work of Yihalem (2004). The CP contents of herbaceous species biomass in the study sites were significantly higher in open-grazed areas than in the enclosures in the study sites across the three altitude ranges. Due to removal of old pasture by animal from open-grazed areas and regeneration of early maturity of different types of plant vegetation for herbaceous species biomass was may be reason. This is in agreement with the work of (Teka et al., 2012).

The CP content was higher in open-grazed areas than in the enclosures in the medium and top altitude in Abernosa Site except Hadha-Bossa and Gubeta-Arjo sites. Due to early advances in plant maturity and high amount of legumes plants were distribution in the altitude rangeland sites. This is in agreement with the previous researchers (Teka et al., 2012). Likewise, the NDF, ADF and ADL in enclosures along the three altitude ranges were high in the woredas. Most grasses and tree leaves in arid environments are low in their nutritive values mainly because of the high contents of lignin and relatively indigestible cellulose and hemi-cellulose.

6. SUMMARY, CONCLUSION AND RECOMMENDATION

6.1. Summary

This study was conducted in Adami Tullu Jido-Kombolcha and Arsi-Negelle woredas, East Showa and West Arsi Zone, Southern Ethiopia. The aims of this study were to assess grazing land condition, herbaceous species biomass production and chemical composition of herbaceous biomass. The evaluation made on the range condition of the two woredas was conducted in three different rangeland sites (Abernosa, Hadha-Bossa and Gubeta-Arjo) and with two levels of grazing types (enclosure and open-grazed areas) and three altitude categories (i.e., top, medium and bottomland). For data collection, the grass species composition, basal, litter covers, age distribution of dominant grasses, common grass species, number of seedling, soil erosion and soil compaction were considered as parameters to be evaluated. The assessment made on the condition of the range in enclosure areas showed a highly significant ($P < 0.05$) basal cover, litter cover, grass composition, age distribution and soil condition than in the open grazed areas.

A total of 28 herbaceous species were recorded across the study sites. Among the herbaceous species 71.4% grass species, 21.4% were non-grass species and 7.1% legume species. The non-grass species comprised of 2 species of legumes, 6 species of forbs and 20 species of grasses. Of the grass species, highly desirable species 28.5%, intermediate desirable 35.7% and less desirable 17.8 % and 7.1% undesirable. The amount of herbaceous biomass production for grass, legumes and forbs in enclosure areas of the rangeland sites were significantly ($P < 0.05$) higher than in the open-grazed areas.

The chemical composition of herbaceous biomass in different altitude zone of three rangeland sites are significantly different and grazing management, as much as possible, the CP content in the open-grazed areas were significantly ($P < 0.05$) higher than in the enclosure areas. The CP contents of herbaceous species in the studied sites across the three altitude ranges are higher in the medium and top altitudes across the study sites.

6.2. Conclusion

In Adami-Tullu Jido-Kombolcha and Arsi-Negelle woredas, the range condition in the open-grazed areas was in poor condition due to increased grazing pressure and continuous grazing, while the range state in the enclosures was in good condition as a result of reduced disturbance and rest from grazing for certain period of time. From the result of this study the enclosure areas was in good condition and identifying key forage species for pasture improvement and conservation to be potential for the sustainable use of rangeland resources.

To prolong the cattle production as pastoral system in the open-grazed areas, the study confirms that, safeguarding, monitoring rangeland, proper supervision and evaluation to be potential rangeland. Biomass production in the enclosures areas was high and less production in the open-grazed areas. Chemical composition of herbaceous plants at different altitudes and sites was different.

6.3. Recommendations

The outcome of study showed that, the rangeland condition of the enclosure areas is measured as good condition. Unlike, an open-grazed area is reversed to poor rangeland condition and correctly used natural grazing lands. Therefore, from the result of study, the following are recommended:

To prevent the decline of rangeland resources in the future, in particular, understanding of the relationships between the use of vegetation resources and implementing appropriate land-use policy based on the actual information and accepts political analysis.

Rehabilitation for indigenous multi-purpose highly threatened plant species should be given emphasis.

Establishment of enclosure areas will found to be one of the ways to improve the regeneration potential of the grazing lands.

REFERENCE

- Abule E. 2003. Rangeland evaluation in relation to pastoralists' perceptions in the middle awash valley of Ethiopia. A Ph.D Thesis Presented to the University of the Free State, Bloemfontein, and South Africa. 297p.
- Abule E, Snyman H.A and Smith G.N. 2005. The influence of woody plants and livestock grazing on grass composition yield and soil nutrients in the middle Awash valley of Ethiopia. *J. Arid Env.*60: 243-358
- Admasu T. 2006. Pastoralists' perceptions on range-livestock management practices and rangeland assessment in Hamer and Benna-Tsemay districts of South Omo Zone. M.Sc Thesis Presented to the School of Graduate Studies of Alemaya University, Ethiopia. 159p.
- Ahmed B. 2003. Soil condition and vegetation cover in human impacted rangelands of Jijiga, Somali Regional State. M.Sc Thesis Presented to the School of Graduate Studies of Alemaya University. 108p.
- Ahmed H. 2006. Assessment and utilization practices of feed resources in Basona Worana Woreda of North Shoa. M.Sc. Thesis Presented to the School of Graduate Studies of Haramaya University, Ethiopia.114pp.
- Alemayehu M.1998. The Borana and the 1991-92 droughts: A Rangeland and Livestock Resource Study. Institute for sustainable development, French Catholic committee against hunger and for development. Addis Ababa, Ethiopia. 90p.
- Alemayehu M. 2004. Rangeland: Biodiversity Concepts, Approaches and the way forward. Addis Ababa University, Faculty of Science, Addis Ababa, Ethiopia, 80p

- Alemayehu M.2005. Rangelands: Biodiversity Conservation and Management and Inventory and Monitoring. Addis Ababa University, Faculty of Science, Addis Ababa, Ethiopia.103p.
- Alemu T. 1982. Grass land composition and current feeding systems in Nekemite Awraja. M.Sc Thesis Presented to the School of Graduate Studies of Addis Ababa University, Ethiopia. 92p.
- Amaha K. 2006. Characterization of rangeland resources and dynamics of the pastoral Production system in the Somali region of Eastern Ethiopia. A Ph.D Thesis Presented to the University of the Free State, Bloemfontein, South Africa. 232p.
- Ammar H, Lopez S, Gonzalez, J.S and Ranilla, M.J. 2004. Seasonal variations in the chemical composition and in vitro digestibility of some Spanish leguminous shrub species. *Animal Feed Science and Technology*.115; 327–340
- Amsalu S. and Baars R.M.T.2002. Grass composition and rangeland condition of the major grazing areas in the mid rift valley, Ethiopia.*Afric. J. Range and Forage Science*.9: 161-166.
- Amsalu S. 2000. Herbaceous species composition, dry matter production and condition of the major grazing areas in the Mid Rift Valley of Ethiopia. M.Sc Thesis Presented to the School of Graduate Studies of Alemaya University.95pp.
- Angassa A. and Oba .G (2008). Herder perceptions on impacts of range enclosures, crop farming, fire ban and bush encroachment on the rangelands of Borana, southern Ethiopia. *Human. Ecolo.* 36: pp. 201-215.
- Angassa A. 2014. Effects of grazing intensity and bush encroachment on herbaceous species and range land condition in southern Ethiopia.*J.Ldeg and Dev't*.25:438-451

- AOAC (Association of Official Analytical Chemists). 2000. Official methods of analysis (15th ed). Inc., Washington D.C., USA.
- Angassa A. and Fekadu B. (2003). Current range condition in southern Ethiopia in relation to traditional management strategies: The perceptions of Borana pastoralists. *Tropical Grasslands*, 37(1); 53-59.
- Angassa A. and Baars R. M. T. 2000. Ecological condition of encroached and non- encroached rangelands in Borana, Ethiopia. *Africa. J. Ecolo.* 38: 321-328.
- Angassa A. 1999. Range Condition and Traditional Grazing Management system in Borana. M.Sc Thesis Presented Alemeya University, Dire Dawa, Ethiopia. 55
- Baars, R.M.T. and Said, M. A. 1999. Pastoralists' perception towards rangeland degradation. Case study in Shinile zone, Eastern Ethiopia. pp. 25-36. Proceeding of the 7th National Conference of the Ethiopian Society of Animal Production. Addis Ababa, Ethiopia, 26-27 May 1999.
- Baars R.M.T., Chileshe E.C and Kalokoni D.M. 1997. Technical Note. Range Condition in high cattle density areas in the Western Province of Zambia. *J. of Tropic. Grasslands.* 31: 565-573.
- Bekele M. 2007. Plant species composition, biomass production and condition assessment in montane grasslands of kokosa district of Bale, South eastern Ethiopia. M.Sc Thesis Presented to the School of Graduate Studies of Haramaya University, Ethiopia. 136p.
- Belaynesh D. 2006. Floristic composition and diversity of the vegetation, soil seed bank flora and condition of the rangelands of the Jijiga Zone, Somali Regional State, Ethiopia. M.Sc Thesis Presented to the School of Graduate Studies of Alemaya University, Ethiopia. 144pp.

- Beruk Y. and Tafesse M. 2000. Pastoralism and agro-pastoralism: Past and present. pp. 54-65. Proceeding of the 8th Annual Conference of Ethiopia Society of Animal production Addis Ababa, Ethiopia, 24-26 August 2000.
- Beruk Y. 2003a. The declining pastoral environment and variability status and adaptation strategies. pp. 154-165. Proceedings the 10th Annual Conference of Ethiopia Society of Animal Production of Addis Ababa, Ethiopia, 22-24 August 2003.
- Bezuayehu T., Gezahegn A., Yigezu A., Jabbar M.A. and Paulos D. 2002. Nature and causes of land degradation in the Oromiya Region: A review. Socio-economic and Policy Research Working paper 36. ILRI (International Livestock Research Institute), Nairobi, Kenya. 82p.
- Coppock D.L. 1994. The Borana plateau of Southern Ethiopia: Synthesis of pastoral research, development and change, 1980-1991. ILCA, Addis Ababa, Ethiopia. 418pp.
- Crawley, M.J., 1986. The structure of the plant communities. pp. 1-50. In: M.J. Crawley, (ed.) plant ecology, Blackwell, London
- Dahlberg, A.C. 2000. Vegetation diversity and change in relation to land use, soil and rainfall-a case study from North-East District, Botswana. Journal of Arid Environments 44: 19-40.
- Dawit A. 2000. Pastoralism and pastoral production system. pp. 1-5. Proceedings of the 8th Annual Conference of Ethiopia Society of Animal Production. Pastoralism and Agro-pastoralism
- EARO (Ethiopia Agricultural Research Organization), 2001. Dry land research strategy draft manual. Pastoral and agro-pastoral development strategy. Addis Ababa Ethiopia. 65p
- Friedel M.H., Laycock W.A and Basin G.N 2000. Assessing rangeland condition and trend. pp 227-261. In: L.T.

- Friedel, M.H., 1991. Range condition assessment and the concepts of thresholds: A view point. *Journal of Range Management*. 44(5): 422-426.
- Fynn R.W.S. and O'Connor T.G. 2000. Effects of stocking rate and rainfall on rangeland dynamics and cattle performance in a semi-arid savanna, South Africa. *J. App. Ecolo.* 37: 491-507.
- Gemedo D. (2006). Rangeland condition and trend in the semi-arid Borana lowlands, southern Oromia, Ethiopia. *Africa. J. Range and Forage Sci.* 23, 49-58.
- Gemedo D. 2004. Vegetation Ecology, Rangeland Condition and Forage Resources Evaluation in the Borana Lowlands, Southern Oromia, and Ethiopia. A Ph.D Thesis Presented to the University of the Göttingen, Germany. 253 pp.
- Goldsmith F.B., Harrison C.M and Morton A.J 1994. Description and Analysis of vegetation. In: Moore, P.D. and Chapman, S.B. (Ed), *Methods in plant ecology*. Second edition. Blackwell Scientific Publications. Oxford, UK.
- Hardy, M.B. and C.R. Hurt, 1989. An evaluation of veld condition assessment techniques in highland sourveld. *Journal of the Grassland Society of Southern Africa* 6: 51-58.
- Holechek J.L., Pieper R.L and Herbel C.H. 2001. *Range Management, Principles and Practices*. 4th edition. Prentice Hall, Upper Saddle, River, NJ. 452p.
- Ilius A. and O'Connor T.G. 1999. On the relevance of non-equilibrium concepts to arid and semiarid grazing systems. *Ecological Applications* 9:798-813.
- ILCA (International Livestock Center for Africa), 1990. *Livestock Research Manual*. ILCA, Addis Ababa, Ethiopia. 2: 31-54
- International Union for the Conservation of Nature and Natural Resources (IUCN), 1999. *Biological Diversity of Dry lands, Arid, Semiarid, Savanna, Grassland and Mediterranean Ecosystems*. IUCN, the World Conservation Union.

- Lishan Ts. 2007. Woody and herbaceous species composition and the condition of the rangelands in Shinile zone of Somali Regional State of Ethiopia. M.Sc. Thesis .Presented to the School of Graduate Studies of Haramaya University, Ethiopia.146pp.
- Mahala A.G., Nsahlai I.V., Basha N.A.D and Mohammed L.A. 2009. Nutritive evaluation of natural pasture at early and late rainfall season in Kordofanand Butana, Sudan.*Aust J Basic Appl. Sci.* 3: 4327-4332.
- Mapinduzi.A.L.,Oba.G,Weladji R.B and Colman J. 2003.Use of indigenous ecological knowledge of the Maasai pastoralists for assessing rangeland biodiversity in Tanzanian.Afri. J. Ecol. 41: 329-336.
- Mittal G.K. Sharma, K.M. Maheshwari, M.L and Barsaul, C.S. 2012. Chemical composition of some natural available fodder resources in Hill area of Chakrata (Utter Pradesh). *Indian J. Anim. Nutr.*5: 341-344.
- MOA (Ministry ofAgriculture), 2000.Proceeding on National Pastoral Extension System Addis Ababa, Ethiopia.
- Nigussie T. 2008. Traditional grazing land utilization, floristic composition and condition assessment of Babile-Erer valley, East hararge, Oromia, Ethiopia. M.Sc. Thesis Presented to the School of Graduate Studies of Haramaya University, Ethiopia. 110pp.
- O'Connor T.G. and Pickett, 1999.The influence of grazing on seed production and seed banks of some African Savanna grasslands. *Journal of Applied Ecology*.
- Oba G. and Kotile D.G., 2001. Assessment of landscape level degradation in Southern Ethiopia: pastoralists versus ecologist. pp 1-19.In: International conference on policy andinstitutional options for the management of rangelands in dry areas. Hammamet, Tunisia, 7-11 May.

- Oba G. 1998. Assessment of indigenous range management knowledge of the Borana pastoralists of Southern Ethiopia. Borana lowland pastoral development program/GTZ consultancy paper. Negelle/Borana, May 1998.
- Oba G. 2001. Indigenous ecological knowledge of landscape change in East Africa. International Association for Landscape Ecology Bulletin. Vol. 19(3): 1-3.
- Oba G. Post, E. Syvertsen, P. O. and Stenseth, N. C. 2000. Bush cover and range condition assessments in relation to landscape and grazing in southern Ethiopia. Landscape Ecol.15: 535-546.
- OESPO (2003) Regional Government of Oromia; Oromia Economic Study Project Office. Adami Tullu-Jido Kombolcha Woreda Based Development Programme.
- OESPO (2003) Regional Government of Oromia; Oromia Economic Study Project Office. Arsi-Negelle Woreda Based Development Programme.
- Phaulos A, Kedir Nefo, Tekeleyohanis Berhanu, Shambel Kumbi, Tadel Tadesse, Diriba Bekere, Bekele Hundie, K and Feyissa Tadesse, 1999. 80p. Ethiopia agricultural research organization (Agro-ecological based Agricultural Production Constraints Identification Survey. SM1-1 sub agro ecology (Rayitu, districts, Bale zone) Sinana Agriculture Research Center Oromiya Agricultural bureau (unpublished).
- Pratt D.J. and Gwynne, M.D. 1977. Rangeland management and ecology in East Africa SEPR (Socio-Economic Profile of Rayitu), 1998.
- Range Inventory Standardization Committee (RISC), 1983. Guidelines and terminology for range inventory and monitoring.
- Shankute.B, Abubeker Hassen, Abule Ebro, Tadese Asefa and Nura Amen. 2011. Identification of potential untapped herbaceous flora in the mid rift valley of Ethiopia and their nutritive value. Afri. J. Agri. res. 6 (17):4153-4158.

- Sisay A. 2006. Livestock production systems and available feed resources in different agro-ecologies of North Gondar Zone, Ethiopia. M.Sc. Thesis Presented to the School of Graduate Studies of Haramaya University, Ethiopia.139pp.
- Snyman H.A. 1998. Dynamics and sustainable utilization of rangeland ecosystems in arid and semi-arid climates of Southern Africa.J. Arid Env. 39:645-666
- Solomon D. 2000. Pastoralism and natural resources management. Case of the pastoral Borena in South Ethiopia,pp.17-27. Proceedings of the 8th Annual Conference of the Ethiopia Society of Animal production. Addis Ababa, Ethiopia, 24-26 August 2000.
- Sub-halakshmi B., Bhuyan R., Sama D.N., Sharma K.K. and Bora A. 2011. Effect of variety and stage of harvest on yield , chemical composition and invitro digestibility of hybrid Napier (*Pennisetum purpureum x P.americanum*). *Indian J. Anim. Nutr.* 28: 418-420.
- Tafesse M. 2000. An overview and analysis of the history of public policy towards the development of pastoralism in Ethiopia. pp. 35-43. Proceedings of the National Conference on Pastoral Development in Ethiopia. Addis Ababa, Ethiopia, February 2, 2000, Pastoral Forum Ethiopia.
- Tainton N.M. 1981. The Assessment of Veld Condition. In: N.M. Tainton (Eds.).Veld Pasture Management in South Africa. Shutter and Shooter Ltd: Pietermaritzburg, South Africa.255pp.
- Tainton N.M.1999.Veld management in South Africa, University of Natal Press, Pietermaritzburg South Africa. 472p.
- Teka H, I. Casper Madakadze, Ayana Angassa, Abubaker Hassen. 2012. Effect of seasonal variation on the nutritional quality of key herbaceous species in semi-arid Areas of Borana, Ethiopia. *Indian J. Anim. Nutr.* 29 (4):324-33.

- Tesema Z. 2000. Productivity, nutritive value and digestibility of Elephant grass (*Pennisetum purpureum*) as influenced by height of harvesting and different sources of fertilizer applications. M.Sc Thesis Presented to the School of Graduate Studies of Alemaya University, Ethiopia. pp110.
- Teshome A. 2007. Traditional utilization practices and condition assessment of the rangelands in Rayitu district of Bale zone, Ethiopia. MSc Thesis Presented to the School of Graduate Studies of Haramaya University, Ethiopia. 1 29p.
- Tewoldeberhan G. E. 1991. Diversity of Ethiopian flora. In : Engles, J. M. M., Hawkes, J. G. and Melaku Worede (eds.), Plant Genetic Resources of Ethiopia . Cambridge University Press, Cambridge
- United Nations Environmental Program (UNEP), 1992. World Atlas of Desertification. London. 66pp. University of Agriculture, Alemaya, Ethiopia. 78pp
- Van der Westhuizen H.C, Van Rensberg, W.L.J. and Snyman, H.A. 1999. The quantification of range condition in semi-arid grassland of Southern Africa. *Afr.J. Range and Forage sci.* 16 (3): 49-61.
- Van der Westhuizen HC, Snyman HA, Van Rensburg WLJ, Potgieter JHJ (2001). The quantification of grazing capacity from grazing and production values for species in the semi-arid grassland biome of Southern Africa. *Afr. J. Range and Forage sci.* 18, 43-52.
- Van Soest, P.J. and Robertoson, J.B. 1985. Analysis of forage and fibrous foods. A laboratory manual for Animal Science 613. Cornell University, USA.
- Yates, C. J., Norton, D. A. and Hobbs, R. J. 2000. Grazing effects on plant cover, soil and microclimate in fragmented woodlands in south-western Australia: implications for restoration. *Austral Ecology* 25(1): 36-47.

Yihalem D. 2004. Assessment of Botanical Composition and Stage of Harvesting of Selected Natural Pasture for Optimum Utilization as Hay at Andassa Livestock Research Center, Northwestern Ethiopia. M.Sc Thesis Presented to the School of Graduate Studies of Alemaya University. 69p.

Zerihun W. 1999. Forests in the vegetation types of Ethiopia and their status in the geographical context. In: Proceedings of the National Forest Genetic Resources Conservation Strategy Development Workshop (Edwards, S., Abebe Demissie, Taye Bekele and Gunther Haase, (eds.), pp1-39. Addis Ababa, Ethiopia.

APPENDIX

Appendix Table 1: ANOVA test result on the effect of enclosures versus open grazed areas found in three different Sites

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected model	Grass Composition	61.014 ^a	5	12.203	5.592	.000
	Basal cover	778.300 ^p	5	155.660	165.084	.000
	Litter cover	411.142 ^c	5	82.228	96.790	.000
	Number of seedling	.000 ^d	5	.000	.	.
	Age distribution	49.137 ^e	5	9.827	17.718	.000
	Soil erosion	63.758 ^f	5	12.752	32.185	.000
	Soil compaction	73.906 ^g	5	14.781	38.331	.000
Intercept	Grass Composition	4977.845	1	4977.845	2.281E3	.000
	Basal cover	2749.036	1	2749.036	2.915E3	.000
	Litter cover	3184.842	1	3184.842	3.749E3	.000
	Number of seedling	.000	1	.000	.	.
	Age distribution	1645.624	1	1645.624	2.967E3	.000
	Soil erosion	918.423	1	918.423	2.318E3	.000
	Soil compaction	826.258	1	826.258	2.143E3	.000
Site	Grass Composition	6.308	2	3.154	1.445	.240
	Basal cover	1.308	2	.654	.693	.502
	Litter cover	1.543	2	.772	.908	.406
	Number of seedling	.000	2	.000	.	.
	Age distribution	.418	2	.209	.377	.687
	Soil erosion	.461	2	.230	.581	.561
	Soil compaction	.140	2	.070	.182	.834
Management	Grass Composition	48.926	1	48.926	22.420	.000
	Basal cover	776.354	1	776.354	823.357	.000
	Litter cover	407.604	1	407.604	479.786	.000
	Number of seedling	.000	1	.000	.	.
	Age distribution	47.920	1	47.920	86.397	.000
	Soil erosion	62.949	1	62.949	158.883	.000
	Soil compaction	73.444	1	73.444	190.458	.000

Site * management	Grass Composition	5.298	2	2.649	1.214	.301
	Basal cover	1.784	2	.892	.946	.391
	Litter cover	2.591	2	1.295	1.525	.222
	Number of seedling	.000	2	.000	.	.
	Age distribution	.585	2	.292	.527	.592
	Soil erosion	.223	2	.111	.281	.756
	Soil compaction	.133	2	.066	.172	.842
Error	Grass Composition	248.778	114	2.182		
	Basal cover	107.492	114	.943		
	Litter cover	96.849	114	.850		
	Number of seedling	.000	114	.000		
	Age distribution	63.230	114	.555		
	Soil erosion	45.167	114	.396		
	Soil compaction	43.960	114	.386		
Total	Grass Composition	5315.000	120			
	Basal cover	3641.000	120			
	Litter cover	3701.000	120			
	Number of seedling	.000	120			
	Age distribution	1770.000	120			
	Soil erosion	1033.000	120			
	Soil compaction	950.000	120			
Corrected total	Grass Composition	309.792	119			
	Basal cover	885.792	119			
	Litter cover	507.992	119			
	Number of seedling	.000	119			
	Age distribution	112.367	119			
	Soil erosion	108.925	119			
	Soil compaction	117.867	119			

a. R Squared = .197 (Adjusted R Squared = .162)

b. R Squared = .879 (Adjusted R Squared = .873)

c. R Squared = .809 (Adjusted R Squared = .801)

d. R Squared = . (Adjusted R Squared = .)

e. R Squared = .437 (Adjusted R Squared = .413)

f. R Squared = .585 (Adjusted R Squared = .567)

g. R Squared = .627 (Adjusted R Squared = .611)

Appendix Table 2: ANOVA test result on the effect of enclosures versus open grazed areas in three different altitude Sites

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Grass Composition	83.363 ^a	17	4.904	2.209	.008
	Basal cover	796.030 ^b	17	46.825	53.209	.000
	Litter cover	426.682 ^c	17	25.099	31.486	.000
	Number of seedling	.000 ^a	17	.000	.	.
	Age distribution	53.914 ^c	17	3.171	5.534	.000
	Soil erosion	72.615 ^f	17	4.271	11.999	.000
	Soil compaction	81.176 ^g	17	4.775	13.275	.000
Intercept	Grass Composition	4977.845	1	4977.845	2.242 E3	.000
	Basal cover	2749.036	1	2749.036	3.124 E3	.000
	Litter cover	3184.842	1	3184.842	3.995 E3	.000
	Number of seedling	.000	1	.000	.	.
	Age distribution	1645.624	1	1645.624	2.872 E3	.000
	Soil erosion	918.423	1	918.423	2.580 E3	.000
	Soil compaction	826.258	1	826.258	2.297 E3	.000
Site	Grass Composition	4.839	2	2.419	1.090	.340
	Basal cover	.702	2	.351	.399	.672
	Litter cover	5.507	2	2.753	3.454	.035
	Number of seedling	.000	2	.000	.	.
	Age distribution	1.775	2	.887	1.549	.218
	Soil erosion	3.024	2	1.512	4.247	.017
	Soil compaction	3.794	2	1.897	5.274	.007
Management	Grass Composition	48.926	1	48.926	22.040	.000
	Basal cover	776.354	1	776.354	882.20 2	.000
	Litter cover	407.604	1	407.604	511.32 5	.000
	Number of seedling	.000	1	.000	.	.
	Age distribution	47.920	1	47.920	83.621	.000
	Soil erosion	62.949	1	62.949	176.83 6	.000

	Soil compaction	73.444	1	73.444	204.175	.000
Altitude	Grass Composition	6.308	2	3.154	1.421	.246
	Basal cover	1.308	2	.654	.743	.478
	Litter cover	1.543	2	.772	.968	.383
	Number of seedling	.000	2	.000	.	.
	Age distribution	.418	2	.209	.365	.695
	Soil erosion	.461	2	.230	.647	.526
	Soil compaction	.140	2	.070	.195	.823
Site * Management	Grass Composition	11.691	2	5.845	2.633	.077
	Basal cover	7.635	2	3.817	4.338	.016
	Litter cover	5.391	2	2.696	3.382	.038
	Number of seedling	.000	2	.000	.	.
	Age distribution	1.093	2	.547	.954	.389
	Soil erosion	2.310	2	1.155	3.244	.043
	Soil compaction	1.325	2	.662	1.842	.164
Site * Altitude	Grass Composition	4.003	4	1.001	.451	.772
	Basal cover	4.477	4	1.119	1.272	.286
	Litter cover	3.720	4	.930	1.167	.330
	Number of seedling	.000	4	.000	.	.
	Age distribution	.572	4	.143	.250	.909
	Soil erosion	2.317	4	.579	1.627	.173
	Soil compaction	1.669	4	.417	1.160	.333
Management * Altitude	Grass Composition	5.298	2	2.649	1.193	.307
	Basal cover	1.784	2	.892	1.013	.367
	Litter cover	2.591	2	1.295	1.625	.202
	Number of seedling	.000	2	.000	.	.
	Age distribution	.585	2	.292	.510	.602
	Soil erosion	.223	2	.111	.313	.732
	Soil compaction	.133	2	.066	.184	.832
Site * Management * Altitude	Grass Composition	1.613	4	.403	.182	.947
	Basal cover	4.420	4	1.105	1.256	.292
	Litter cover	.887	4	.222	.278	.892
	Number of seedling	.000	4	.000	.	.
	Age distribution	1.372	4	.343	.599	.664
	Soil erosion	1.540	4	.385	1.082	.370
	Soil compaction	.667	4	.167	.464	.762
Error	Grass Composition	226.429	102	2.220		

	Basal cover	89.762	102	.880
	Litter cover	81.310	102	.797
	Number of seedling	.000	102	.000
	Age distribution	58.452	102	.573
	Soil erosion	36.310	102	.356
	Soil compaction	36.690	102	.360
Total	Grass Composition	5315.000	120	
	Basal cover	3641.000	120	
	Litter cover	3701.000	120	
	Number of seedling	.000	120	
	Age distribution	1770.000	120	
	Soil erosion	1033.000	120	
	Soil compaction	950.000	120	
Corrected Total	Grass Composition	309.792	119	
	Basal cover	885.792	119	
	Litter cover	507.992	119	
	Number of seedling	.000	119	
	Age distribution	112.367	119	
	Soil erosion	108.925	119	
	Soil compaction	117.867	119	

- a. R Squared = .269 (Adjusted R Squared = .147)
b. R Squared = .899 (Adjusted R Squared = .882)
c. R Squared = .840 (Adjusted R Squared = .813)
d. R Squared = . (Adjusted R Squared = .)
e. R Squared = .480 (Adjusted R Squared = .393)
f. R Squared = .667 (Adjusted R Squared = .611)
g. R Squared = .689 (Adjusted R Squared = .637)

Appendix Table 3: ANOVA test result on the effect of enclosures versus open grazed areas found in three different Sites

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected model	Grass	285363.462 ^a	7	40766.209	6.591	.000
	Forbs	26232.001 ^b	7	3747.429	5.154	.000
	Legumes	3623.498 ^c	7	517.643	6.185	.000
Intercept	Grass	329547.689	1	329547.689	53.279	.000

	Forbs	39339.707	1	39339.707	54.104	.000
	Legumes	5889.026	1	5889.026	70.369	.000
Site	Grass	20716.344	3	6905.448	1.116	.349
	Forbs	508.645	3	169.548	.233	.873
	Legumes	147.613	3	49.204	.588	.625
Management	Grass	87436.914	1	87436.914	14.136	.000
	Forbs	7266.137	1	7266.137	9.993	.002
	Legumes	766.624	1	766.624	9.161	.004
Site * management	Grass	14110.690	3	4703.563	.760	.520
	Forbs	424.729	3	141.576	.195	.900
	Legumes	112.929	3	37.643	.450	.718
Error	Grass	395863.506	64	6185.367		
	Forbs	46534.962	64	727.109		
	Legumes	5355.983	64	83.687		
Total	Grass	1656726.481	72			
	Forbs	187374.926	72			
	Legumes	26111.412	72			
Corrected total	Grass	681226.968	71			
	Forbs	72766.963	71			
	Legumes	8979.481	71			

a. R Squared = .419 (Adjusted R Squared = .355)

b. R Squared = .360 (Adjusted R Squared = .291)

c. R Squared = .404 (Adjusted R Squared = .338)

Appendix Table 4: ANOVA test result on the effect biomass production (kg/ha) for enclosures versus open grazed areas in different three altitude sites

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	Grass	228805.982 ^a	8	28600.748	3.983	.001
	Forbs	31220.928 ^b	8	3902.616	5.918	.000
	Legumes	2693.623 ^c	8	336.703	3.375	.003
Intercept	Grass	975499.512	1	975499.512	135.839	.000
	Forbs	114607.963	1	114607.963	173.790	.000
	Legumes	17131.931	1	17131.931	171.705	.000
Site	Grass	20432.981	2	10216.491	1.423	.249
	Forbs	508.597	2	254.299	.386	.682
	Legumes	146.342	2	73.171	.733	.484
Altitude	Grass	.000	0	.	.	.
	Forbs	.000	0	.	.	.
	Legumes	.000	0	.	.	.
Management	Grass	.000	0	.	.	.
	Forbs	.000	0	.	.	.
	Legumes	.000	0	.	.	.
Site * Altitude	Grass	.000	0	.	.	.
	Forbs	.000	0	.	.	.
	Legumes	.000	0	.	.	.
Site * Management	Grass	.000	0	.	.	.
	Forbs	.000	0	.	.	.
	Legumes	.000	0	.	.	.
Altitude * Management	Grass	.000	0	.	.	.
	Forbs	.000	0	.	.	.
	Legumes	.000	0	.	.	.
Site * Altitude * Management	Grass	.000	0	.	.	.
	Forbs	.000	0	.	.	.
	Legumes	.000	0	.	.	.
Error	Grass	452420.986	63	7181.285		
	Forbs	41546.035	63	659.461		
	Legumes	6285.858	63	99.776		
Total	Grass	1656726.481	72			
	Forbs	187374.926	72			
	Legumes	26111.412	72			
Corrected Total	Grass	681226.968	71			

Forbs	72766.963	71
Legumes	8979.481	71

A. R Squared = .336 (Adjusted R Squared = .252)

B. R Squared = .429 (Adjusted R Squared = .357)

C. R Squared = .300 (Adjusted R Squared = .211)

Appendix Table 5: ANOVA test result on the effect Chemical composition of herbaceous biomass at different Site and management of three sites.

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	DM	173.859 ^a	5	34.772	6.014	.000
	Ash	228.753 ^b	5	45.751	7.443	.000
	NDF	1407.167 ^c	5	281.433	45.505	.000
	ADF	1501.254 ^d	5	300.251	8.499	.000
	ADL	27.830 ^e	5	5.566	9.843	.000
	CP	322.590 ^f	5	64.518	31.595	.000
Intercept	DM	608493.863	1	608493.863	1.052E5	.000
	Ash	4224.337	1	4224.337	687.202	.000
	NDF	259724.665	1	259724.665	4.199E4	.000
	ADF	85829.841	1	85829.841	2.429E3	.000
	ADL	5084.353	1	5084.353	8.991E3	.000
	CP	8514.473	1	8514.473	4.170E3	.000
Site	DM	.028	1	.028	.005	.944
	Ash	.019	1	.019	.003	.955
	NDF	328.406	1	328.406	53.099	.000
	ADF	539.945	1	539.945	15.283	.000
	ADL	1.061	1	1.061	1.876	.175
	CP	89.579	1	89.579	43.868	.000
Management	DM	116.296	2	58.148	10.057	.000
	Ash	132.615	2	66.307	10.787	.000
	NDF	73.567	2	36.784	5.947	.004
	ADF	334.104	2	167.052	4.728	.012
	ADL	22.753	2	11.376	20.118	.000
	CP	.662	2	.331	.162	.851
Site * management	DM	57.535	2	28.767	4.976	.010
	Ash	96.119	2	48.060	7.818	.001
	NDF	1005.194	2	502.597	81.264	.000
	ADF	627.205	2	313.602	8.877	.000
	ADL	4.016	2	2.008	3.551	.034

	CP	232.349	2	116.175	56.892	.000
Error	DM	381.596	66	5.782		
	Ash	405.712	66	6.147		
	NDF	408.192	66	6.185		
	ADF	2331.723	66	35.329		
	ADL	37.322	66	.565		
	CP	134.773	66	2.042		
Total	DM	609049.319	72			
	Ash	4858.802	72			
	NDF	261540.024	72			
	ADF	89662.817	72			
	ADL	5149.505	72			
	CP	8971.836	72			
Corrected Total	DM	555.456	71			
	Ash	634.465	71			
	NDF	1815.359	71			
	ADF	3832.976	71			
	ADL	65.152	71			
	CP	457.363	71			

A. R Squared = .313 (Adjusted R Squared = .261)

B. R Squared = .361 (Adjusted R Squared = .312)

C. R Squared = .775 (Adjusted R Squared = .758)

D. R Squared = .392 (Adjusted R Squared = .346)

E. R Squared = .427 (Adjusted R Squared = .384)

F. R Squared = .705 (Adjusted R Squared = .683)

Appendix Table 6: ANOVA test result on the effect chemical composition of herbaceous biomass at different Site and management of three altitude sites.

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	DM	192.364 ^a	17	11.316	1.683	.075
	Ash	240.864 ^b	17	14.168	1.944	.033
	NDF	1440.633 ^c	17	84.743	12.212	.000
	ADF	1530.112 ^d	17	90.007	2.111	.020
	ADL	28.713 ^e	17	1.689	2.503	.005

	CP	344.732 ¹	17	20.278	9.722	.000
Intercept	DM	608493.863	1	608493.863	9.050E4	.000
	Ash	4224.337	1	4224.337	579.556	.000
	NDF	259724.665	1	259724.665	3.743E4	.000
	ADF	85829.841	1	85829.841	2.013E3	.000
	ADL	5084.353	1	5084.353	7.535E3	.000
Site	CP	8514.473	1	8514.473	4.082E3	.000
	DM	116.296	2	58.148	8.648	.001
	Ash	132.615	2	66.307	9.097	.000
	NDF	73.567	2	36.784	5.301	.008
	ADF	334.104	2	167.052	3.917	.026
Management	ADL	22.753	2	11.376	16.859	.000
	CP	.662	2	.331	.159	.854
	DM	.028	1	.028	.004	.948
	Ash	.019	1	.019	.003	.959
	NDF	328.406	1	328.406	47.325	.000
Altitude	ADF	539.945	1	539.945	12.661	.001
	ADL	1.061	1	1.061	1.572	.215
	CP	89.579	1	89.579	42.948	.000
	DM	11.023	2	5.512	.820	.446
	Ash	.889	2	.444	.061	.941
Site * Management	NDF	.689	2	.345	.050	.952
	ADF	1.395	2	.697	.016	.984
	ADL	.106	2	.053	.078	.925
	CP	2.323	2	1.161	.557	.576
	DM	57.535	2	28.767	4.278	.019
Site * Altitude	Ash	96.119	2	48.060	6.594	.003
	NDF	1005.194	2	502.597	72.427	.000
	ADF	627.205	2	313.602	7.354	.001
	ADL	4.016	2	2.008	2.975	.059
	CP	232.349	2	116.175	55.699	.000
Site * Altitude	DM	2.382	4	.595	.089	.986
	Ash	6.484	4	1.621	.222	.925
	NDF	.805	4	.201	.029	.998

	ADF	14.444	4	3.611	.085	.987
	ADL	.617	4	.154	.229	.921
	CP	7.386	4	1.846	.885	.479
Management *	DM	2.161	2	1.080	.161	.852
Altitude	Ash	.861	2	.430	.059	.943
	NDF	18.345	2	9.173	1.322	.275
	ADF	4.646	2	2.323	.054	.947
	ADL	.083	2	.041	.061	.941
	CP	4.122	2	2.061	.988	.379
Site * Management *	DM	2.939	4	.735	.109	.979
Altitude	Ash	3.877	4	.969	.133	.970
	NDF	13.627	4	3.407	.491	.742
	ADF	8.374	4	2.093	.049	.995
	ADL	.078	4	.020	.029	.998
	CP	8.312	4	2.078	.996	.418
Error	DM	363.091	54	6.724		
	Ash	393.601	54	7.289		
	NDF	374.726	54	6.939		
	ADF	2302.864	54	42.646		
	ADL	36.439	54	.675		
	CP	112.631	54	2.086		

Total	DM	609049.319	72
	Ash	4858.802	72
	NDF	261540.024	72
	ADF	89662.817	72
	ADL	5149.505	72
	CP	8971.836	72
Corrected Total	DM	555.456	71
	Ash	634.465	71
	NDF	1815.359	71
	ADF	3832.976	71
	ADL	65.152	71
	CP	457.363	71

A. R Squared = .346 (Adjusted R Squared = .141)

B. R Squared = .380 (Adjusted R Squared = .184)

C. R Squared = .794 (Adjusted R Squared = .729)

D. R Squared = .399 (Adjusted R Squared = .210)

E. R Squared = .441 (Adjusted R Squared = .265)

F. R Squared = .754 (Adjusted R Squared = .676)

BIOGRAPHICAL SKETCH

The author, Mulugeta Gudisa Goro, was born in May 1982 in the west Arsi zone of Oromia regional state, in Arsi Negelle town. He started his education at Heban Degaga elementary and Arsi Negelle junior school and completed his senior secondary education at Arsi Negelle Secondary School.

Upon successful completion of his high school studies, then joined Samara University Faculty of Agriculture, in September 2007 and which after graduated in BSc, degree in Animal Science in June 2010. Thereafter, he was employed at West Arsi Zone in Shashemene Woreda Livestock Resource, Development Health care Office as a poultry expert and Animal nutrition expert in the woreda. The author served there for 2 years. After serving the Shashemene Woreda Livestock Resource, Development Health care office for two years, he joined the School of Graduate Studies at Hawassa University in September 2012 G. C. to pursue his MSc study in Animal Production.