

**EFFECT OF ENCLOSURES ON VEGETATION COMPOSITION, SPECIES
DIVERSITY AND SOIL PHYSICOCHEMICAL PROPERTIES IN SEMI-ARID
RENGE LANDS OF MEYUMULUKE DISTRICTS, EAST HARARGHE, ETHIOPIA.**

MSc THESIS

AHMEDJOWAR MOHAMMEDAMIN YUSUF

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Effect of Enclosures on Vegetation Composition, Species Diversity and Soil Physico-Chemical Properties in Semi-Arid Range lands of Meyumulu Districts East Hararghe, Ethiopia

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Ahmedjowar Mohammedamin Yusuf

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HARAMAYA UNIVERSITY, HARAMAYA

HARAMAYA UNIVERSITY

Postgraduate Programs Directorate

I hereby certify that I have read and evaluated this thesis entitled Effect of Enclosures on Vegetation Composition, Species Diversity and Soil Physico-Chemical Properties in Semi-Arid Range lands of Meyumulu Districts East Hararghe, Ethiopia, prepared under our guidance by Ahmedjowar Mohammedamin Yusuf. I recommend that it be submitted as fulfilling the thesis requirement.

Haftay Hailu (Assi. Prof)

Major-advisor

Signature

Date

Sintayehu Workeneh (Ph.D.)

Co-advisor

Signature

Date

As members of the Board of Examiners of the M.Sc. Thesis Open Defense Examination, I certify that I have read and evaluated the thesis prepared by Ahmedjowar Mohammedamin Yusuf and examined the candidate. I recommend that this thesis be accepted as fulfilling the thesis requirements for the *Degree of Master of Science in Range Ecology and Biodiversity*

Sileshi Gadissa (Ph.D.)

Chairperson

Signature

Date

Takele Wolkaro (Ph.D.)

Internal examiner

Signature

Date

Kidane Gebremeskel (Ph.D.)

External examiner

Signature

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DEDICATION

I dedicate this thesis manuscript to my father Mohammedamin Yusuf, my mother Johara Adem and my wife Kalisa Mohammed, for caring for me with love and for their dedicated partnership in the success of my life up to this level.

STATEMENT OF THE AUTHOR

By my signature bellow, I declare and affirm that this thesis is my own work. I have followed all ethical and technical principle of scholar ship in the preparation data collection, analysis, and completion of this thesis. Any scholarly matter that is included in the thesis has been given recognition through citation.

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Name: Ahmedjowar Mohammedamin Yusuf

Signature: _____

Place: Haramaya University, Haramaya

Date of Submission: _____

BIOGRAPHICAL SKETCH

The author was born in February of 1990 in Ifabas kebele of Meyumuluke districts, East Hararghe zone of Oromia, Ethiopia. He attended and completed his primary school at Chulul 07 School, Meyumuluke districts. He attended his High School at Meyumuluke secondary school and Preparatory school at Girawa Senior Secondary School. Upon his successful completion of his secondary school education, he joined Haramaya University in October 2010 with B.Sc. Degree in *Range Management and Ecotourism*, graduated in July 06, 2013. After his graduation, he has been working in Meyumuluke pastoral development office (PADO) for five years. Then, he decided to pursue his education and he joined the School of Graduate Studies (SGS) of Haramaya University for his M.Sc. study in *Range Ecology and Biodiversity* in 2018/2019 academic years.

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ABBREVIATIONS AND ACRONYMS

AU-IBAR	African Union-Inter African Bureau for Animal Resource
BC	Before Christ
CG	Communal Grazing Land
CSA	Central Statistical Agency
DPFSO	Disaster Prevention and Food Security Office
EA	Enclosure Area
EC	Electrical conductivity
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
ILRI	International Livestock Research Institute
MEA	Millennium Ecosystem Assessment
MoA	Ministry of Agriculture
OC	Organic carbon
OPADC	Oromia Pastoral Area Development Commission
PADO	Pastoralist area development Office
pH	Power of hydrogen
SOM	Soil organic matter
SRM	Society of Rangeland Management
SSA	Sub-Saharan Africa
TLU	Tropical Livestock Unit
TN	Total nitrogen
UNDP	United Development Program

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Effect of Enclosures on Vegetation Composition, Species Diversity and Soil Physico-Chemical Properties in Semi-Arid Range lands of Meyumulu districts, East Hararghe, Ethiopia

ABSTRACT

Grazing is the most important factor affecting vegetation and soil properties in range lands. It has a critical impact on range land biodiversity and vegetation composition. Use of enclosures area in many parts of semiarid range lands of the world has gained widespread acceptance as means to restore degraded range land ecosystems. Therefore, this study assesses the effect of range land enclosures on vegetation composition and species diversity and soil physico-chemical properties in semi-arid range lands of Meyumulu districts in East Hararghe Zone, Oromia Region of Ethiopia. For the vegetation and soil data collection, line transect technique was used for enclosure and communal grazing area in this study. In both enclosure and communal grazing areas a total of 36 quadrants of 20mx20m were established along 12 parallel line transects by 200m interval. These 20mx20m quadrants were used for woody vegetation data collection. Within quadrants of 20mx20m again five 5m×5m (for shrub) and five 1mx1m (for herbaceous and soil) sub-quadrants were established, four at the corners one at the center. This forms the total of 180 (5mx5m) and 180 (1mx1m) for both enclosure and communal grazing areas. T-test was employed to compare mean differences between enclosures and communal grazing areas. Enclosure area enhances herbaceous species diversity and reduces the woody species compared to communal grazing area. The result indicated that Shannon diversity index and species richness of woody vegetation were significantly ($P<0.05$) higher in communal grazing area, while, the Shannon diversity index and species richness of herbaceous vegetation were significantly ($P<0.05$) higher in enclosure area compared to communal grazing area. Likewise textural differences were also observed between enclosure and communal grazing area. Where the study revealed that, sand fraction was significantly ($P<0.05$) higher in communal grazing, while, silt fraction was significantly ($P<0.05$) higher in enclosure area. The soil chemical property such as soil organic matter, nitrogen and soil reaction of the enclosure area were significantly ($P<0.01$) higher as compared to communal grazing area. In general the result of this study showed that the establishments of enclosure area in semi-arid range land has positive effects on herbaceous vegetation composition that could also, improve soil properties while it reducing the diversity of woody vegetation.

Keywords: *Communal grazing area, herbaceous plant species, woody plant species, soil texture*

1. INTRODUCTION

Range lands are globally the most extensive ecosystem which cover approximately more than the half of the world land mass which account 40-70% of the world earth surface (Kutoya *et al.*, 2018; Niamir *et al.*, 2012). In addition, range land ecosystem which more than 80 % located in arid and semiarid zones (Behmanesh *et al.*, 2015). These ecosystems are extremely important to societies in terms of the ecosystem supportive, regulatory, and provision services they provide to societies. Globally range land ecosystem supports 1 to 2 billion people and provides habitats for domestic livestock and wildlife globally (Niamir *et al.*, 2012). In addition, Range land ecosystems provide habitats to nearly half of the endemic bird species and the largest concentrations of terrestrial wild animals (Niamir *et al.*, 2012).

The range land ecosystems occupy 66% surface area of the African continents and are the home to 268 million people (Bolo *et al.*, 2019). Particularly, in sub-Saharan Africa (SSA) range lands accounts 62% of SSA land area and these area supports 38% of SSA population (Liniger and Mekdaschi, 2019). Friedel *et al.* (2000) reported that, range lands in Africa are the major sources of feed for animals and constitute about 65 % of the total land area which supports 59 % of all ruminant livestock. Approximately 25 million pastoralists and 240 million agro-pastoralists are found in SSA (AU-IBAR, 2012).

The Ethiopian range lands comprise 62% (767,000km²) of the total area of the country are mainly located within the arid and semi-arid agro-ecological regions below 1,500 masl (Alemayehu *et al.*, 2018). In Ethiopia, 12-15 million pastoralists people (Gebremichael *et al.*, 2010) depend on livestock as their primary source of income. In Ethiopia, pastoralists have thought to live and spread across seven regions of the country and these areas accounted 60-65% of the total area of the country (Sisay *et al.*, 2015). In Oromia Region, 43 Districts has categorized as pastoral and semi pastoral, occupying about 40% of the landmass in Oromia Region (Zewdie *et al.*, 2020). MoA (2020) reported that, range land ecosystems supports about 37% of the Ethiopian people, of which 17% were mobile pastoralists and 20% were agro-pastoralists. Ethiopian range lands supports 100% of Ethiopia's camels, 28% of its cattle, 70% of its goats and 30% of its sheep (Reid *et al.*, 2021).

However, range lands in East Africa in general that of Ethiopia in particular have been faced many different forms of land degradation due to poor management, population growth, deforestation, continuous heavy grazing, as well as land use and climate changes over the last 50 years (Tessama, 2011; Angasa and Teshome, 2016). Hence, the loss of range land resources and biodiversity are serious challenges, causing negative impacts on the range land ecosystems, livestock production and livelihoods of the pastoral communities in dry land areas of Ethiopia (Tessama, 2011; Buli, 2018).

Although extensive livestock grazing pressure is dominant in Ethiopia, it is also common to see the practice of different customary management practices as an adaptive strategy to livestock feed shortage. Pastoralists in Ethiopia have various traditional natural resource management strategies. The knowledge includes mobility, prescribed fire, herd splitting, range land enclosure, and bush thinning and cutting invasive trees (Angasa *et al.*, 2012). Indigenous knowledge of pastoralists (customary management practices) provides a basis for developing alternative ways of managing resources in dry land (Angasa and Teshome, 2016).

Meyumuluke district, which is located in East Hararghe Zone of Oromia Region, Ethiopia, typically characterized with arid and semi-arid climatic condition. East Hararghe has five districts where pastoralism and agro-pastoralists livelihood has practiced from which Meyumuluke district is one of them. This district is an important site in East Hararghe Zone, which has relatively larger range land (dominated by grass and shrubs) and large amount of livestock population herding. Meyumuluke districts accounting for about 20% coverage of the land area of East Hararghe Zone and the second largest district after Kumbi districts in terms of livestock population holding (Zewdie *et al.*, 2020). The district has characterized by arid and semi-arid climate condition with erratic and highly variable rainfall coupled with long dry spells after which the existing animal feed resource become inadequate.

In the past, pastoralists use range land based on season pattern (dry and wet season grazing area). Presence of rich pastureland and palatable bushes that exist within districts was the main grazing resources for their livestock during the wet season. Recently because of human settlement for the border conflict and agricultural expansion in districts, mobility is restricted to the only wet season grazing area, result range land degradation. Currently pastoralist in the

districts shifting range lands to private area enclosure in response to range land resource degradation and livestock feed shortage. The local community started range land rehabilitation efforts through the implementation of enclosure area since 2012/13 national government started watershed management strategy. In the districts, the privately managed enclosure area has more practiced than government and other organization means in the districts there has only privately owned and managed enclosure.

Although many studies have conducted in most range land areas of Ethiopia on the effects of range land enclosure response on vegetation and soil physico-chemical properties (Mekuria and Mastewal, 2013; Mekuria *et al.*, 2017; Nuru, 2019; Tesfaye *et al.*, 2020; Fenetahun *et al.*, 2021). Research and development agents concerning effects of enclosure on range land vegetation and soil properties, specific to the current study area is not exist. In addition, unlike pastoral area of Ethiopia like Somali (Amaha *et al.*, 2012; Buli, 2018; Dargo and Haftay, 2019), Afar (Asheber et al, 2010 Mohammed *et al.*, 2018) and Borana (Alemayehu *et al.*, 2018; Fenatahun *et al.*, 2018, 2021) relatively less emphasis is given to East Hararghe pastoral area. Information is very scarce with regard to range land condition, management strategy and their response on livestock grazing management system in the semiarid range lands of East Hararghe, especially in Meyumulu district. Because of the range lands in Ethiopia are so widespread, temporally and spatially and diverse in structure and function, conducting site-specific research is important to design or to implement sustainable ways of using range land resources and the long-term enhancement of range land productivity.

Therefore, this study was been designed to assess the impact of enclosure area managements on range land vegetation composition, distribution, species diversity and soil physico-chemical property in the semi-arid range lands in Meyumulu districts of East Hararghe. This research output would help as firsthand information for stakeholders to get comprehensive valuable information to identify examples of best practice in the development, implementation and assessment of biodiversity and ecosystem services action plans in pastoral land use systems and decide the way forward how it will governed for biodiversity conservation and improving range land productivity. As a result, enhancement of range land resources potential in the vast range land ecosystems is expecting to improve the food security, climate change adaptation and mitigation capacities of the pastoral communities in Ethiopia.

1.1. Objectives of the Study

1.1.1. General objective

The general objective of the study was to assess the effect of enclosures area on vegetation composition, species diversity and soil physico-chemical properties in semi-arid range lands of Meyumulu districts of East Hararghe, Ethiopia.

1.1.2. Specific objectives

The specific objective these studies were:-

- To assess the effects of enclosures area on woody vegetation floristic composition and species diversity of range lands in Meyumulu districts
- To assess the effects of enclosures area on herbaceous vegetation floristic composition and species diversity in Meyumulu districts
- To determine the effects of range land enclosure on soil physico-chemical properties in the Meyumulu districts

2. REVIEW OF LITERATURE

2.1. Overview of Rangelands Resources

Rangelands are the vastest terrestrial ecosystems on the earth, of which more than 80 % located in arid and semiarid zones (Behmanesh *et al.*, 2015). Rangelands cover 54% of global terrestrial surface (Niamir *et al.*, 2012; ILRI *et al.*, 2021) and it supports 78% of the global grazing area (Asner *et al.*, 2004; ILRI *et al.*, 2021). All dry lands are found in range land areas. 78% of range lands are classified as dry lands (ILRI *et al.*, 2021) Rangelands include grasses, grass-like plants that combined with various degrees of bush and tree cover, predominantly grazed or browsed, and used for the production of livestock and safeguarding of wildlife and additional ecosystem services (Allen *et al.*, 2011). Major vegetation types of the global range land are: grassland 42%, shrub land 23% and woodland 12%, with the other vegetation types forming 23% of the earth's land surface (ILRI *et al.*, 2021).

In African range lands ecosystem estimated to occupy, 66% surface area of the continents (Bolo *et al.*, 2019) and are the home to 268 million people (Anderson *et al.*, 2004). Across different African country there are variations, for example, land surface coverage of range land areas 44% in Uganda and 65% in Ethiopia and 74% in Tanzania and over 80% in Kenya (Bolo *et al.*, 2019). In sub-Saharan Africa (SSA) range lands accounts 62% of SSA land area and these area supports 38% of SSA population (Liniger and Mekdaschi, 2019). In sub-Saharan Africa, 40% of dry lands are used primarily for livestock production under pastoralist and agro-pastoralists systems (Nyberg *et al.*, 2019).

These ecosystem are extremely important to societies for the ecosystem supportive, regulatory, and provision services they provide to societies. It supports 1 to 2 billion people and provide habitats for domestic livestock and wildlife globally (Niamir *et al.*, 2012). Range land ecosystems provide habitats to nearly half of the endemic bird species and the largest concentrations of terrestrial wild animals (Niamir *et al.*, 2012).

Rangelands have environmental, social and economic benefits, including support to national economies through tourism and employment (Bolo *et al.*, 2019). In addition, range lands in Africa provide important forage resources for herbivores; particularly perennial grasses

provide grazing for domestic and wild herbivores (Tessama, 2011). These ecosystems support large domestic and wild herbivores in of SSA that, 57% cattle, 55% goats, 56% sheep and 17.4 protected area of SSA (Liniger and Mekdaschi, 2019). Approximately 25 million pastoralists and 240 million agro pastoralists in SSA depend on livestock as their primary source of income (AU-IBAR, 2012).

The Ethiopian range lands comprise 62% (767,000km²) of the total area of the country are mainly located within the arid and semi-arid agro-ecological regions below 1,500 masl (Alemayehu *et al.*, 2018). The Ethiopian range lands as reported by (Gemedo *et al.*, 2006) consist of mainly native vegetation (grass, forbs and woody plant species), which are major sources of feed for grazing and browsing. In Ethiopia, Gebremichael *et al.* (2010) reported that 12-15 million pastoralist people have thought to live in these areas and spread across seven regions of the country. In the same way Alemayehu (2004) reported that range lands play an important role in the national economies of less developed countries like Ethiopia, in which a large number of the population depend on the native forage produced by range lands. Ethiopian range lands supports 100% of Ethiopia's camels, 28% of its cattle, 70% of its goats and 30% of its sheep (Reid *et al.*, 2021).

2.2. Cause of Range Land degradation in Ethiopia

Rangelands are currently being lost because of land degradation, conservation projects, to crop and urban land and other factors at an alarming rate (Milne 2016). The decline in range land resources and livestock productivity are among the most serious problems worldwide (Oba *et al.*, 2000) and Ethiopia is not exceptional. Niguse and Gizachew (2014) reported that most of the tropical country's range lands have lost the productivity mainly due to wrong ways of resources exploitation. Hussein (2021) reported that in the low lands of Ethiopia, range land degradation continues to be a major hindrance to improving pastoral livelihoods. Similarly, Mohammed *et al.* (2016) reported that in Ethiopia range land has resulted in substantial declines in range land condition, water potential, soil status, and animal performance.

The commonly cited causes of range land degradation in Ethiopia in dry land areas were climate change, overgrazing, bush encroachment, population pressure, drought, policies, encroachment of rain-fed agriculture, and the demise of traditional resource management

institutions (Alamayehu *et al.*, 2018; Hussein, 2021; Reid *et al.*, 2021). Similarly, Angasa and Teshome (2016) and Musa *et al.* (2016) reported that, heavy grazing, recurrent droughts, range land cultivation, bush encroachment, human population pressures are the possible causes of range land degradation in Ethiopia.

Among the cause of range land productivity reduction, overgrazing due to extensive livestock production is one of critical problems that resulted in deterioration of the range land condition in most tropical countries (Niguse and Gizachew, 2014). Overgrazing is one of the primary contributors to grassland degradation around the world, through the reduction in vegetation cover, degradation of topsoil, causing soil compaction (Alemyehu, 2004). In addition, Tesema *et al.* (2011) and Asheber *et al.* (2010) reported that, heavy grazing in a semi-arid savanna of Ethiopia reduced in soil quality parameters which consequently affected the growth, diversity, abundance, above ground standing biomass and the basal cover of herbaceous species.

2.2. Range land and Pastoralism in Ethiopia

Ethiopian pastoralists are the major pastoral constituency of the Horn of Africa pastoralist people (Amaha, 2002). In Ethiopia pastoral community are found in North-Eastern, Eastern, Southern-Eastern, and Southern, and Southwestern part of the country (MoA, 2020). The dry lands of Ethiopia has been dominated by range land-based livestock production systems known as pastoralism and agro pastoralism, and comprise about 62% (767, 000 km²) of the country's land area (Alemayehu *et al.*, 2018). MoA (2020) reported that, range land ecosystems supports about 37% (26.6 million) of the Ethiopian people, of which 17% (12.2 million) were mobile pastoralist and 20% (14.4 million) were agro-pastoralist. Likewise, Reid *et al.* (2021) reported that, Ethiopian range lands supports 100% of camels, 28% of cattle, 70% of goats and 30% of sheep out of the countries livestock.

In pure pastoral areas, the density of settlement is generally lower and spatial coverage of any given Kebele is larger than in the highlands (MoA, 2020). In Ethiopia Pastoralists are exists in seven regions including Afar, Somali, Southern nation nationalities and people, Oromia, Diredawa, Benshangul Gumuz and Gambella Regional States (Sisay *et al.*, 2015). Likewise, Buli (2018) reported that the distribution of Ethiopian pastoralist as whole of Somali region 57% of pastoralists, the Afar region 26% of pastoralists and Oromia region 10% of pastoralist.

The remaining 7% of Ethiopian pastoralists inhabit the lowlands of the Southern, Gambella and Beni Shangul regions (Sisay *et al.*, 2015; MoA, 2020). In Oromia, 43 woredas are categorized as pastoral and semi pastoral, occupying about 40% of the landmass (Zewdie *et al.*, 2020).

2.3. Traditional Rangeland Management Practice in Ethiopia

East African Pastoralists has their own traditional indigenous knowledge of resource use systems that enable them to cope with harsh environmental condition and to assess the suitability of grazing lands (Oba, 2009; Angasa and Teshome, 2016). This indigenous knowledge of pastoralist traditional grazing management practices provides a basis for developing alternative ways of managing resources in dry land (Angasa and Teshome, 2016). MoA (2020) reported that, range land ecosystems supports about 37% (26.6 million) of the Ethiopian people, of which 17% (12.24 million) were mobile pastoralist and 20% (14.4 million) were agro-pastoralist.

Local community in different parts of Ethiopia (Borana, Afar and Somali pastoralists) has their own customary institutions as means of common resource management (Galgalo *et al.*, 2016; Galgalo, 2018). Likewise, MoA (2020) reported that, traditionally, the pastoralist of Borana, Somali, Afar, SNNPR (Mursi and Hamar) and Gambella (Nuer) have important traditional systems and institutions, which has to consider. The pastoral community has managed their range lands resources under collective common property arrangements through their customary system for centuries (Sisay *et al.*, 2015). Customary pastoral range land management practices exist in Ethiopia include mobility, use fire, herd splitting, range land enclosure, bush thinning and cutting invasive trees (Angasa *et al.*, 2012; Angasa and Teshome, 2016).

In Eastern Africa including Ethiopian pastoralist, livestock grazing has geographically distributed in terms of dry season and the wet season for grazing area (Oba, 2009; MoA, 2020). Pastoralist's customary resource management which has been carried under institutional structure of the communities has maintained the resources in sustainable way for long period. Galgalo (2016) and MoA (2020) reported that Borana herders categorize their landscape into two macro landscapes, namely *badda* (cool sub humid uplands) as dry-season grazing and

gamoji (warm lowlands) as used for wet-season grazing. Range land rotation during the wet and dry seasons traditionally prevented overgrazing (Angasa and Oba, 2008). In addition, Agrawal (2010) reported that mobility is the most common and seemingly natural response to environmental risks. However, this good system of pastoralist livelihood of using natural resource in dry lands has weakened because of different internal and external factors. Excellent system of resource management has weakened through time with influence of different external factors like state intervention, privatizations of range land resources and marginalization of indigenous knowledge of community natural resource management (Galgalo, 2018).

2.4. Vegetation Structure and Species Diversity

The term species diversity refers to a variety of vegetation existed in a given area. Species diversity is a fundamentally multidimensional concept that includes species richness, abundance, and evenness (Purvis and Hector, 2000). Species diversity has identified as one of the key indices of sustainable land-use practices that thought to be helpful in the restoration of degraded and depleted areas (Shackelton, 2000). Biodiversity is the number (variety and variability of living organisms) and it measured at three levels (alpha, beta, and gamma) diversity.

On the other hand, the diversity of species (species richness and evenness) will be determined using the Shannon-Wiener Diversity Index (H') and Evenness or Equitability Index (E) (Krebs, 1999). Richness is the total number of given species in a quantified area and Evenness is a measure of similarity of the abundances of the different species in a given site (Krebs, 1999). Species richness and evenness are one of the diversity measurement techniques of a given area. The species richness index has great importance in assessing taxonomic, structural and ecological values of a given habitat, whereas evenness is a measure of the abundance of the different species that make up the richness of the area (Kent and Coker, 1992).

2.5. Rangeland Soil and Their Physico-chemical Properties

Soil is the most important component and is the factor that can determine the productivity of rangeland ecosystems. The survival and physical condition of plants depend on the regular

supply of mineral nutrients from the soil to the vegetation (Badshah, *et al.*, 2012). Azis *et al.* (2015) reported that the determiner of soil physico-chemical (soil nutrient) includes; soil moisture content, soil pH, soil electrical conductivity, nitrogen content, soil organic matter, phosphorus content, etc. Besides it has been reported that, acidity or pH, salinity and conductivity of the soil highly affect plant growth and somehow, relate to SOM, but inversely proportional. The other physical soil property is soil moisture content, which depends on the water content in the soils. The amount of water in the soil was mostly influenced by the quantity of precipitation occurred in that area and is determined by the gravimetric method (oven-drying method) (Carter, 1993).

There is a linear relationship between soil factors such as organic carbon and soil organic matter and plant diversity and species richness. The pH parameters and electrical conductivity has found to be closely related each other, because both parameters refer to the number of ions present in the soils (Azis *et al.*, 2015). Improvement in vegetation has significant effects on soil pH and electrical conductivity. The effect of soil pH is confounded with other soil chemical properties; there is a tendency of positive relationships between vegetation species richness and increased soil pH (Buli, 2018).

2.6. Impact of Grazing on Vegetation structure

Grazing is the most important factor affecting vegetation and soil in range lands; it has a critical impact on range land biodiversity and vegetation species composition (Angasa, 2014; Azis *et al.*, 2015; Buli, 2018). Holechek *et al.* (1998) defined grazing intensity as the cumulative effects grazing animals have on range lands during a particular time and its measurement include Percent herbage use, amount of forage standing crop remaining at the end of the grazing cycle, etc. The degree of grazing strongly affects the structure, composition of vegetation and soil quality (physical and chemical property) on range lands; this shows an overgrazing has strong influence of on the soil chemical properties (Buli, 2018). Alemayehu (2006) reported that grazing management is very important for range lands to increase vegetation cover and livestock productivity. In conditions of poor vegetation cover due to overgrazing, practicing the controlled grazing management has considered beneficial to restore

degraded range lands as it enhances vegetation cover and the vigor of mature perennial grasses (AU-IBAR, 2012).

In Ethiopia, numerous studies have examined the influence of grazing on the vegetation and soil properties of the range land ecosystem in different parts of Ethiopia (Asheber *et al.*, 2010; Angasa, 2014; Mengistu *et al.*, 2015). All these authors showed that, the degree of grazing (heavy, moderate and light grazing) has their impact on range land condition. All of them argued that it is significantly different between heavily grazed and lightly grazed sites on vegetation structure and soil condition.

2.7. Impact of grazing on species diversity

Species diversity refers to a quantitative measure of species within an area and it represented by species richness and diversity the evenness of species in a given area. A finding of many authors confirms that the degree of grazing has its effect on vegetation structure and species diversity of a range lands. Grazing intensity has its effects on range land vegetation structure and species diversity (Coppock, 1994; Solomon *et al.*, 2007). The study of (Tesema *et al.*, 2011; Angasa, 2014) confirmed that grazing had a significant effect on herbaceous species richness that, heavy grazed sites had less herbaceous species richness than light and moderately grazed the site. Therefore, grazing can cause both negative and positive impacts on range land to depend on the degree of intensity.

Negative impact has caused by over exploitation of forage resources in range areas due to growing animal population especially livestock, causes changes of botanical composition (open grassland into dense bush land) and nutritional quality of vegetation because of overgrazing. Angasa and Baars (2000) and Solomon *et al.* (2007) reported that in range land overgrazing increase woody bush by reducing herbaceous biomass production and shift in vegetation botanical composition. In addition, Tesfay *et al.* (2020) in northern Ethiopia range land and Dargo and Haftay (2019) in eastern Ethiopia range land reported that the enclosure management had higher herbaceous species richness than the grazed site. Similarly, Tesama *et al.* (2011) reported that the lightly grazed sites had significantly higher herbaceous diversity compared with the heavy grazed sites.

On the other hand, positive effects of light to moderate grazing can increase plant regeneration. For instance, numerous authors argued that synchronized with grass growth stages were beneficial to plant growth mechanisms and ecosystem processes and stimulates greater herbage production. Asheber *et al.* (2010) reported that properly managed livestock grazing contributes to improved pasture and range land management and stimulus to grass vigorous growth and healthy root systems. Besides, Angasa (2014) reported that light and moderate grazing could promote herbaceous species richness while heavy grazing intensity adversely affects species richness. In the same way Angasa and Oba, (2008) suggested that livestock grazing used to increase soil fertility and facilitate pollination of the vegetation.

Heavy grazing cause undesirable change in herbaceous species composition as it replaces perennials with annual grasses (Fenetahun *et al.*, 2018). Mengistu *et al.* (2015) and Angasa, (2014) reported that, heavy grazing pressure reduces plant species composition and basal cover. In addition, Asheber *et al.* (2010) reported that, botanical composition of the herbaceous plants which are highly desirable perennial (decreasers) species were decreasing while increasers increasing as grazing intensity increase. On the other hand, Amaha *et al.* (2008) indicated that, encroached bush woody species increases in Borana range land due to overgrazing.

Traditionally, pastoralist was practicing systematic seasonal mobility between dry and wet season grazing area (Oba, 2009). Now a day, this system has disrupted because of the expansion of cultivation and following sedentarization. Kidane, (2006) reported that, the biophysical condition such as vegetation cover, soil fertility, feed biomass production, and plant bio-diversity in Ethiopian range lands have been degraded at an alarming rate causing the loss of perennial species due to the management system (lack of pastoral mobility).

2.8. Impact of grazing management system on soil physico-chemical property

Soil is the most important component of range land ecosystems; survival and physical condition of plants depend on the regular supply of mineral nutrients from the soil (Badshah *et al.*, 2012). Millennium ecosystem assessment (MEA, 2005) indicated that the maintenance of

healthy soils in range lands is a critical management issue that determining vegetation production, cover, and composition the livelihood of over 2.5 billion people, most of whom their life directly relies upon the ecosystem services of range lands.

Livestock grazing has often perceived as the prime cause of range land degradation. It has a critical impact on range land biodiversity, soil erosion, soil nutrient cycling, hydro logical processes, etc. Overgrazing, is the major cause of range land degradation that, soil macro nutrients, such as nitrogen, phosphorus and potassium, those greatly determine the ecosystem productivity (Bolo *et al.*, 2019). Livestock grazing and their trampling have marked effects on vegetative cover, soil quality and nutrient loss due to erosion (Lipson *et al.*, 2011). These are due to the exposition of degradation of sparse range land vegetation by overgrazing exposes the soil to erosion by wind and water. Grazing affects the flux of nutrients in grazing lands through trampling, consumption, excreta deposition, redistribution, and export (Tessema *et al.*, 2011). In addition, Tessama (2011) reported that the total nitrogen, cation exchange capacity, and pH were higher under light grazing and electrical conductivity has not significantly affected by grazing pressures.

2.9. Enclosure Area as a Degraded Range land Restoration Measure

The enclosure is the way that made the range land area free from grazing for a specified period and it is highly practiced in a different part of Ethiopia (Mohammed *et al.*, 2016). As reported by AU-IBAR, (2012), enclosure is a common technique that has been successfully tested in restoring degraded range lands whereby grazing is excluded for a specified period. Use of enclosures as a means to restore degraded range land ecosystems in many parts of the world's semiarid range lands has gained widespread acceptance (Verdoodt *et al.*, 2009). In addition, Mekuria *et al.*, (2017) reported that the establishment of enclosure area has become a common practice in the Ethiopian highlands as degraded ecosystems restoration measure. Likewise, Mekuria *et al.* (2018) reported that enclosure area establishment on degraded lands could support the restoration of degraded native vegetation and soil properties, which consequently enhance the ecosystem services.

Communal grazing enclosures, depending on their size, can threaten overall livestock mobility and increase grazing pressure outside enclosures but also have the potential to restore desired

plant cover (Reid *et al.*, 2021). Enclosures have both positive and negative impacts on pastoralism, depending on whether they are used to rehabilitate the range land or used to excise range land for other uses (Reid *et al.*, 2021). Sometimes pastoralists use enclosures to protect forage for later use or to rehabilitate range lands that have been invaded by woody plants or lost vegetation (Reid *et al.*, 2021). Enclosures are not a panacea for dry land development, but their use need to be recognized and understood (Nyberg *et al.*, 2019).

In different part of Ethiopia enclosure area managed in various forms. Buli (2018) reported that grazing reserves (enclosure) exist in various forms in Somali regional state range land. This includes communal enclosure that group of villages use on communal basis, NGOs introduced enclosure but used by community and private enclosure. Enclosure area management widely practiced in different part of Ethiopia, many authors indicated that enclosure management has positive effect on vegetation and soil nutrient rehabilitation (Mekuria. 2018; Seid *et al.*, 2020; Tesfaye *et al.*, 2020). Likewise, Yayneshet (2011) reported that in the Northern part of Ethiopia, establishment of area enclosure has been taken as an important strategy for degraded rangeland rehabilitations.

2.9.1. Impact of enclosure on herbaceous species composition

As numerous studies indicated, herbaceous species composition in the enclosure sites was in a better condition than those in the open grazing sites. In these regards, Angasa *et al.* (2010) and Tesfaye *et al.* (2020) reported that herbaceous species richness and diversity were greater in enclosures area than in continuously open grazed areas. In addition, Angasa (2014) and Haftay (2017), it has been indicated that continuous open grazing has caused a reduction in species richness, plant abundance, standing biomass and basal cover than the enclosure. In addition Mengistu *et al.* (2015) reported that, the open grazing site had low dry matter yield of herbaceous species, which might be attributed to increased grazing pressure.

Enclosure area displayed higher woody species density, basal area and above ground woody biomass compared to the adjacent grazing land (Mekuria *et al.*, 2018). In addition, Fikadu and Argaw (2021) reported that the floristic composition, density and diversity of woody species as well as the structural composition under enclosures are considerably improved. However, Angasa (2005) indicated that the bush encroachment is a major threat in these enclosures over

time as compared to more regularly grazed range lands. Similarly, Tessema *et al.* (2011) reported that heavy grazing/browsing might cause a reduction of plant species density and diversity over time. Likewise, Tesfaye *et al.* (2019) reported that communal grazing land reduce the density abundance, diversity and richness of woody vegetation as compared with protected natural vegetation area.

2.9.2. Impact of enclosure on soil Physico-chemical property

The impact of the enclosure has not only on vegetation structure but also on the range land soil condition. Continuous overgrazing and overstocking highly affect soil physical, chemical and biological properties of soil (Bolo *et al.*, 2019). Free grazing in turn accelerates soil erosion by wind, since it enhance reduction in ground cover that cause low primary productivity due to in coarseness of the surface soil and loss of nutrients (Qin *et al.*, 2015). Mengistu *et al.* (2015) reported that, as grazing pressure increase in open grazed site the eroded, soil compactness and loss of the soil has higher than the sample from the enclosure. Likewise, Mekuria *et al.* (2018) reported that, enclosure and land management improves soil properties, which consequently supports the restoration of native vegetation while free grazing in the adjacent communal grazing land aggravates soil and vegetation degradation.

Area enclosures promote vegetation coverage, which enhances the amount of accumulated soil organic matter leading to improved physical and chemical properties of soil and overall health of the ecosystem (Mengistu, 2011). In addition, enclosures area management can successfully contribute to biodiversity restoration in highly degraded lands, perhaps due to improvements in the important microclimate conditions such as moisture and organic matter (Fikadu and Argaw, 2021). Similarly, Haftay (2017) indicated that soil nutrients like potassium, soil organic matter and soil organic carbon were higher in the enclosure areas than in the open grazing areas. Besides Haftay (2017) reported that, soil pH, nitrogen, phosphorus, electrical conductivity and soil silt content were higher in open grazing areas than the enclosure. Moreover, Mekuria *et al.* (2013) reported that, enclosure area management enhances the concentrations of soil organic matter and total nitrogen compared to adjacent communal grazing lands. Similarly, Amaha *et al.* (2012) reported that as range land condition decreased from excellent to poor condition and the amount of soil organic matter, organic

carbon and electrical conductivity measured shows significant reduction. Similarly Mekuria et al. (2018) reported that enclosure area establishment enhance the level of electrical conductivity compared to the communal grazing area. This can be higher herbaceous cover at enclosure area than communal grazing land and reduce nutrient leaching by erosion that make soil nutrient higher at enclosure area. In contrary Mekuria et al. (2014) reported that management of enclosure area as no significant effect on the level of electrical conductivity.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

3.1.1. Geographical location

The study was conducted in Meyumulu districts, which is one of the 20 districts located in the East Hararghe Zone, Oromia Regional State, Ethiopia. The district is located 150 km West of Harar the capital city of East Hararghe Zone. It lies between $7^{\circ} 32'$ and $8^{\circ} 54'$ N latitude and $41^{\circ} 39'$ and $42^{\circ} 11'$ E longitude (figure 1).

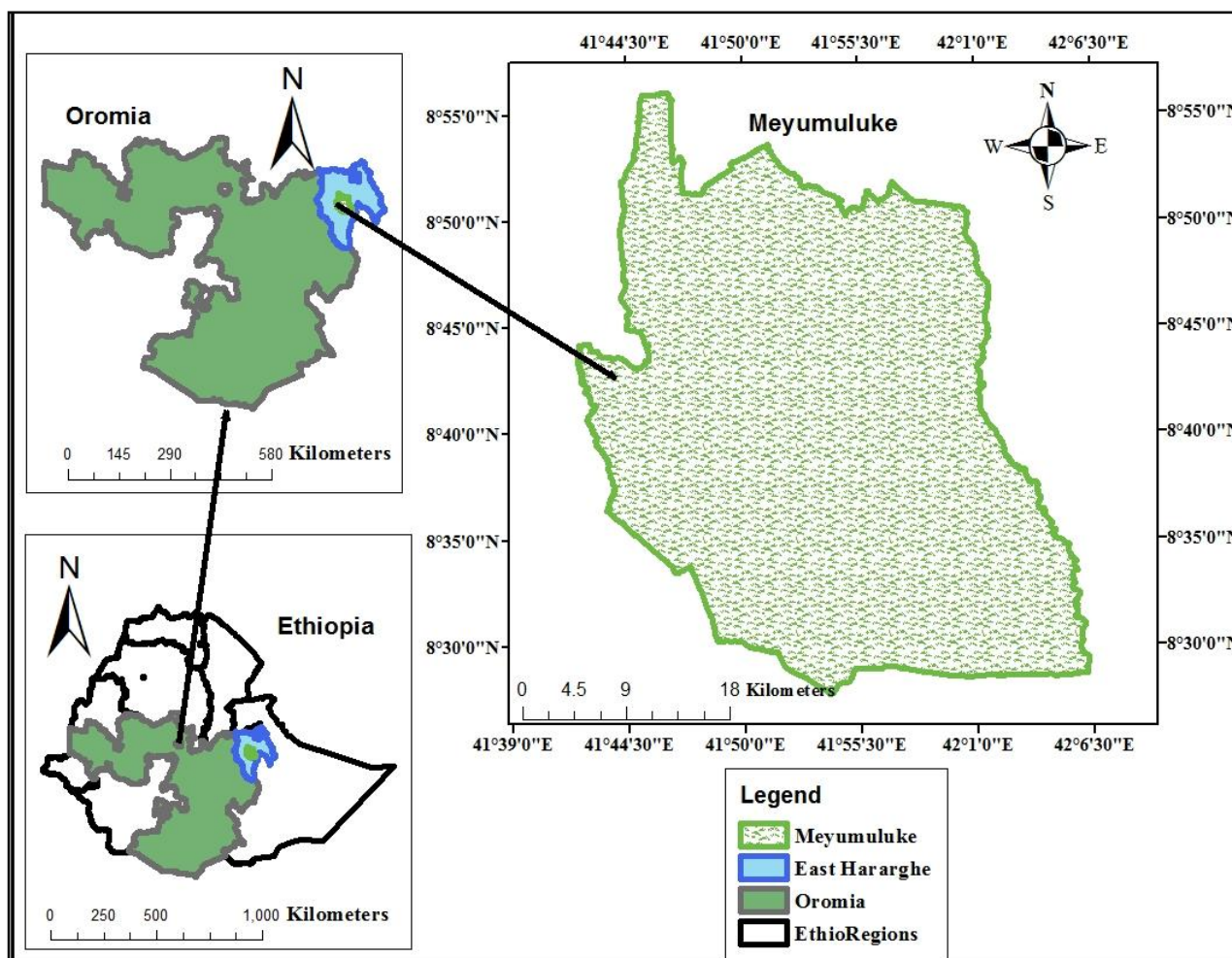


Figure 1: Map of the Study Area

Meyumuluke district has a boundary joints with Girawa and Bedeno districts to the North, Gola Oda district to the West, Kumbi district to the southwest, Midega Tola district to the East and Somali Regional State to the South. Meyumuluke district is composed of totally 19 kebeles of which 18 are rural kebeles and one is urban kebele known as Huse, which is the administrative center of the district.

3.1.2. Climate and topography of the study area

The Meyumuluke districts lies between altitude ranges of 500-1500 meters above sea level with arid and semi-arid (*Kolla*) climatic condition that characterize the district. A significant and major part of the districts falls under the warm semi-arid (kola) climatic zone. The study area experiences a bimodal rainfall pattern with two rainfall seasons, the spring or long rainy season (*Arfasa*) rains starts mid-March- to the end of July and the summer or the short rainy season (*Ganna*) rains starts in September and extend to November while the rest of the year remains dry. The minimum and maximum annual rainfall of the district ranges between 400mm and 600mm and its average minimum and maximum daytime temperature is between 14 and 37 degrees Celsius.

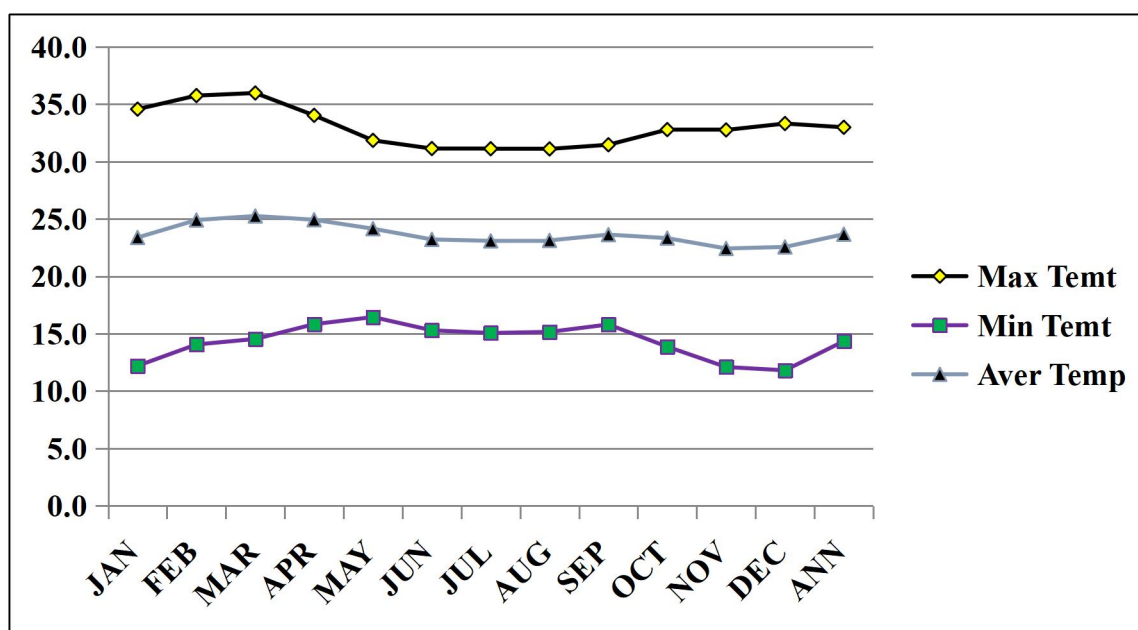


Figure 2: Maximum and minimum monthly and annual average temperature of Meyumuluke district for twelve years (2009-2021).

3.1.3. Human population and Livelihood of the community

The 2007 national census reported total populations of the districts were 46,210, of whom 23,400 were men and 22,810 were women; with 99.48% of the population were Muslim believer (CSA, 2007). However, as recently documented by Zewdie *et al.* (2020), the total human population of the district as of June, 2019, was estimated to be about 90,210 and 93% of them lives in rural kebele.

The communities living in Meyumuluke district are pastoralists and agro-pastoralists who continue to face food insecurity from re-occurring drought and subsequent livestock losses during drought time. More than 55.3% of the population of the district is fully pastoralists while 44.6% is agro pastoralists. Pastoralism plays a vital role in the economy of the district. Pastoralists rear all types of livestock such as camel, cattle, sheep, goats and donkey in the district. Agriculture is practiced by agro-pastoralists in the study area and mostly rain fed, with a subsistence mixed farming system and the most practiced crop was maize and sorghum.

3.1.4. Land use and land cover

Meyumuluke district covers a total area of 4,500 -5000 Km² (450,000 – 500,000 hectares) land coverage and account 20-22% of the East Hararghe land area as documented districts (Zewdie *et al.*, 2020). The forest area covers 290,567 hectares, which is the largest land use/cover of the district and followed by Grazing land that accounts for 111,925 hectares. The agricultural area accounts about 20,154 hectares while the remaining 27354 hectares is covered by Settlement areas and other land use type. There are any perennial rivers and intermittent streams, which are of vital importance to the districts community and pass down across the districts. The major ones include Mojo, Gobeles and Erer rivers.

3.1.5. Vegetation types and wild animals

The vegetation of the study district is predominantly composed of different woody and herbaceous species. Among the woody species of the genera *Acacia*, *Balanite*, *Boswelvia*, *Combretum*, *Commiphora*, *Dichrostachys*, *Grewia*, and *Terminalia* are common. The herbaceous species grass species, of the genera: *Aristida*, *Bothriochloa*, *Cenchrus*, *Cynodon*, *Dactyloctenium*, *Digitaria*, *Eragrostis*, *Echinochloa*, *Heteropogon*, *Hyparrhenia*, *Hypoestes*,

Setaria and *Sporobolus* were the dominant/common species. The genera forbs species of the area are *Chrotalaria*, *Indigofera*, *Belapharis*, *Leucas*, *Ageratum*, *Tribulus*, *Solanum*, *Otostegia* and *Parthenium*.

Babile elephant's territory covers some kebele of the districts and the scout office has been built in two kebeles but not well functional. Wild animal those predominantly existing in the districts includes, smaller animals like Rabbit, Diddic, and Apes and the bigger animal like Hyena, Foxes, Monkey, Tiger, Lion and Elephants, etc. so, also animals that live in water bodies like different variety of fish and crocodile exists in the Mojo river on which recently big irrigation project has been initiated to start in short period coming.

3.1.6. Type of grazing system in the study area

Meyumulu District is one of the pastoral districts, is where the communities livelihood mostly depends on the productivity of range land. The district is characterized by arid and semi-arid climate with erratic and highly variable rainfall coupled with long dry spells in which the existing water sources become inadequate. Pastoral and agro-pastoralist of the districts use seasonal enclosure that used as reserve for the dry season. Rangelands in the district take the largest share being available feed source for the domestic and wild herbivores.

In the past, pastoralists use range land based on season pattern delineating the grazing areas (dry and wet season grazing area). Recently because of human settlement, expansion of agriculture, conflict are the common phenomena in districts in which mobility is restricted to the only wet season grazing area. As a result, the grazing system in the district now a days is continuous rather than rotational. On the other hand, the district is faced repeatedly occurring drought that cause loss of the livestock from year to year. For instance, pastoralist and agro pastoralist communities of Meyumulu districts is continually facing food insecurity from the re-occurring drought and subsequent loss of livestock from shortage of feeds. From 2007-2017, the community had suffered three severe droughts (2007, 2011 and 2017) in which large-scale livestock deaths and migration to neighboring woredas were the devastating challenges of the communities at large (Zewdie *et al.*, 2020).

Even though, the Meyumulukey district is endowed with vast tracts of grazing lands, low and intermittent amount of rainfall has been causing feed shortage, especially during the dry season (Zewdie *et al.*, 2020). In response to natural resource degradation and livestock feed shortage the local community started range land rehabilitation efforts through the implementation of enclosure establishment since 2012/13 inline to the initiative of the government started watershed management strategy. In the districts, the privately managed enclosure area has more practiced than government and other organization.

3.1.7. Livestock population and estimated stoking rate

Meyumulukey is one of East Hararghe districts in which large livestock husbandry is the predominantly practiced for their livelihood. Zewdie *et al.* (2020) reported that Meyumulukey is the second largest districts of East Hararghe Zone after Kumbi in terms of livestock population. Livestock are kept for multiple purposes including source of meat and milk, transportation, means of income and traction purpose. Hence, the districts have known for the high potential of domestic animals. Cattle, goats, sheep, camels and donkeys are the main species of livestock. In the year, 2018 the estimated total number of each herds were 283, 228 heads from which 173,612 (37%) cattle, 156,211 (33.4%) goats, 40,512 (8.7%) sheep, 17,224 (3.1%) donkeys, and 49,312 (10.5%) camels (Table 1).

Table 1: livestock type and population in Meyumulukey districts

No	Livestock type	Total livestock	TLU Factor (FAO 1988)	TLU Equivalent
1	Cattle	173,612	1	173612
2	Goat	156,211	0.1	15621.1
3	Sheep	40,512	0.1	4051.2
4	Camel	49312	1.25	61651.3
5	Donkey	17224	0.5	8612
6	Poultry	30650	0.01	306.5
Total TLU		467,530		263854.1

Source: Meyumulukey pastoral area development office (PADO, 2018); Meyumulukey Districts

Stocking rate is the number of animals on a grazing land for a specified period and usually expressed in TLU ha⁻¹ year⁻¹ (Meshesha *et al.*, 2019). The total TLU in the study area was 263854.1 and the grazing land accounted to be 111,925 ha; from these the stocking density estimated as 2.36 TLU/ha/year.

3.2. Methodology

3.2.1. Site selection and sampling design

Reconnaissance survey was conducted in the study area before the actual fieldwork in order to obtain sufficient information about the condition of range lands and enclosure area managements. In the identified enclosure area selection for data collection the opinion of pastoralist, range land managements and development agents of the agricultural office were involved to assure the similarity among enclosure. Three-enclosure areas with age variability (7-9 years), their size varies (5ha- 9ha) and with approximately same elevation were selected. Near the selected enclosure area three adjacent communal grazing areas were selected to assess the effect of range land enclosures on vegetation structure and species diversity and soil physico-chemical properties in the districts. The open communal grazing area are the vast range land that grazed year-round and exposed to heavy grazing, while enclosure areas refer to protected grazing lands (*kalo*) that are protected by the local community to conserve grass for the dry season grazing.

For the vegetation and soil data collection, systematic line transect technique was used in this study. The total of 12 parallel line transects (6 transects enclosure and 6 transects in communal grazing) were laid down with 100m interval between two transects. Each transect was laid at 70m distances from the edge to avoid the disturbance effects (Tesfaye *et al.*, 2019). By 200m interval along transect three 20mx20m (400m²) quadrant was laid down for woody plants data collection. Which form in total 36 quadrants (18 quadrants enclosure and 18 quadrants in communal grazing) (3 quadrants x 12 transects = 36 quadrants of 20mx20m). For shrub collection, five sub-quadrants of 5mx5m (25m²) within each 20x20m one at the center and four at the corner. Which forms in total 180 sub-quadrants 90 in enclosure area and 90 in communal grazing area (36quadrants x five sub-quadrats = 180). For herbaceous vegetation soil sample collection also five 1mx1m sub-quadrants, one at the center and four at the corner

of 20x20 (at the center of each 5mx5m) were used (Seid *et al.*, 2020). Which in total forms 180 quadrants of 1mx1m 90 in enclosure and 90 in communal grazing area. The mean value of these five sub-plot were use in the analysis.

3.2.2. Vegetation sampling and data collection methods

Woody and herbaceous vegetation species assessment has been conducted after the main rainy season in the month of July 2021 when most plants are in full flowering stage. For the woody vegetation data collection three 20mx20 m quadrant along transects of 200m interval was established for both enclosure and communal grazing areas. This makes a total of 36 quadrants were each 18 of the quadrants were for enclosure and communal grazing. For shrub vegetation's sample data collection, in each quadrant in each 20mx20m five 5mx5m sub quadrants, four at the corner and one at the center forming totally 180 (36x5) quadrants was established in enclosure and communal grazing areas. Likewise for herbaceous species five 1mx1m sub-quadrant was established one at the center and four at the corner of each 20mx20m quadrants of enclosure and communal grazing areas. Making a total 180 (36 quadrant x5 sub-quadrant) quadrants.

In the data collection each the existing tree, shrubs, herbs and grass in the quadrants were counted. The collected data was used to estimate the diversity, frequency, density, abundance of vegetation and for comparison between management systems. Plant identification was undertaken at the field level using their local name with the supports of the local people. The identified plants with local name were translated to scientific name with the help different trees identification manuals and with the help of previous studies conducted on plants species in the area. Furthermore, tree identification was done with the help of Useful Trees and Shrubs for Ethiopia (Bekele, 1993; Fromann and Person, 1974). Each woody plant that were listed at the field and again cross-checked its botanic name using volumes of Flora of Ethiopia and Eritrea and for unrecognized and uncharacterized plants in the Haramaya University herbarium.

3.2.3. Soil sampling and data collection method

To investigate changes in soil parameters within 20mx20m quadrants by zigzag fashion five sub-quadrat of 1mx1m (1m²) four at corner and one at the middle positions quadrants were taken at the depth of 20 cm. Which forming in total of 180 sub quadrants (36 quadrants of 20mx20m x five quadrants of 1mx1m). The soil samples from the same sampling site were pooled and mixed together to form one composite soil sample for each of the six sampling sites. Plant roots, shoots and soil debris were handpicked and discarded from the sample. The composite soil samples was divided into four equal parts, out of which two opposite partition will be randomly taken and dried under the shade of tree. Then each composites were sampled separately and taken to Haramaya university laboratory to test analyze soil Physico-chemical property. Then six composites of soil sample were tested for soil texture, soil pH, total nitrogen, soil organic matter, organic carbon and electrical conductivity were been analyzed at Haramaya University soil laboratory.

In the laboratory, soil samples were oven dried at 105°C for 24 hr. Then, the dried soil was sieved with a sifter of 2 mm to analyze the soil physico-chemical property. For analyzing, Hydrometer method (Gee and Bauder, 1986), Walkley Block method (Walkley and Black, 1934), and Kjeldahl method (Bremmer and Mulvaney, 1982), have used to determine the soil texture, organic carbon and total nitrogen respectively. For soil pH, soil water suspension will be prepared using a soil to water ratio of 1:2.5. The contents will be allowed to equilibrate for 30 minutes and then the pH will be recorded using pH meter with combined glass electrode.

3.3. Data Analysis

3.3.1. Vegetation Data Analysis

For assessing woody and herbaceous species response to enclosure and communal grazing management practices, data was analyzed using different variable response like that of density, frequency, Abundance, species diversity and species similarity.

Density: density has been defined as the total number of individual plants species per unit area.

Relative density (RD): of the species were calculated by using the following formula.

$$RD = \frac{\text{Number of individual species}}{\text{Total number of individuals}} \times 100$$

Frequency (F): Frequency is defined as the probability or chance of finding a plant species in a given sample area or quadrant (Kent & Coker 1992). Frequency is obtained by number of quadrats occupied by a given species per number quadrants thrown and more often and expressed as percentage.

$$F = \frac{\text{Number of quadrats in which a species occur}}{\text{Total number of quadrats throughout the study site}} \times 100$$

Relative Frequency (RF): is the importance of a species within the frequency that can be obtained by comparing the frequency of occurrences of the entire species present.

$$RF = \frac{\text{frequency of a species}}{\text{sum of all frequencies}} \times 100$$

Abundance (AB): abundance was calculated as the sum of the number of all individual species from all quadrats divided by the total number of quadrats.

Relative abundance (RA) was calculated as the ratio of percentage of the abundance of each species divided by the total stem number of all species per hectare.

Diversity: The diversity of species (species richness and evenness) was determined using the Shannon-Wiener Diversity Index (H') and Evenness or Equitability Index (E) (Krebs, 1999).

Species richness: is the total number of given species in a quantified area. Measure this by counting the number of taxa (distinct groups of organisms) within the ecosystem. Species diversity (richness) was calculated using the Shannon–Wiener diversity index (H') (Shannon–Weiner, 1949) which is determined by the following equation:

$$H' = - \sum_{i=1}^s p_i \ln p_i$$

Where: H' = Shannon diversity indices,

s = the number of species,

P_i = the proportion of individuals belonging to the i^{th} species for each quadrant and

$\ln$ = log base

Species evenness: is a measure of the relative abundance of the different species making up the richness of an area. As species richness and evenness increase, so diversity increases. Evenness is a measure of similarity of the abundances of the different species in a given site (Krebs, 1999). Evenness index (J) of species calculated using the Shannon Evenness index by the equation:

$$J = \frac{H'}{H_{\max}} = \frac{\sum_{i=1}^s P_i \ln p_i}{\ln s}$$

Where J = Shannon Evenness index,

S = the number of species,

$H_{\max}$ = is the maximum level of diversity possible within a given population.

3.4. Statistical Data Analyses

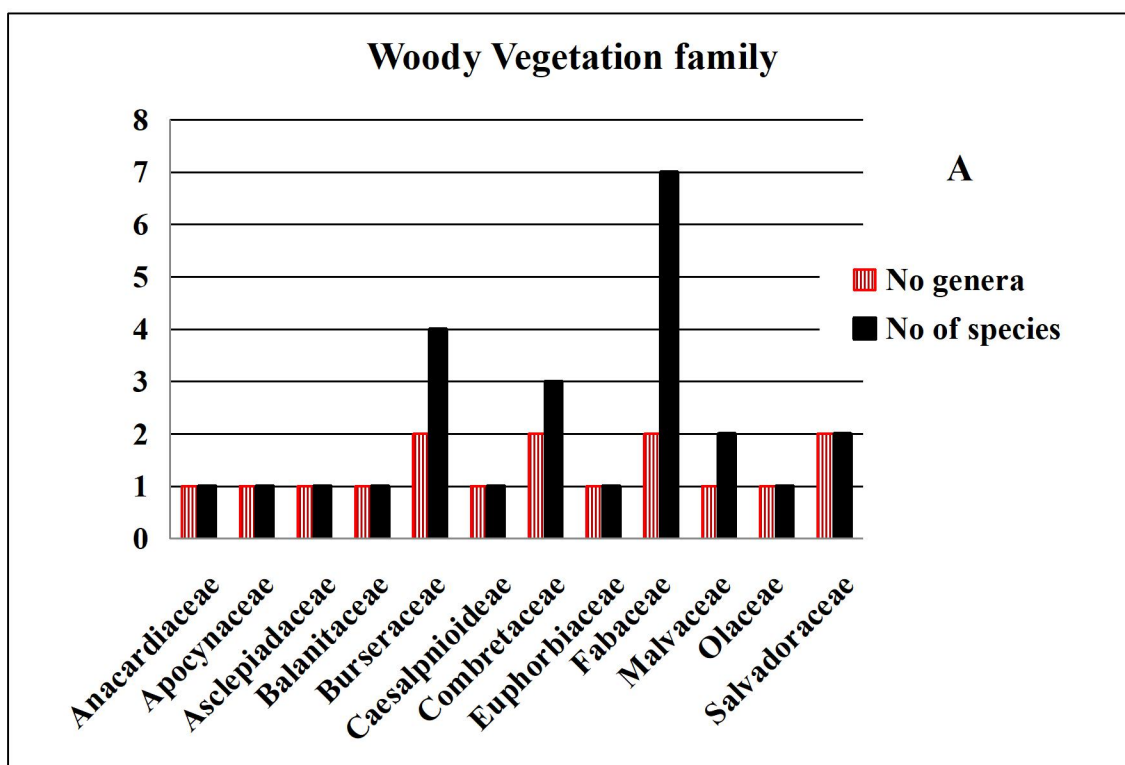
The measured vegetation variable (plant abundance, species richness, species composition, species diversity) and soil properties (Soil texture, SOM, pH, OC, TN and EC) were calculated. The vegetation and soil properties variable mean difference between enclosure and communal

grazing areas were tested with t-test. The mean difference between enclosure and communal grazing area were considered significant at $P < 0.05$. All data were analyzed on the spreadsheet of SSPS 20 software after some descriptive statistics has done with MS-Excel spreadsheet version 2016.

4. RESULT AND DISCUSION.

4.1. Woody Species Botanical Composition

In the study area 12 family, 16 genera and 25 species of woody vegetation were recorded (Figure 3A) the life form distribution of Tree, Shrub Tree/Shrub account 44 % (11 Species), 40 % (10 Species) and 16% (4 Species) respectively (Figure 3B). *Fabaceae*, *Burseraceae*, *Combretaceae* and *Salvadoraceae* family holds 50% (8) of the study area genera by comprising each two genera, while the rest eight family accounts only the rest 50% (8) genera,. In the study area, *Fabaceae* was found to be the most species-rich family comprising 28% (7) of the total plant species identified, followed by *Burseraceae* and *Combretaceae* account 16% (4 species), and 12% (3 species) of total plans species recorded. *Salvadoraceae* and *Malvaceae* families were contributed 8% (2) species each while the rest seven families (Fig. 3A) were less diverse and contributed only one species individually.



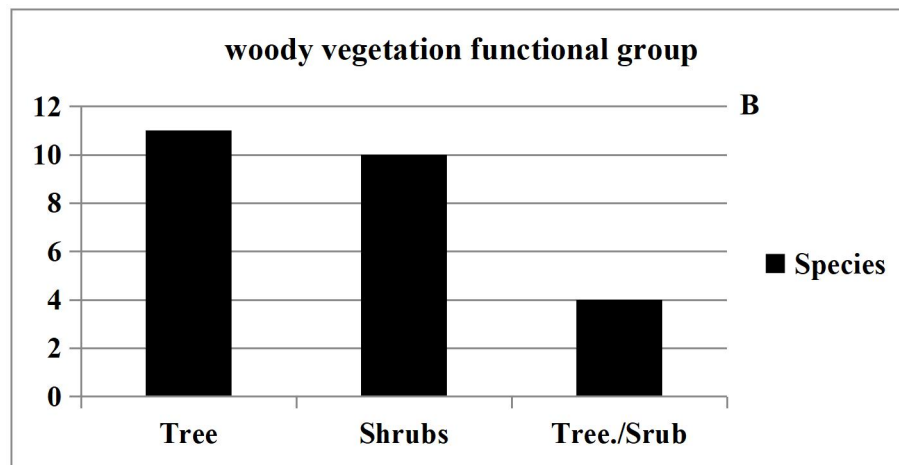


Figure 3: Composition of the woody species by (A) family, genera and species, (B) by functional group proportion in the range lands of study area

The study resulted with lower species composition but in respect to functional groups proportion was in agreement with other studies under taken in different part of Ethiopia of approximately the same agro-ecology. Fikadu and Arggaw (2021) recorded that 74 species in southern Ethiopian lowlands and Seid *et al.* (2020) reported 40 woody species in Afar range lands.

In this study, the result indicated that, the *Fabaceae* species were the common and diverse vegetation communities followed by *Burseraceae* and *Combretaceae*. In the study that has done in northern Ethiopia *Fabaceae* has higher dominance than other species (Tesfay *et al.*, 2019). Mekuria *et al.* (2018) reported that *Fabaceae* family contributed greater number of species as compared to other family. Similarly, Seid *et al.* (2020) reported that the dominant families of the range land vegetation in Afar region was *Fabaceae* that make the area suitable for livestock grazing and browsing. This dominance could attributed to the adaptation potential of *Fabaceae* family to diverse ecologies of the country (Tesfay *et al.*, 2019).

4.1.1. Effect of enclosure on density, frequency and abundances of woody vegetation

In the study area total woody plants species density per hectares were 1276 in enclosure area, from which Tree, Shrubs and Tree/Shrubs were 515, 535 and 226 respectively. While in communal grazing, the density in total 2021 of which Tree, Shrub and Tree/shrubs were 762,

917 and 342 respectively (Table 2). The total abundance of tree, shrub and tree /shrub in enclosure were 20.7, 21.4 and 9.1 while in communal grazing 30.48, 36.68 and 13.68 were recorded respectively (Table 2).

Table 2: Density, Frequency and Abundances of woody species in enclosure and communal grazing area.

Scientific name	FG	Family name	DE		FR		AB	
			EA	CG	EA	CG	EA	CG
<i>Acacia brevispica</i>	S	<i>Fabaceae</i>	61	112	35	55.5	2.4	4.48
<i>Acacia brusseii</i>	T	<i>Fabaceae</i>	87	156	55.2	72.2	3.5	6.24
<i>Acacia mellifera</i>	T/S	<i>Fabaceae</i>	77	122	43.3	88.8	3.1	4.88
<i>Acacia oerfota</i>	S	<i>Fabaceae</i>	57	161	45	61.1	2.3	6.44
<i>Acacia Senegal</i>	T/S	<i>Fabaceae</i>	72	114	46.6	66.6	2.9	4.56
<i>Acacia tortilis</i>	T	<i>Fabaceae</i>	79	111	61	81	3.2	4.44
<i>Balanite aegyptiaca</i>	T	<i>Balanitaceae</i>	24	39	28.8	38.3	1	1.56
<i>Boswellia neglecta</i>	T/S	<i>Burseraceae</i>	45	54	38.8	38.8	1.8	2.16
<i>Calotropis procera</i>	S	<i>Asclepiadaceae</i>	28	28	22.2	22.2	1.1	1.12
<i>Carrisa adulis</i>	S	<i>Apocynaceae</i>	50	84	35.3	33.3	2	3.36
<i>Cassia singueana</i>	S	<i>Caesalpniioideae</i>	44	47	38.8	44.4	1.8	1.88
<i>Combritum collinum</i>	T	<i>Lamiaceae</i>	39	45	23.3	43.3	1.6	1.80
<i>Combritum molle</i>	T	<i>Combretaceae</i>	22	34	22.2	26.6	0.9	1.36
<i>Commiphora erythraea</i>	T	<i>Burseraceae</i>	39	80	33.3	43.3	1.6	3.20
<i>Commiphora kua</i>	T	<i>Burseraceae</i>	33	49	33.3	43.3	1.3	1.96
<i>Commiphora myrrha</i>	T	<i>Burseraceae</i>	21	22	16.6	36.6	0.8	0.88
<i>Dichrostachys cineria</i>	S	<i>Fabaceae</i>	110	177	63.3	83.3	4.4	7.08
<i>Dobera glabra</i>	T	<i>Salvadoraceae</i>	33	43	33.3	47.3	1.3	1.72
<i>Euphorbia abyssinica</i>	T	<i>Euphorbiaceae</i>	93	144	32.2	77.7	3.7	5.76
<i>Grewia frginea</i>	S	<i>Malvaceae</i>	67	128	56.6	72.2	2.7	5.12

Continued

Table 2

Scientific name	FG	Family name	DE		FR		AB	
			EA	CG	EA	CG	EA	CG
<i>Grewia villosa</i>	S	<i>Malvaceae</i>	61	91	44.4	44.4	2.4	3.64
<i>Rhus natalensis</i>	S	<i>Anacardiaceae</i>	33	55	23.3	33.3	1.3	2.20
<i>Salvadora perisica</i>	T/S	<i>Salvadoraceae</i>	32	52	17.2	22.2	1.3	2.08
<i>Terminalia browni</i>	T	<i>Combretaceae</i>	45	39	38.8	38.8	1.8	1.56
<i>Ximenia Americana</i>	S	<i>Olacaceae</i>	24	34	31.3	33.3	1	1.36
			1276	2021	919.1	1248	51	80.8

FG=Functional group; T = Tree; S = Shrub; T/S = Tree or shrub, DE = Density, FR = Frequency, AB= Abundance, EA = Enclosure Area, CG = Communal Grazing area.

The density, frequency and abundances of woody plants in enclosure and communal grazing areas were presented in (Table 2). In the enclosure area *Dichrostachys cineria*, the most abundant species with 110 individual ha⁻¹ (8.6%) followed by *Euphorbia abyssinica* 93 individual ha⁻¹ (7.3%), *Acacia brusei* with 81 individual ha⁻¹ (6.8%), *Acacia tortilis* 79 individual ha⁻¹ (6.2%) and *Acacia mellifera* (6.03%). In communal grazing area the most abundant species by density were *Dichrostachys cineria* 177 individual/ha (9%), *Acacia oerfota* 161 individual ha⁻¹ (8%), *Acacia brusei* 156 individual ha⁻¹ (7.7%) and *Euphorbia abyssinica* 144 individual ha⁻¹ (7.1%). However, the less abundant species in both enclosure and communal open grazing area were *Combretum molle*, *Commiphora myrrha*, *Ximenia Americana* *Salvadora perisica* and *Rhus natalensis* (Table 2).

The most frequent tree species in the enclosure area was *Acacia tortilis* 61%; followed by *A. brusei* with 55.2% and *Terminalia browni* 38.8% frequency of occurrence while in communal grazing *Acacia tortilis* 81%, *Euphorbia abyssinica* 77.7% and *Acacia brusei* 72.2% were the most frequent species. The less frequent tree species in enclosure area were *Commiphora myrrha* (16.6%), *Combretum molle* (22.2%), and *Combretum collinum* 22.3 % while in communal grazing *Balanite aegyptica* 26.6%, *Commiphora myrrha* 36.6% and *Combretum molle* 38.3% were the least frequent species. The frequencies of shrub species in enclosure area were *Dichrostachys cineria* 63.3%, *Grewia feruginea* 56.6%, *Acacia oerfota* 45% and

Grewia villosa 44.4% while in communal grazing *Dichrostachys cineria* 83.3%, *Grewia feruginea* 72.2%, *Acacia oerfota* 61% and *Acacia brevispica* 55.5% and *Salvadora persica* (30.5%). The less frequent shrub species in both enclosure and communal grazing areas were *Calotropis procera* with (22.2%, 22.2%) and *Rhus natalensis* (22.3%, 33.3%) frequency of occurrences (Table 2).

The finding of this study indicated that, the mean density, frequency of occurrences, and abundance of woody species of all functional group (tree, shrub and tree/shrub) were higher in communal grazing as compare to enclosure (Table 3). The average density of tree, shrub and tree/shrub species in communal grazing were 69.3, 91.7 and 85.5 respectively. While in enclosure area were the mean density of tree, shrub and tree/shrub were 46.8, 53.5 and 56.5 respectively. The average frequency of tree, shrub and tree/shrub in communal grazing area were 34.36, 39.5 and 36.5 while in enclosure area 49.9, 48.3 and 54 respectively. The mean frequency of tree species was significantly higher in communal grazing than enclosure area at ($p < 0.05$) but the other were not enough to significantly different ($P > 0.05$) between two lands. The average abundance of tree, shrub and tree/shrub of enclosure area were 1.8, 2.14 and 2.26 while in communal grazing area 2.7, 3.67 and 3.42 respectively (Table 3).

The average density, frequency and abundances of woody vegetation in study area were presented in (Table 3). Woody species as higher density frequency and abundances in communal grazing area than in enclosure. In these study the result indicated that woody plant species of the study area has significantly ($t = -2.79$; $P = 0.01$) higher mean density of individual species in communal grazing area (80.84 individual stem/hectare) than the average density in enclosure areas (50.04 individual stem/hectare). In addition, the result indicated that, woody vegetation has higher ($t = -2.77$; $P = 0.01$) frequency of occurrence in communal grazing area (49.9%) than in enclosure area (36.7%). Similarly, there higher woody plant abundances ($t = -2.79$; $P = 0.01$) in communal grazing area (3.23 individual stem/plot) than in enclosure area (2.04 individual/plot).

Table 3: Mean density, frequency and abundances of woody plants by functional group EA and CG lands in study area.

Parameter	FG	Species	Mean $\pm$ Std. Error		Df	T- value	P- value
			EA	CG			
Density	Tree	11	46.8 $\pm$ 5.16 ^a	69.3 $\pm$ 6.8 ^a	20	-1.38	0.18
	Shrub	4	53.5 $\pm$ 4.9 ^a	91.7 $\pm$ 7.2 ^a	18	-2.08	0.05
	Tree/shrub	10	56.5 $\pm$ 4.6 ^a	85.5 $\pm$ 6.13 ^a	6	-1.34	0.23
	Total	25	51.04 ^a	80.84 ^b	48	-2.79	0.01
Frequency	Tree	11	34.4 $\pm$ 3.6 ^a	49.9 $\pm$ 4.28 ^b	20	-2.26	0.03
	Shrub	4	39.5 $\pm$ 3.6 ^a	48.3 $\pm$ 4.4 ^a	18	-1.18	0.25
	Tree/shrub	10	36.5 $\pm$ 3.6 ^a	54.1 $\pm$ 5.4 ^a	6	-1.08	0.32
	Total	25	36.76 ^a	49.9 ^b	48	-2.77	0.01
Abundance	Tree	11	1.8 $\pm$ 0.6 ^a	2.7 $\pm$ 0.7 ^a	20	-1.36	0.18
	Shrub	4	2.14 $\pm$ 0.57 ^a	3.67 $\pm$ 0.7 ^a	18	-2.08	0.05
	Tree/shrub	10	2.04 $\pm$ 0.3 ^a	3.4 $\pm$ 0.3 ^a	6	-1.32	0.23
	Total	25	2.04 ^a	3.23 ^b	48	-2.79	0.01

Means with a different superscript letter (a, b) in a row are significantly different ($P < 0.05$) and same superscript letter (a, a) are not significantly different significantly different ($P \geq 0.05$). EA = enclosure area CG = communal grazing area

In general, the result of these studies indicated that, density, frequency and abundance of woody vegetation were higher on communal grazing lands than at enclosure area. The result was in consistence with the study of (Buli, 2018) enclosure area reduces the abundances of woody vegetation. The result was not in agreement with different study those done in different low lands of Ethiopia. Fikadu and Argaw, (2021) documented higher density and frequency of the woody species in the enclosures than in the open grazing lands of South East Ethiopia. In the same way, Tesfay *et al.* (2019) recorded lower species abundances and density in enclosure area than protected natural vegetation. This difference could attributed to in study area the owner of enclosure manage for the purpose of grass production and cutting woody

vegetation found in enclosure area. Anthropogenic factor of pastoralist, cutting tree manually as bush from their enclosure reduce woody vegetation abundances in enclosure area.

4.1.2. Effect of enclosure on woody vegetation species diversity, richness and evenness

The diversity index variable measured were Shannon diversity index, species richness, equitability index (evenness) and number of individual plants of species were presented in (Table 4). Diversity, richness of woody vegetation across grazing management system was significantly different.

Table 4: Diversity index, species richness, species evenness and number of individual species of woody vegetation

Diversity measurement	Management type		T-value	P-Value
	EA	CG		
Shannon Diversity Index	2.68 $\pm$ 0.7 ^a	3.14 $\pm$ 0.14 ^b	-2.93	0.01
Species Richness	10.56 $\pm$ 0.8 ^a	11.17 $\pm$ 0.7 ^b	-2.21	0.03
Species Evenness	0.7 $\pm$ 0.1 ^a	0.8 $\pm$ 0.07 ^a	-0.94	0.36
No of Individual species	17.3 $\pm$ 4.8 ^a	25.1 $\pm$ 6.3 ^b	-6.54	0.00

Means with a different superscript letter (a, b) in a row are significantly different ($P < 0.05$) and same superscript letter (a, a) are not significantly different significantly different ($P \geq 0.05$). EA = enclosure area CG = communal grazing area

The result indicated that the mean value of Shannon diversity index of woody vegetation was significantly ($t = -2.93$; $P = 0.03$) higher, which was in 3.14 in communal grazing areas as compared to 2.68 in enclosure area. Similarly, woody species richness were significantly ($t = -2.21$; $P = 0.01$) higher in communal grazing than in enclosure area, which was 11.17 and 10.56 species in communal grazing and enclosure area respectively (Table 4). Number of individual plants of the woody species recorded in enclosure area and communal grazing area were significantly ($t = -6.54$; $P < 0.00$) lower in enclosure area (17.3) than that of communal grazing (25.1) area. On the other hand, grazing has no significant effect on species evenness ($t = -0.94$; $p = 0.36$), even the result indicated there were slightly higher species evenness in communal grazing area (Table 4).

Most of the studies reviewed were document higher woody species richness and diversity index in in enclosure compared to communal grazing area. Tesfay *et al.* (2019) and Fikadu and Argaw (2021) reported that Shannon diversity index recorded for enclose were higher than that of communal grazing areas. In addition, some authors suggested as woody vegetation diversity of enclosure area were reduced as age increased. Likewise, Fenetahun *et al.* (2021) reported the higher Shannon diversity index for short-term enclosure as compared to long terms enclosure in Borana range lands. In addition, Amaha *et al.* (2008) reported that, encroached bush woody species increases in Borana rangeland due to overgrazing.

In the study area, the rangeland woody and shrub plants were dominated by species of the *Fabaceae* family from which acacia species were the most abundant and diverse species, in both enclosure area and continues grazing area. In this study the result indicated that the mean value of Shannon diversity index of woody vegetation in open grazed area were significantly ($P < 0.05$) higher than enclosure area and woody plants species richness were significantly higher in communal grazing than enclosure area with ($p < 0.05$). This finding was in agreement with the study of Buli (2018) which indicated woody species richness and Shannon-Weiner diversity has reduced in Enclosures area but increases at outside enclosure. Similarly, Haftay *et al.* (2013) reported that Woody species richness was higher in the open-access grazing areas than in the enclosures, which was the result of the removal of the undesirable shrubs and trees in the enclosures by pastoralists manually. In the study area enclosure were predominantly practiced for dry season grazing and the time of livestock feed shortage, the result of lower woody species diversity in enclosure area were pastoralist could cutting tree in enclosure area as management purpose.

4.2. Floristic Composition of Herbaceous Vegetation

In the study area 12 family, 31 genera and 37 species of herbaceous vegetation were recorded (Figure 4) from which *Poaceae* family contributed 45.6% (14) Genera, followed by *Fabaceae* and *Acanthaceae* both contribute 9.8% (3) genera each to the herbaceous vegetation. *Asteraceae* and *Malvaceae* contribute 6.45% (2) genera each respectively. On the other hands by species contribution, *Poaceae* family account 37.8% (13) species followed by *Fabaceae*, *Acanthaceae* and *Lamiaceae* each contribute 10.8% (4) species (Figure 4).

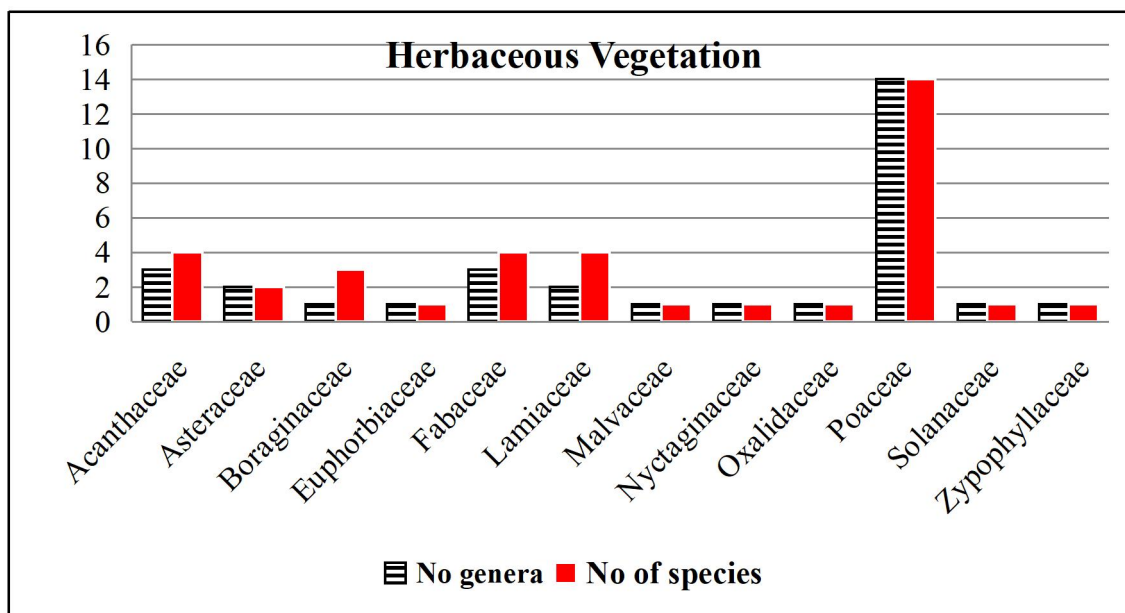


Figure 4: Herbaceous species composition by family, genera and species in the range lands of study area

The life forms of herbaceous vegetation species in study area were grass 35% (5 species) annual and 64% (9 species) perennial. Forbs were 78.9% (15 species) annual and 21% (4 species) perennial and legumes were 50% (2 species) annual and 50% (2 species) perennial (Figure 5).

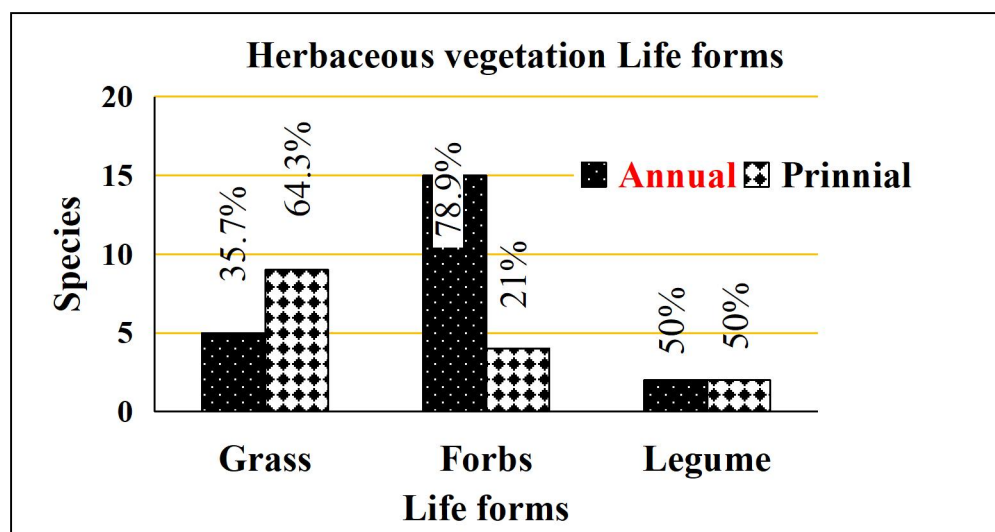


Figure 5: Herbaceous species composition by functional group and life forms in the rangelands of study area

The result of these study indicated that by species composition the *Poaceae* family contribute high species to the herbaceous species of the study area. Followed by *Fabaceae*, *Acanthaceae* *Asteraceae* and *Malvaceae* families by their species number recorded. The result was in line with previous work done in different part of Ethiopia, *Poaceae* and *Fabaceae*, family was the common and diverse with herbaceous species. The result was in line with the studies undertaken in different parts of Ethiopia. In range lands of (Ashebir *et al.*, 2010; Mohammed *et al.*, 2018; Tesfaye *et al.*, 2020) reported that the grass species (*Poaceae* families) contribute the greater proportion to the herbaceous vegetation of the study area.

4.2.1. Effect of enclosure on density, frequency and abundances of herbaceous vegetation

The density frequency and abundance of herbaceous vegetation were calculated for each plants encountered in enclosure area and communal grazing area. The calculated value for each plants were presented in (Table 5).

Table 5: Density, Frequency and Abundances of herbaceous species in enclosure area and communal grazing in the study area

Scientific name	Family	FG	LF	Density		Frequency		Abundance	
				EA	CG	EA	CG	EA	CG
<i>Abuliton indicum</i>	<i>Malvaceae</i>	F	A	120	120	50	50	2.3	2.3
<i>Acalypha indica</i>	<i>Euphorbiaceae</i>	F	A	140	130	56	50	2.5	2.7
<i>Ageratum longzoides</i>	<i>Asteraceae</i>	F	A	100	100	39	33	2.6	3
<i>Arestida adoensis</i>	<i>Poaceae</i>	G	A	260	100	72	55	3.6	1.8
<i>Belapharis ciliaris</i>	<i>Acanthaceae</i>	F	P	80	80	44	50	1.7	1.67
<i>Belapharis mulluginipholia</i>	<i>Acanthaceae</i>	F	A	120	120	50	50	2.3	2.3
<i>Bothriochloa insulpita</i>	<i>Poaceae</i>	G	P	170	80	72	44	2.4	1.7
<i>Cenchrus ciliaris</i>	<i>Poaceae</i>	G	P	190	120	94	55	2.1	2.1
<i>Chloris gayana</i>	<i>Poaceae</i>	G	P	130	90	50	44	2.7	2.1
<i>Crotalaria juncea</i>	<i>Fabaceae</i>	L	P	100	90	56	44	1.8	2.13
<i>Cummicarpus verticillatus</i>	<i>Nyctaginaceae</i>	F	P	70	70	33	39	2.2	1.8

Continued

Table 5

Scientific name	Family	FG	LF	Density		Frequency		Abundance	
				EA	CG	EA	CG	EA	CG
<i>Cynodon dactylon</i>	<i>Poaceae</i>	G	P	90	70	39	33	2.3	2.2
<i>Dactyloctenium aegyptium</i>	<i>Poaceae</i>	G	A	280	140	89	56	3.2	2.6
<i>Digitaria ciliaris</i>	<i>Poaceae</i>	G	A	130	80	50	39	2.7	2
<i>Echinochloa colona</i>	<i>Poaceae</i>	G	P	130	110	56	50	2.3	2.2
<i>Eragrostis curvula</i>	<i>Poaceae</i>	G	A	80	60	44	38	1.7	1.5
<i>Heleotropium somalensis</i>	<i>Boraginaceae</i>	F	A	90	110	50	50	1.8	2.1
<i>Heleotropium fruticosum</i>	<i>Boraginaceae</i>	F	A	60	70	22	33	2.5	2
<i>Heleotropium longflorum</i>	<i>Boraginaceae</i>	F	A	40	40	22	22	2	2
<i>Heteropogon contortus</i>	<i>Poaceae</i>	G	P	290	110	67	61	4.3	1.7
<i>Hyparrhenia hirta</i>	<i>Poaceae</i>	G	P	230	100	61	50	3.8	2
<i>Hypoestes forsaolli</i>	<i>Acanthaceae</i>	F	P	90	80	50	50	1.9	1.6
<i>Iliusine indica</i>	<i>Poaceae</i>	G	A	180	40	61	28	3	1.4
<i>Indigofera hochstetteri</i>	<i>Fabaceae</i>	L	P	50	30	39	33	1.3	1
<i>Indigofera tinctoria</i>	<i>Fabaceae</i>	L	A	100	40	50	28	2	1.6
<i>Leucas microphla</i>	<i>Fabaceae</i>	L	A	80	60	39	33	2.1	2
<i>Ocimum basilicum</i>	<i>Lamiaceae</i>	F	A	110	70	38	38	3	2
<i>Otostegia fruticosa</i>	<i>Lamiaceae</i>	F	A	50	60	22	28	2.3	2.
<i>Otostegia perisica</i>	<i>Lamiaceae</i>	F	A	70	50	39	33	1.7	1.5
<i>Otostegia tomentosa</i>	<i>Lamiaceae</i>	F	A	100	50	44	27	2.3	2
<i>Oxalis latifolia</i>	<i>Oxalidaceae</i>	F	A	80	60	38	39	2	1.6
<i>Parthenium hysterophorus</i>	<i>Asteraceae</i>	F	A	130	50	44	22	3	2.3
<i>Rullia patula</i>	<i>Acanthaceae</i>	F	A	70	60	50	56	1.3	1.2
<i>Solanum indicum</i>	<i>Solanaceae</i>	F	P	60	70	27	50	2.2	1.3
<i>Sporobolus pyramidalis</i>	<i>Poaceae</i>	G	P	330	90	83	44	4	2
<i>Themeda triandra</i>	<i>Poaceae</i>	G	P	160	80	72	39	2.2	2.1
<i>Tribulus terrestris</i>	<i>Zypophyllaceae</i>	F	A	90	120	33	44	2.7	3.1

FG = Functional group; LF = Life forms; A = Annual; P = Perennial.

In the enclosure area, species like *Sporobolus pyramidalis*, *Heteropogon contortus*, *Dactyloctenium aegyptium* and *Arestida adoensis* have higher relative density, while *Heleotropium species*, *Indigofera hochstetteri*, *Ocimum basilicum*, *Cummicarpus verticillatus* and *Belapharis ciliaris* were the least species by their density relative to other (Table 5). On the other hand, in communal/open grazed area *Dactyloctenium aegyptium*, *Tribulus terrestris*, *parthenium hysterophorus*, *Acalypha indica*, and *Belapharis mulluginipholia* have higher density, while, species like *Arestida adoensis*, *Cenchrus ciliaris*, *Indigofera hochstetteri*, *Iliusine indica* have least diversity (Table 5). The abundance, frequency and density of both perennial and annual grass such as *Sporobolus pyramidalis*, *Heteropogon contortus* and *Themeda triandra* relatively higher compared to herbs and legumes higher between two management systems even they were higher in enclosure area. For some herbaceous plant other than grass communal grazing land show positive impact on herbs like *Abuliton indicum*, *Belapharis cilliaris*, *Tribulus terrestris*, and *Heleotropium somalensis* (Table 5).

Table 6: Mean density, frequency and abundances of herbaceous vegetation in enclosure and communal grazing area.

Parameters	FG	LF	SN	Group (Mean + Std.Error)		T- value	P- value
				EA	CG		
Density	Grass	Annual	5	186 ^a	84 ^a	2.45	0.05
		Perennial	9	191.1 ^a	94.4 ^b	3.60	0.01
		Total	14	189.3 ⁺ 4.12 ^a	90.7 ⁺ 1.34 ^b	4.51	0.00
	Forbs	Annual	15	91.3 ^a	80.6 ^a	0.95	0.35
		Perennial	4	75 ^a	75 ^a		1.00
		Total	19	87.9 ⁺ 1.11 ^a	79.5 ⁺ 0.8 ^b	0.92	0.35
	Legumes	Annual	2	90 ^a	50 ^a	2.83	0.10
		Perennial	2	75 ^a	60 ^a	0.38	0.74
		Total	4	82.5 ⁺ 1.84 ^a	55 ⁺ 2.2 ^a	1.55	0.17
Total			37	125.67 ^a	81.1 ^b	3.52	0.001
Frequency	Grass	Annual	5	186 ^a	84 ^a	2.45	0.05
		Perennial	9	66 ^a	46.67 ^b	3.09	0.01
		Total	14	64.6 ⁺ 0.91 ^a	45.43 ⁺ 0.5 ^b	3.82	0.00
	Forbs	Annual	15	39.82 ^a	38.33 ^a	0.37	0.71
		Perennial	4	38.5 ^a	47.25 ^a	-1.48	0.19
		Total	19	39.5 ⁺ 0.58 ^a	40.02 ⁺ 0.42 ^a	-0.19	0.84
	Legumes	Annual	2	45.5 ^a	30.5 ^a	2.32	0.26

Abundances		Perennial	2	47.5 ^a	38.5 ^a	0.89	0.46
		Total	4	71.3 $\pm$ 0.78 ^a	45.6 $\pm$ 0.85 ^a	2.13	0.07
		Total	37	49.86^a	41.56^b	2.47	0.015
	Grass	Annual	5	2.84 ^a	1.86 ^b	2.54	0.04
		Perennial	9	2.9 ^a	2.01 ^b	2.98	0.02
		Total	14	2.87 $\pm$ 0.2 ^a	1.96 $\pm$ 0.1 ^b	4.04	0.00
	Forbs	Annual	15	2.28 ^a	2.14 ^a	0.81	0.42
		Perennial	4	2 ^a	1.6 ^a	2.52	0.05
		Total	19	2.15 $\pm$ 0.1 ^a	1.96 $\pm$ 0.1 ^b	1.2	0.02
	Legumes	Annual	2	2.05 ^a	1.8 ^a	1.21	0.44
		Perennial	2	1.55 ^a	1.56 ^a	-0.02	0.98
		Total	4	1.37 $\pm$ 0.014 ^a	1.46 $\pm$ 0.02 ^a	0.38	0.07
	Total	37	2.43^a	1.96^b	3.42	0.001	

Means with a different superscript letter (a, b) in a row are significantly different ($P < 0.05$) and same superscript letter (a, a) are not significantly different significantly different ($P \geq 0.05$). EA = enclosure area CG = communal grazing area

There were variation in density, frequency and abundances of herbaceous species between enclosure area and communal grazing areas (Table 6). The densities of perennial and annual grass were higher in enclosure area than communal grazing area. Forbs and legumes has small variation between two areas. The abundance, frequency and density of perennial grass relatively higher compared to herbs and legumes higher between two management systems even they were higher in enclosure area (Table 6). The mean density of perennial grass in enclosure area these could be the result of selective behavior of herbivore result for lower perennial grass at open grazing area. Heavy grazing cause undesirable change in herbaceous species composition, it replaces perennials with annual grasses (Fenetahun *et al.*, 2018). In addition, ((Angasa, 2014; Mengistu *et al.* 2015) reported that heavy grazing pressure reduces plant species composition and basal cover.

For some herbaceous plant other than grass communal grazing land, show no more impact on herbaceous vegetation of legume and forbs species. This could be due to the unrestricted grazing pressure and time of grazing. Perennial species will decline in density and frequency (getting low in perennial vegetation cover). Mainly due to not allowing the perennial to set seed and shutter for new seeding to come out and replace the old mothers. This can be

selective behavior of livestock at communal grazing land cause for reduction of grass species specially the perennial one. Wang *et al.* (2015) reported that because of grazing non-grass component of the herbaceous vegetation species richness and diversity has increased at heavy grazed site than not grazed one. Similarly, Asheber *et al.* (2010) reported that botanical composition of the herbaceous plants which are highly desirable perennial (decreasers) species were decreasing while increasers increased as grazing intensity increase. Also the canopy of densely populated woody vegetation at communal grazing area has negative effects on herbaceous vegetation due to competition for available soil nutrients, and water (Teshome *et al.*, 2012). Likewise scattered woody plants at enclosure area have positive effect on the herbaceous layer by altering resource availability and micro climatic condition (Mohamed *et al.*, 2018).

4.2.2. Effect of enclosure on herbaceous vegetation species diversity, richness and evenness

Species richness of herbaceous plants was 18.87 in enclosure and 15.72 in communal grazing area. Shannon diversity index were 2.87 and 2.47 in enclosure and communal grazing area respectively. The species evenness (evenness index) of herbaceous vegetation was 0.93 in enclosure and 0.91 in communal grazing area. The mean number of all individual species recorded per plot was 46.6 in enclosure and 30.6 in communal grazing area (Table 7).

Herbaceous vegetation species richness and diversity were significantly different between communal grazing and enclosure however, the evenness of species was not significantly different between the management practices. In the study area the result indicated that, the herbaceous species richness was significantly ($t=2.68$, $P<0.01$) higher in enclosure than communal grazing. Herbaceous vegetation were more diverse in enclosure than communal grazing, for instance, Shannon diversity index of herbaceous vegetation were significantly higher ($t=1.17$, $P<0.001$) in enclosure as compared to communal grazing (Table 7). The species evenness of herbaceous vegetation was not significantly different even the recorded mean value in enclosure was somewhat greater than that of recorded in communal grazing area. In addition the recorded mean stem of individual of herbaceous species per quadrants were

significantly ($t=9.10$, $P<0.000$) higher in enclosure area than adjacent communal grazing areas (Table 7).

Table 7: Diversity, species richness, species evenness and number of individual species of herbaceous vegetation

Diversity measurement	Management type		T-value	P-value
	EA	CG		
Shannon Diversity Index	2.87 $\pm$ 0.08 ^a	2.47 $\pm$ 0.08 ^b	1.17	0.001
Species Richness	18.87 $\pm$ 0.7 ^a	15.72 $\pm$ 0.8 ^b	2.68	0.010
Species Evenness	0.93 $\pm$ 0.01 ^a	0.91 $\pm$ 0.05 ^a	0.54	0.646
No of Individual species	46.6 $\pm$ 1.2 ^a	30.6 $\pm$ 1.3 ^b	9.10	0.000

Means with a different superscript letter (a, b) in a row are significantly different ($P<0.05$) and same superscript letter (a, a) are not significantly different significantly different ($P\geq 0.05$). EA = enclosure area CG = communal grazing area

The results of this study finding showed significant variations in terms of herbaceous plant biodiversity between enclosures and open grazed areas. Herbaceous vegetation species richness and diversity were significantly different between communal grazing and enclosure area while there were not significant different with species evenness comparison. Previous studies in different part of Ethiopia confirmed that species diversity and species richness were higher in the enclosures as compared to that of the open grazed area. Angassa *et al.* (2010) reported that herbaceous species richness and diversity were higher in enclosures compared to communal grazing areas in the range land of southern Ethiopia. In addition, Tesfay *et al.* (2020) in northern Ethiopia range land and Dargo and Haftay (2019) in eastern Ethiopia range land reported that the enclosure management had higher herbaceous species richness than the grazed site. Likewise, Tesfay *et al.* (2020) indicated the higher diversity of herbaceous plants in area of enclosure than communal grazing land, which may be a consequence of the high species richness in enclosure area. Moreover, Tesama *et al.* (2011) reported that the lightly grazed sites had significantly higher herbaceous diversity compared with the heavy grazed sites.

4.3. Effects of Enclosure on Soil Physic-Chemical Property

4.3.1. Impact of enclosure on soil physical property

Physical and chemical properties of soils of in enclosure and communal grazing land was presented in (Table 8). In these studies, textural differences were tested for physical properties' of soil between enclosure area and communal grazing area and show that enclosure area management has significant effects on the proportion of soil texture. Textural differences were observed with sand and silt fraction in study area.

Table 8: Mean of soil texture (sand, silt and clay) in enclosure area and adjacent communal grazing area

Soil property	Mean $\pm$ Std.Error		T-value	p-value
	EA	CG		
Sand	50.33 $\pm$ 1.3 ^a	55.33 $\pm$ 0.3 ^b	-3.64	0.022
Silt	32.66 $\pm$ 0.5 ^a	28 $\pm$ 2.1 ^b	7.00	0.002
Clay	17 $\pm$ 0.9 ^a	16.66 $\pm$ 0.7 ^a	0.32	0.073

Means with a different superscript letter (a, b) in a row are significantly different ($P < 0.05$) and same superscript letter (a, a) are not significantly different ($P \geq 0.05$). EA = enclosure area CG = communal grazing area

Mean Sand fraction were 50.33 in enclosure area and 55.33 in communal grazing area and it was significantly ($t = -3.64$; $P = 0.022$) higher in communal grazing area as compared to enclosure area. The mean value of silt fraction were 32.6 and 28 in enclosure area and communal grazing area respectively, which were significantly ($t = 7.00$, $P = 0.002$) higher in enclosure than communal grazing. Clay fraction were not significantly ($t = 0.32$, $P = 0.073$) different even their mean value was slightly higher in enclosure area as compared to continuously grazed area (Table 8).

Soil texture was shows variation between continuously grazed and enclosure area in the study area. The result of this study showed that, sand fraction were significantly ($P < 0.05$) higher in communal grazing than in enclosure area. Lighter particle of silt fraction were significantly

($P < 0.5$) higher in enclosure than communal grazing site and clay particles showed no significant difference between communal and enclosure area. Contrary to these, MacLachlan (2013) reported that the soil sample in communal grazing area possessed a greater proportion of sand compared to enclosure area while clay and silt fraction were lower. Similarly, Tesama (2011) reported that the fraction of sand particles was significantly higher in light grazing as compared to heavy grazing site. In the same way Mureithi *et al.* (2014) reported that even there were no significant difference between EA and CG, on the fraction of sand, but at open grazing lands there was the greater value as compared to enclosure area. At communal grazing land, herbaceous vegetation cover is low so erosion was higher result for leaching out of lighter particle and left high sand fraction than enclosure area. Debela *et al.* (2011) reported that under conditions of vegetation cover degradation loss of clay and silt fractions has high since loss of vegetation cover increase erosion because high leaching of lighter soil particle. Livestock grazing and their trampling have marked effects on vegetative cover, soil quality and nutrient loss due to erosion (Lipson *et al.*, 2011). These existence of sparse range land vegetation due to overgrazing exposes the soil to erosion by wind and water. Tessema *et al.* (2011) documented that grazing affects the flux of soil nutrients in grazing lands through trampling, consumption, excreta deposition, redistribution, and export in range land ecosystems.

4.3.2. Impact of Enclosure on Soil Chemical Property

Among soil chemical property in these study the impact of grazing on soil pH, electrical conductivity (EC), organic carbon (OC), soil organic matter (SOM), and total nitrogen content were tested within enclosure communal grazing area (Table 9). The recorded value of soil organic matter, in enclosure area (6.8) was significantly ($t=9.867$; $p=0.001$) higher than communal grazing area (5.6). The mean organic carbon in enclosure (3.9) as significantly ($t=7.01$; $p=0.002$) higher than that of communal grazing area (2.9). Similarly mean of total nitrogen was significantly ($t=7.18$; $p=0.002$) higher in enclosure (0.3) than in communal grazing area (0.19). The result also indicated the analyzed soil pH in enclosure and communal grazing was 8 and 6.6 respectively which show significant difference with ($t=6.33$; $P=0.003$) value between two area. The grazing has no significant effect ($t=2.63$;

P=0.058) on EC, but enclosure area has slightly higher value than open grazing even they were not significantly different (Table 9).

Table 9: Soil chemical property measured in enclosure and communal grazing area

Soil chemical property	Mean $\pm$ Std.Error		T-value	p-value
	EA	CG		
pH	8 $\pm$ 0.12 ^a	6.6 $\pm$ 0.18 ^b	6.33	0.003
EC	2.5 $\pm$ 0.12 ^a	2.14 $\pm$ 0.06 ^a	2.63	0.058
OC	3.9 $\pm$ 0.06 ^a	2.9 $\pm$ 0.14 ^b	7.01	0.002
SOM	6.8 $\pm$ 0.09 ^a	5.6 $\pm$ 0.09 ^a	9.87	0.001
TN	0.3 $\pm$ 0.01 ^a	0.19 $\pm$ 0.01 ^b	7.18	0.002

Means with a different superscript letter (a, b) in a row are significantly different ($P < 0.05$) and same superscript letter (a, a) are not significantly different ($P \geq 0.05$). EA = enclosure area CG = communal grazing area. pH = power of hydrogen, EC = electrical conductivity, SOM = soil organic matter and TN = total nitrogen

Range land enclosure area has positive effects on and showed higher record on SOM, OC and TN as compared to communal grazing land. The finding of these study were in agreement with the result of Qin *et al.* (2015) that reported grazing exclusion enhanced organic carbon and total nitrogen accumulation. In addition, Mekuria *et al.* (2013) documented that, enclosure area management enhances the concentrations of soil organic matter and total nitrogen compared to adjacent communal grazing lands. Likewise, Amaha *et al.* (2012) as range land condition decreased from excellent to poor condition the amount of soil organic matter, organic carbon and electrical conductivity measured shows significant reduction. This can be higher herbaceous cover at enclosure area than communal grazing land and reduce nutrient leaching by erosion that make soil nutrient higher at enclosure area. For instance in the study of Mekuria *et al.* (2018) enclosure, land management improves soil properties which consequently supports the restoration of native vegetation while free grazing in the adjacent communal grazing land aggravates soil and vegetation degradation.

The result soil pH and electrical conductivity were also in agreement with other studies. The result point out that enclosure area increases pH value than communal grazing lands. While result of electrical conductivity shows no variation between enclosure and communal grazing area. The result was in line with Buli (2018) reported that, soil pH has significantly increased at inside of enclosure area than outside enclosure. In addition, Amaha *et al.* (2012) documented that both pH and electrical conductivity value were highly decreased as degradation was increased. In conclusion, the herbaceous layers (grasses and forbs) showed better efficiency in arresting water run-offs and control of soil erosion than the woody tree canopies (Amaha *et al.*, 2012). Therefore, herbaceous vegetation cover was the result for improvement of physical and chemical properties of soil in enclosure area as compared to communal open grazing lands.

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary and Conclusion

This study was undertaken to analyze the effects of enclosure on vegetation composition, species diversity and soil physico-chemical properties in the range lands of Meyumulu districts. Regional state, Eastern Ethiopia. Meyumulu is one of the pastoral area districts found in in East Hararghe Zone of Oromia, Ethiopia. The districts account about 22% of the Zone land coverage with vast range land biodiversity and is the second largest in terms of livestock holding. In the districts large amount of livestock population has herded, is the second in terms livestock population holding from the zone. These studies contributes the basic data on the impact of enclosure area on floristic composition of woody and herbaceous plant species and soil properties, as well as provide a baseline data for future further studies and development activities.

To evaluate the impact of enclosure area first reconnaissance survey was used to assess the condition of range lands as well as that of enclosure area. After that, the enclosure area and adjacent communal grazing lands were selected those with approximately the same age elevation and other environmental effect. For the vegetation and soil data collection, line transects technique was used and for woody plants quadrants of 36 quadrants of (20mx20m) were laid along transects by 200m interval and inside it five 5mx5m (90 in EA and 90 in CG sub-quadrants) were laid for shrub. For herbaceous vegetation soil sample collection five 1mx1m laid within each main 20mx20m quadrants (180 (90 in EA and 90 in CG) sub-quadrants). In the study area, the 20 family and 62 species were recorded floristically from which 25 species, 12 families were of woody vegetation, and 37 species and 12 families were of herbaceous vegetation.

The management of enclosure in range lands of Meyumulu districts was found to have significant effect on herbaceous, woody vegetation and soil physico-chemical properties. The results of the study revealed that, enclosure area managements have shown quite higher improvement in herbaceous vegetation composition, diversity and species richness. Shannon diversity index and species richness value of herbaceous vegetation were shows enclosure area

has a positive effect on the environments improvements. Proportionally of the functional group of herbaceous vegetation, grass shows improvement by enclosure than forbs and legume. With life forms enclosure area the density of perennial herbaceous vegetation were higher in enclosure area.

Likewise, the result indicated that, range lands enclosure area has great advantage for improving soil physical and chemical properties of range lands of study area. The result of this study showed that, sand fraction were higher in communal grazing than in enclosure area. Lighter particle of silt fraction were higher in enclosure than communal grazing area. Enclosure area has positive effects on soil chemical properties. Soil organic matter, organic carbon, total nitrogen, and soil pH showed higher record at enclosure area compared to communal grazing areas. This may be due to lower herbaceous cover at communal grazing lands cause soil erosion by winds and water result for leaching out lighter mineral of silt and clay, and higher density of herbaceous vegetation in enclosure area improve soil properties.

On the other hands enclosure, area reduces woody plants composition and diversity as compared to communal grazing land, which could attribute to management strategy than effect of grazing. Shannon diversity index and species richness value were higher in communal grazing area than enclosure area. The diversity index of enclosure area and communal grazing lands were 2.68 and 3.14 which was significantly ($p=0.01$) higher in communal grazing area. The density abundance and frequency of woody vegetation were higher in communal grazing lands. This indicates that enclosure area management on range lands in study area with other human factor has negative impact on woody vegetation.

In general, by comparing all parameter of interest to evaluate the impact of area enclosure on range land vegetation composition, species diversity and soil physico-chemical properties. Enclosure area increases the density, diversity and richness of herbaceous vegetation as compared to their adjacent communal grazing land. The woody vegetation diversity decreased in enclosure area as compared to adjacent communal grazing lands. Enclosure area improve soil properties than communal grazing area due to more herbaceous vegetation abundances than communal grazing lands. Therefore, to enhance the productivity of range lands by

maintaining soil physical and chemical properties with preferable herbaceous compositions it is important to mitigate range land degradation with enclosure area managements.

5.2. Recommendation

Based on the result of the study the following recommendations were drawn to assure continuity and sustainability of the range land biodiversity and ecosystem.

- I. In the study area even though there were no organization participating in range land ecosystem conservation, local community did use range land enclosure with their knowledge to overcome livestock feed shortage though conserving the range lands. So, these should be considerable knowledge and discussing with them and all other stakeholder will result more functional.
- II. Enclosure area management has potential to enhance vegetation diversities especially herbaceous and soil properties. These show that, communal grazing areas of the range lands require conservation for rehabilitation and sustainable use of range lands.
- III. Although enclosure area enhance woody species attributes in the results of many studies that undertaken in different part of Ethiopia, the result of these studies show the lower value of woody plants. The enclosure area only based on the knowledge of local community in the area will not functioning further toward biodiversity enrichment without the interference of researchers. These require be further studies on the cause of woody species diversity reduction and how it should managed to balance biodiversity.
- IV. There were no study under taken in the study area and particularly on range land, the district was marginalized from research and development intervention coverage. Therefore, as the potential range lands and livestock population of East Hararghe are found in the districts, it is important to study on the capacity and its productivity of range lands including Meyumulu range lands.
- V. Finally, because of lack of financial and boundary conflict that exist in district the study could not include all area (kebele) in practicing enclosure at different elevation and intensity of grazing by determining the range land capacity. In the study area this study could be used as a base line for further study to evaluate performance enclosure area for broad biodiversity conservation.

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APPENDICES TABLES

Appendix Table 1: List of Woody Species Collected from Meyumuluke range lands per all sampled plots.

Scientific Name	Family Name	Local Name (Afan Oromo)	Habitat forms
<i>Acacia brevispica</i>	<i>Fabaceae</i>	Hamaresa	Shrub
<i>Acacia brusei</i>	<i>Fabaceae</i>	Halo	Tree
<i>Acacia mellifera</i>	<i>Fabaceae</i>	Gorsa	Tree/Shrub
<i>Acacia oerfota</i>	<i>Fabaceae</i>	Ajo	Shrub
<i>Acacia Senegal</i>	<i>Fabaceae</i>	Gorsa adi	Tree/Shrub
<i>Acacia tortilis</i>	<i>Fabaceae</i>	Dhadacha	Tree
<i>Balanite aegyptiaca</i>	<i>Balanitaceae</i>	Badano	Tree
<i>Boswelvia neglecta</i>	<i>Burseraceae</i>	Dakaro	Tree/Shrub
<i>Calotropis procera</i>	<i>Asclepiadaceae</i>	-	Shrub
<i>Carrisa adulis</i>	<i>Apocynaceae</i>	Agamsa	Shrub
<i>Cassia singueana</i>	<i>Caesalpinioideae</i>	Adulala	Shrub
<i>Combritum collinum</i>	<i>Lamiaceae</i>	Rukelu	Tree
<i>Combritum molle</i>	<i>Combretaceae</i>	Rukesa	Tree
<i>Commiphora erythraea</i>	<i>Burseraceae</i>	Agarsu	Tree
<i>Commiphora kua</i>	<i>Burseraceae</i>	Kasale	Tree
<i>Commiphora myrrha</i>	<i>Burseraceae</i>	Kumbi	Tree
<i>Dichrostachys cineria</i>	<i>Fabaceae</i>	Jirime	Shrub
<i>Dobera glabra</i>	<i>Salvadoraceae</i>	Ade	Tree
<i>Euphorbia abyssinica</i>	<i>Euphorbiaceae</i>	Hadami	Tree
<i>Grewia frginea</i>	<i>Malvaceae</i>	Mudhugure	Shrub
<i>Grewia villosa</i>	<i>Malvaceae</i>	Ogomti	Shrub
<i>Rhus natalensis</i>	<i>Anacardiaceae</i>	Dabobesa	Shrub
<i>Salvadora perisica</i>	<i>Salvadoraceae</i>	Adiga	Tree/Shrub
<i>Terminalia browni</i>	<i>Combretaceae</i>	Birensa	Tree
<i>Ximenia Americana</i>	<i>Olaceae</i>	Hudha	Shrub

Appendix Table 2: The family, genera and species composition of woody and herbaceous vegetation with their species distribution in study area

Family name	No of genera				No of species			
	Woody	%	Herb	%	Woody	%	Herb	%
<i>Acanthaceae</i>			3	9.68			4	10.8
<i>Anacardiaceae</i>	1	6.25			1	4		
<i>Apocynaceae</i>	1	6.25			1	4		
<i>Asclepiadaceae</i>	1	6.25			1	4		
<i>Asteraceae</i>			2	6.45			2	5.4
<i>Balanitaceae</i>	1	6.25			1	4		
<i>Boraginaceae</i>			1	3.23			3	8.1
<i>Burseraceae</i>	2	12.5			4	16		
<i>Caesalpnioidae</i>	1	6.25			1	4		
<i>Combretaceae</i>	2	12.5			3	12		
<i>Euphorbiaceae</i>	1	6.25	1	3.23	1	4	1	2.7
<i>Fabaceae</i>	2	12.5	3	9.68	7	28	4	10.8
<i>Lamiaceae</i>			2	6.45			4	10.8
<i>Malvaceae</i>	1	6.25	1	3.23	2	8	1	2.7
<i>Nyctaginaceae</i>			1	3.23			1	2.7
<i>Olaceae</i>	1	6.25			1	4		
<i>Oxalidaceae</i>			1	3.23			1	2.7
<i>Poaceae</i>			14	45.2			14	37.8
<i>Salvadoraceae</i>	2	12.5			2	8		
<i>Solanaceae</i>			1	3.23			1	2.7
<i>Zygophyllaceae</i>			1	3.23			1	2.7
	16		31		25		37	