EVALUATION OF FARMERS ADAPTATION STRATEGY TO DECREASE DEGRADATION AND EFFECT OF CLIMATE CHANGE ON LIVESTOCK FEED PRODUCTION IN ALAJE DISTRICT, SOUTHERN ZONE OF TIGRAY, NORTHERN ETHIOPIA

M.Sc. THESIS

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THESIS SUMITED TO THE

DEPRTMEN OF AGROFORESTRY WONEDO GENET COLLEGE OF FORSTRY AND NATURAL RESOURCES HAWASSA UNIVERSITY WONDO GENT ETHIOPIA

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF "MASTER OF SCIENCE" IN CLIMATE SMART AGRICULTURAL LANDSCAPE ASSESSMENT

OCTOBER, 2019

APPROVAL SHEET

This research thesis entitled as "**Evaluation of Farmers adaptation strategy to Decrease degradation and effect of climate change on livestock feed production in Alaje Woreda, Southern Zone of Tigray, Ethiopian"** has been submitted in Partial Fulfillment of the Requirements for the Master of Science Degree in climate smart agriculture and landscape.

Submitted by:

Merga Bayssa (Ph.D.)	___________________	_______________
Name of Major advisor	*Signature*	*Date*

THESIS ACCEPTANCE SHEET

This is to certify that the thesis entitled "**Evaluation of Farmers adaptation strategy to decrease degradation and effect of climate change on Livestock Feed Production in Alaje Woreda, Southern Zone of Tigray, Ethiopian"** has been Submitted in partial fulfillment of the requirements for the Master of Science Degree in climate smart agriculture and landscape and it is a record of original research carried out by Gebreselassie Hagos. ID.No MSc/CSAL/R010/10, under my supervision, and no part of the thesis has been submitted for any other degree or diploma. The assistance and help received during the course of this investigation have been duly acknowledged. Therefore, I recommend that it be accepted as fulfilling the thesis requirements.

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ABBREVIATIONS and ACRONYMS

CP	Crude Protein
CSA	Central Statistical Agency
DM	Dry Matter
FGD	Focus group discussion
GDP	Growth Domestic Product
GHGs	Green House Gases
GLTs	Grazing Land Types
HHs	Households
IPCC	Intergovernmental Panel on Climate Change
KII	key informants' interviews
M.a.s.l	Meters above sea level
PAs	Peasant Associations
PC	Palatability composition
SPSS	Statistical Package for Social Science
TLUs	Tropical Livestock Units
UNFCCC	United Nations Framework Convention on Climate Change
WPC	Weighted Palatability Composition
IFTGs	Indigenous fodder trees and grass species

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Evaluation of Farmers Adaptation Strategy to Decrease Degradation and Effect of Climate Change on Livestock Feed Production in Alaje Woreda, Southern Zone of Tigray, Northern Ethiopia

Gebresilase Hagos, Major advisor: Merga Bayssa (Ph.D.)

ABSTRACT

The study was conducted in Alaje district of South Zone of Tigray region to evaluate farmers' perception on adaptation strategies on response to range land degradation and climate change effect on livestock feed production. Data was collected from 212 respondents within 3kebelle of two agroecology (highland and midland) using simple random sampling techniques for collecting information about HHs using questionnaire, kII and FGD with farmers and experts. Dropping pin technique was used to collect data on species composition, biomass, and palatability from the different grazing systems. In each of the grazing systems, a sampling block of 1.2km x1km was demarcated in a separate way. In each of the plot, 1x1m^2 quadrates for herbaceous species evaluation were used randomly by thrown a quadrate in to aback. The collected household data was organized and analyzed using SPSS Version 23. The study shows that farmers' perceptions were confirmed by the indication from rainfall and temperature data obtained from metrological station. Findings reveal increased temperature, high rainfall variability and inter annual and intra seasonal variation. The result shows that major adaptation strategies is change in crop variety, reduce number of livestock, diversification of farm enterprise and home feeding, respectively were the farmers adapted to long-term changes in climate. The research findings revealed that majority of respondents viewed the rangeland condition as poor and degraded. The main feed resources to the livestock in both agroecology were natural pasture, crop residues and stubble grazing. During dry season, crop residues was the first livestock feed source followed by stubble grazing and natural pasture in both altitudes. However, during wet season, natural pasture was the first livestock feed source followed by stubble grazing in all altitudes. In terms of DM crop residues contributed the highest proportion (45.64%) of the total feed sources. The DM obtained from crop residues significantly differed ($P<0.05$) between the two agroecology. The total annual dry matter does not meet the total livestock requirement per annum in the study area. The total annual estimated available feed supply to maintain the livestock in the area fulfilled only 67.4%. 21 IFGS were identified and rank 10 top locally preferred species by FGD with purposively selected 20 experienced farmers, community elders, and local development agents. The criteria identified by locals of a given species were very diverse (N= 20), but can be categorized in to three groups; Animal-based: Plant based and multipurpose. Species composition of Chloris gayana, Andropogon distachyas, Melinis repens and Eleusine floccifolia was the most dominant species composition in the grazing land types. Species composition was significantly difference ($P<0.01$) among the GLTS. The average dry matter biomass was higher in enclosure site plots shows a higher herbaceous species composition and palatability composition compared with the free grazing and rotational grazing areas. Dry matter yield of grasses in the current study was within the range of 625 Kg/ha and 4835 Kg/ha in free grazed and enclosure sites respectively. Further research and development work is recommended to improve rangeland degradation and animal feed shortage through different adaptation options.

***Key words**:* climate change, farmers' perceptions, adaptations, Rangeland degradation

1. INTRODUCTION

1.1. Background and justification

Ethiopia has the largest livestock population in Africa and the livestock sector is contributing to the livelihood improvements of smallholder farmers (CSA, 2017). Developing countries are greatly vulnerable to climate change since their economy mainly forecasts on rain-fed agriculture that entirely depends on natural factors. The livestock sector plays a significant role in reducing poverty, achieves food security and contributes to national income growth, foreign exchange earnings and climate mitigation and adaptation technologies (Shapiro *et al.*, 2015).

Climate change will overload environmental degradation and natural hazards (UNEP, 2016) and affects all aspect of economic growth especially in least developing countries. To reduce the impact of climate change and enhance food security, adaptation measures are urgently required. Further, climate change impacts will work together with other stressors such as over exploitation of resources (Olsson *et al.*, 2014), affecting a world population (UNDESA, 2015) and growing rapidly (UNDESA, 2017). Ethiopia's climate is naturally both highly diverse and highly variable. However, the climate is intensely changing in recent years (Umer, 2010; Eshetu, 2011 and Mokria *et al.*, 2017).

In Ethiopia, livestock generates more than 85% of the farm cash income. In terms of contribution to the national economy, livestock contribute about 13–16% of total GDP and the share to total exports is about 16% (Yayneshet, 2010). Most rangelands are at best only marginally suitable for arable cropping and in Ethiopia there are extensive areas where livestock raising on the natural vegetation is the only possible types of land use (Coppock, 1994). Rangelands elsewhere are presently undergoing extensive deterioration both in quantity and quality (Desalew *et al.,* 2010). Rangelands are limited capabilities in vegetative production and in providing reasonable animal nutrition and production due primarily to adverse environments including low and seasonal rainfall; soil erosion; inadequate forage and grazing management and overstocking rates (Mengistu, 2005b). Therefore, awareness of the potential benefits from adaptation is an important issue. To minimize the impact of climate change on smallholder farmers', adaptation strategy is vital instrument. Adaptation strategies, such as livestock mobility, diversification and animal destocking are gradually change weak to support their livelihoods (Wassie and Fekadu, 2014 and Kima *et al.,* 2015). Generally, it is believed that the adaptation strategy of rangeland degradation and climate change is vital to enhance the resilience of pastoral and agro-pastoral communities.

Tigray is one of the Regional States in Ethiopia that is being affected by recurrent drought because of both its arid and semi-arid nature. Consequently, the impacts of climate change and variability remain a serious challenge (Deressa *et al.,* 2008). Despite the occurrences of persistent droughts and agricultural failure derived from climate change in Tigray region, livestock provides multiple economic and social benefits.

The study has confirmed that the community views and attitudes of rangeland degradation in Alaje district, in Tigray, Ethiopia is sever. The aims of this study, therefore, seeks to evaluate adaptation strategies on rangeland degradation and climate change on animal feed production by farmers in the area, compare rangeland condition in rangeland grass biomass, species composition, palatability etc. under different grazing management systems. Estimating the actual and potential of major livestock feed resources available in different grazing management system is a requirement for planning and beginning sound livestock production and that largely benefits producers. Understanding the level of degradation of different feed resources is also essential for implementing appropriate adaptation strategy for rangelands.

Overgrazing and deforestation continues to affect the productivity and genetic diversity of resources. Intensified by recurrent droughts, the ultimate outcome of deforestation and degradation of these resources will be desertification, loss of livelihood and increased poverty (Mengistu *et al.*, 2015). Sustainable conservation and utilization of the vegetation resources and rehabilitation of those that have already been degraded provides economic, social and ecological benefits (Mengistu *et al.*, 2005; Kaye-zwiebel & King, 2014). In this regard, different strategies are used to improve and rehabilitate/degraded rangelands.

1.2. Statement of the Problem

Livestock systems in Ethiopian highlands are under stress following shrinking pastureland areas in response to high population growth and land degradation due to its conversion to crop fields and continuous cultivation/over grazing (Funte *et al.*, 2009). This has led to reduction in grazing areas and consequently to shortage of feed to livestock. As a consequence, crop residues have become the dominant ruminant feed resources in the highlands of Ethiopia (Funte *et al.*, 2009). Clearly, farmers have low capacity and vulnerable to the negative impacts of climate variability and change.

In Ethiopia especially for Alaje district, Southern Zone of Tigray region rangeland supports the huge livestock population for the last many years. The management practices and attentions given to these communal grazing lands were minimal. As a result, the production and productivity of communal grazing lands severely decreased from time to time. The over utilization of these resources by livestock still continues by different stakeholders.

As a result, the resources of the communal grazing lands are heavily damaged due to over grazing and climate change. To maintain the optimum productivity and sustainable use of the rangeland resources for the future, knowledge about the current rangeland resources is indispensable.

Moreover, there is very little information on adaptation strategy of rangeland degradation and climate change effects. This study will be intended to fill in the gap in the literature by exploratory the impact of climate change on rangeland production by using household specific simple random survey data.

This study, therefore, intended or designed to identify the adaptation method used by each farmer located at different agro-ecological zone and evaluated famers' perception on climate change and to evaluate to rangeland degradation in the study area of Tigray, Ethiopia.

1.3. OBJECTIVES

1.3.1. General Objectives

To evaluate farmers' adaptation strategy to decrease range land degradation and effect of climate change on livestock feed production in Alaje woreda, Southern zone of Tigray, Ethiopia.

1.3.2. Specific Objectives

- Assess farmers' perception to decrease rangeland degradation and climate change trends in the study area
- Evaluate farmers' adaptation strategy in response to decrease range land degradation and effect of climate change in the study area
- Evaluate rangeland degradation of grass biomass production, species composition and palatability classes.

- Identify the existing climate change impact on smallholder farmers' and rangeland degradation.

1.4. Research Questions

The main research questions in this study are the following;

- What are the farmers' perception to decrease range land degradation and effect of climate change trends in the study area?
- What are the farmers' adaptation strategy on range land degradation and effect of climate change on livestock feed production in the study area?
- What is the status of rangeland grass biomass production, species composition and palatability classes?
- What are the existing climate change impacts on smallholder farmers' to livestock feed and rangeland degradation?

1.5. Significance of the Study

The livestock population of the study area is directly depending on grazing land resources for feed and water. However, conversion of grazing land into crop cultivation lands reduced the available forage resources for the existing livestock population. The climate change effect resulting from decreased grazing lands causes shortage of forage biomass then hampers livestock productivity.

This specific study was to identifying the effects of climate change on range land degradation and farmers' adaptation strategy to decrease rangeland degradation and intensify opportunities for the smallholder farmers to cultivate improved fodders in their farm land to solve the feed shortage problems and hence enhance the productivity potential of their animals. This data surely will benefit too many concerned stockholders such as extensions workers, students, farm managers, farmers and interested individuals were significantly benefited from the results of this study. It has significant importance for the sustainable utilization of range land resources. In addition to this, it may serves as a source of information for other studies in the future endeavors. It is also important for policy makers, researchers and organizations involved in forage production, communal grazing land management practices and utilization methods of fodder species.

1.6. Organization of the Thesis

Thesis document is organized in five chapters: chapter one contains an introduction followed by problem statement, research objectives, and research questions. Chapter two includes basic thesis concepts and literature review, Chapter three describes the materials and methodology of the research. Chapter four presents the result and discussions. Chapter five includes conclusion and recommendations of the thesis.

2. LITERATURE REVIEWS

This chapter reviews relevant literatures on rangelands as an indicator of the environments. It also discusses the adaptation of rangeland degradation and effect of climate change on livestock feed production in Ethiopia.

2.1. Definition of Conceptual Terms

2.1.1. Climate Change

According to (IPCC, 2014), climate change is “a change of climate which is attributed directly or indirectly to human activity that changes the composition of the global atmosphere and which is accumulation to natural climate variability observed over comparable time periods.”

According to (IPCC, 2007), Climate change is a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its belongings and that continues for an extended period, usually decades or longer. It is a trend in one or more climatic variables characterized by a fairly smooth continuous increase or decrease of the average value during the period of record, such as, increasing trend in air temperature and the frequency of drought, increase in frequency of flood and decreasing trend in rainfall with a statistical significance (Gebre *et al.*, 2015).

Therefore, climate change is the slow change in the composition of the global atmosphere, which is caused directly and indirectly by human activities in addition to natural climate variability over time (Koehler-Munro and Goddard, 2010). (Koehler-Munro and Goddard, 2010 and IPCC, 2007) reported that 90-95% of climate change is likely to have been in part caused by human action.

2.1.2. Effect of Climate Change on livestock in Ethiopia

Ethiopia has a diversified climate ranging from semi-arid desert category in the lowlands to humid and warm type (NMSA, 2001). The extent and diversity of major agro-ecological zones reduce it suitable for the support of bulky numbers and classes of livestock (Funk et al., 2012). The frequency and intensity of drought is likely to increase over the coming decades, which will present a serious risk to biodiversity, ecosystems, water, agricultural and human health. Impacts of increased climate variability and change include: increased food insecurity, different outbreaks of livestock and human being diseases such as malaria, dengue fever and water borne diseases due to floods and respiratory diseases associated with droughts and heavy rainfalls which tend to accelerate land degradation (Anders, 2013).

Considering this problem intervention on technologies and practices in climate change adaptation include water use and management, soil management, crop management, Livestock management and farming systems. Similarly, (Altieri and Koohafkan, 2008), underlined multiple cropping, use of local genetic diversity and soil organic matter enhancement as adaptive strategies of smallholders farmers. Moreover, in their consideration of adaptation options and constraints in Ethiopia, (Bryan *et al.*, 2009), identified the use of different crop varieties, planting trees, soil conservation, changing planting dates and irrigation as the most common adaptation strategies. This makes rural agricultural communities a priority in the design of innovative climate change responses.

In addition climate-smart agriculture, contributed to the achievement of sustainable development goals. It integrates the sustainable development of economic, social and environmental by together speaking food security and climate challenges. It is composed of three main pillars: Sustainably increasing agricultural productivity and incomes; Adapting and building resilience to climate change and Reducing and/or removing greenhouse gases emissions, where possible (gebreegziabher and Berhane, 2014).

Climate-smart agriculture is line of developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change. The effects of climate change on agricultural systems make a substantial need to ensure comprehensive integration of these effects into national agricultural planning, investments and programs. The Climate smart agriculture approach is intended to identify and operational sustainable agricultural development within the explicit parameters of climate change (FAO, 2013).

2.1.3. Adaptation to climate Change

Adaptation in the face of climate change, livestock and rangeland management should determine for resilience through a diversity of land uses and promote biodiversity across the rangelands. The main status is that the negative impacts of climate change are mostly beyond the range or control of livestock farmers and the only way to sustain livelihoods is not to fight with nature but to grasp it innovatively. This should be done to reduce losses from pests, parasites, diseases and climate change stressors such as recurrent droughts and floods. The proof of the adaptation concept lies in the understanding that a more diversified diversity of livestock and rangeland management for better food and nutrition security and income streams can act as a buffer against the shocks of climate change.

Adaptation strategies of farmers Adapted to climate change specify different adaptation strategies which include planting trees, soil conservation, use of different crop varieties, changing planting dates and irrigation. The most common adaptation strategy is marketing during shock, home feeding. Most climate change adaptation strategies are existence designed to minimize or eliminate the negative impacts of climate change at the local level by changing the management practice. Adaptation may also seek to compensate for production losses by exploiting positive impacts of climate change in areas of increased rainfall or longer growing seasons. Climate change adaptation strategies often include a resilience element. However, they are generally limited to considering the resilience of the system to changes in precipitation or temperature.

According to (Adger *et al*., 2007; IPCC, 2001), adaptation is an adjustment adequately to human, ecological, physical or socio-economic systems, in response to apparent vulnerability or expected and actual climatic stimuli, their impacts.

2.1.4. Farmers Perception on Climate Change

There are different factors influencing the perception of climate change. Some ways of updating perception are slow and other faster. Farmers' perception of climate change governance and adaptation is vital for future plans aiming to deal with challenges arising as result of climate change. However, in many parts of the world climate change awareness, mitigation and adaptation mechanisms are marginally known.

Rarely farmers' perception about climate change not evidenced from weather monitoring stations (Maddison, 2006). In most parts of Ethiopia, people perceive declining in rainfall and increased in frequency of drought but it did not confirmed from weather station. This lack of congruence could be due to the fact that farmers' evaluate rainfall in relation to the needs of at particular times; small changes in quality, onset and cessation of rain over days or even hours can make a big difference, whereas meteorological data is more likely to measure totals and larger events. (Maddison, 2006), also argued that this lack of similarity between farmers' perception and meteorological records could create from the analysis of short term climate data and/or due to averaging of record from wider areas.

The degree of farmers' perception on climate change also depends on its impact on farmers' livelihood, their social, institutional and economic background. (Mongi *et al.*, 2010) indicated that farmers in Tanzania were able to note the climate change using different indicators like delay of onset and early retreat of rainfall resulted in shortening of growing period and frequent drought, increased temperature and frequency of flood. However, the degree of perception is different and depends mainly on level of education, livelihood activity, location and age. Moreover, this perception is strongly related with level of education and sensitivity of the livelihood that the respondent depends on. (Maddison, 2006) also concluded that most farmers in Africa perceive increased temperature and declined precipitation. (Lema and Majule, 2009) confirms similar situation in Tanzania. (Temesgen *et al.*, 2008) also indicated that majority of farmers in Ethiopia are aware of climate change and perceives an increase in temperature and decrease in precipitation.

2.2. Impact of Climate Change on Agriculture

IPCC, 2007 reports concluded that the increased concentration of greenhouse gases in the atmosphere will have a significant impact on the earth's climate in the coming decades. These changes could impact socio-economic activities, with series implications for the well-being of humans long into the future (Zhai and Zhuang, 2009). Climate change directly affects agricultural production and production efficiency. It affects in terms of productivity, agricultural practices, environmental effects and adaptation (Raghuvanshi, 2017).

2.3. Major Livestock Feed Resources in Ethiopia

According to (Ibrahim, 1999), Livestock in the Sub-Saharan Africa are dependent primarily on natural grasslands and crop residues. Livestock feed resources in Ethiopia are mainly natural grazing and browse, crop residues, improved pasture, forage crops and agro-industrial by-products. Feeding systems include communal or private natural grazing and browsing, cut and carry feeding, hay and crop residues. At present, Livestock are fed almost entirely on natural pasture and crop residues. Grazing is on permanent grazing areas, fallow land and cropland after harvest. Forage availability and quality are not favorable year round and hence gains made in the wet season are totally or partially lost in the dry season (Mengistu, 2005a).

Tigray, one of the regions in Ethiopia belongs to the African dry lands often called the Sudano-Sahelian region (Warren and khogali, 1992). The region is characterized by heaving and hilly escarpments sparse, highly uneven distribution of rainfall and frequent occurrence of drought. The main animal feed resources in the region are crop residues, native pasture, shrubs and aftermath which account for 47%, 35%, 10%, and 8%, respectively (Abesha, 2014) and about 40% of the total land area is used for grazing (Gebremedhin *et al.*, 2002). Despite the fact that forage shortage is the major livestock production problem in the region, a total of 262, 000 hectares have been put under enclosure in Tigray to overcome forage shortage and rehabilitate degraded mountain grazing land (Nedessa *et al.*, 2005).

2.3.1. Feed Availability and Palatability of Rangeland Forages

Inadequate feed supply, both in terms of quantity and quality, is the major constraint affecting livestock production in Ethiopia. Feed shortage is chosen as a factor responsible for the lower reproductive and growth performance of animals especially during the dry season (Legesse, 2008).The dry season is considered by inadequacy of grazing resources as a result of which animals are not able to meet even their maintenance requirements and lose substantial amount of their weight. Animal feeds were classified as natural pasture, crop residue, improved pasture and forage and agro industrial by-products of which the first two contribute the largest share in livestock production (Tolera *et al.,* 2012). Natural pasture communities are very complex consisting of a large range of grasses, shrubs and herbaceous species among which only few species are palatable. Livestock are able to selectively graze a small proportion of the palatable herbage available and ignore the undesirable ones. The most palatable species are selected first and closely defoliated. If the grazing pressure is high, then a decline in the quality and productivity of rangeland occurs (Cossins, 1985). This causes reduced vigor, less seed production and eventually plant death. Overgrazing can also lead to extensive sheet and gully erosion (Mengistu, 2005a).

2.3.2. Natural Pasture

In most areas of sub-Saharan Africa, the key even the only feed source available for large parts of the year in smallholder production systems are natural pasture (Gylswyk, 1995). Despite the continued expansion of croplands the resulting decline in the size of grazing areas, native pasture remain the major contributors of livestock feed in the densely populated highlands of Ethiopia (Gizachew *et al.,* 2002).

Many researchers and development workers agreed that natural pasture contains the largest feed resource but estimates of the contribution of this feed resource vary greatly (Alemayehu, 1998), estimated that 80-85 percent of all feed comes from natural pasture while some estimates indicate the natural pasture provides 88-90 percent. This is because the quantity and quality of native pasture varies with altitude, rainfall, soil and cropping intensity. The total area of grazing and browsing in the country is 62,280 million hectares. Out of this, 12% is in the farming areas (more than 600 mm rainfall) and the rest is around the pastoral areas (Alemayehu, 1985b). In extensive and semi-extensive systems, natural rangeland is a major feed resource (Gambiza, 1996). Communal grazing is normal and managed as a common property resource (Behnke *et al*., 1993). The carrying capacity of the grazing area, if calculated on plant availability, should allow a plant use of 30–50% (de Leeuw and Rey, 1995). A major variable in the system is rainfall, which affects the productivity rangeland and the supply of other feed resources. As listed by (Herbel *et al.*, 1991), the important principles of rangeland management are stocking rate, rest and the frequency of grazing. In communal rangelands, high stocking rates, few rest periods and frequent close grazing and climate change are factors causing debilitating impacts on rangelands.

2.3.3. Crop Residues

Crop residues are the fibrous by-products which result from the cultivation of cereals, pulses, oil plants, roots and tubers and represent an important feed resource (Yayneshet, 2010).They are important in fulfilling feed gaps during periods of serious shortage of other feed resources. A report by (Tolera *et al.*, 2012) indicated that crop residues contribute to about 50% of the total feed supplied in Ethiopia. Apart from being a source of animal feed, residues are sources of building, roofing and fencing materials. They are used also as fuel and as fertilizers or as surface mulch in cropland (Raay and Leeuw, 1970).The amount of crop residue produced is closely related to grain production, farming system, the type of crops produced and intensity of cultivation. About 12 million tons of crop residues were produced annually from 6 million hectare of farmland in Ethiopia (Keftassa, 1988). A report by (CSA, 2016/17) indicted that crop residues production was increased to 12.76 million tones. (Sileshi and Bediye, 1989) reported that 63, 20, 10, and 7% of cereal straws are used for feed, fuel, construction and bedding purposes, respectively. Farmers in the Ethiopian highlands have a tradition of conserving crop residues from teff, barley, wheat and sorghum (Reed and Goe, 1989). Straws from teff, barley and wheat form the largest component of livestock diet in the mid and highland areas, while maize, sorghum and millet Stover's constitute larger proportion of livestock feed in lower to medium altitudes(Alemayehu, 1985a).

Stubble grazing is an important source of feed that is common in Tigray and can yield up to 0.5 tones DM/ha (Zeratsion, 2007), Stubble grazing occurs right after crop harvest at the end of September and/or first week of October and continues until feed is completely depleted in January/February

2.3.4. Improved Forage Crops

The major feed resources in the country are crop residues and natural pasture, with agro industrial byproducts and manufactured feed contributing much less (Gebremedhin *et al.*, 2009). Several introduced forages were tested on station in different ecological zones and considerable efforts were made to test the adaptability of different species of pasture and forage crops under varying agro-ecological conditions over the past decades (Mengistu, 1997). As a result, quite a number of useful forages have been selected for different zone.

2.4. Animal Feeding Practices in Ethiopia

Feeding of livestock in diverse places differs depending on forage availability, climatic variability of a given location to mitigate feed shortage problems during worse conditions, season of the year and type of animal the owner prioritize to feed (Teklu *et al.*, 2011).The feeding systems in the country include communal or private natural grazing and browsing, cut and carry feeding, hay and crop residues. At present, in the country stock are fed almost completely on natural pasture and crop residues. Grazing is on permanent grazing areas, fallow land and cropland after harvest (Desalew, 2008). (Kitabe and Tamir, 2005) reported that the herbage yield and nutritional quality of natural pasture is generally low. In certain areas where improved forage crops have been introduced, farmers failed to utilize them at its optimum developmental stages, which would ensure an appropriate balance between quality and quantity to satisfy livestock requirements and support reasonable animal production (Bayable, 2004). In the mixed crop-livestock systems of the Ethiopian highlands, the feed resources available for livestock production come from permanent pastures and short-lived pastures between cropping cycles, crop residues and crop aftermath grazing. Forage obtained from crop thinning and defoliation from annual crops and perennial crops is important for livestock feeding (Fekadu, 1996).

2.5. Land Holding Size

Average land holding varies considerably in the highlands reflecting differences in population density. The land size selected to individual farmers by a Peasant Association (PA) as per the land reform declaration of 1975, depended on family size, fertility of the land, the number of kebelles members and the total land area available within the kebelles (Asamenew *et al.,* 1986). Most farms in Ethiopia are fragmented and smallholder mixed crop-livestock systems (Wondatir, 2010) and farmers practiced a cereal dominated cropping system in the highland areas of the country (Duguma *et al.,* 2012).According to (Admassu, 2008) reported that land and livestock holdings showed a direct linear relationship, where farmers with large land holdings have higher livestock holdings and when land holdings became smaller there is a trend of keeping more numbers of small ruminants than cattle.

2.6. Livestock Holding Size

The number of livestock owned varies from location to location depending on several factors, like feed availability, disease condition and resource status of the farmers. In mixed farming system of the highlands and mid-altitudes of Ethiopia where crop production is important; cattle are the most important livestock species for cultivation, threshing and manure production (Asamenew *et al.,* 1986).

2.7. Rangeland Potential of Ethiopia

Rangelands of Ethiopia contain of typically native pastures (grass, forbs and woody plant species) they are main feed sources of grazers and browsers (Gemedo and Isselstein, 2006), Natural vegetation integration repeats the whole of the natural environment. If topography, geology and soil are not changed obviously, the change in vegetation usually imitates a change in rainfall (Mengistu, 2005b).The pastoral rangelands of Ethiopia are located around the bordering of the country, almost surrounding the central highland mass (Alemayehu, 2004), the areas are classified as marginally arable and non-arable land. They contain about 62 % (767,600 km^2) of the country's land area. Most of these areas are below 1500masl with the south west and the south eastern areas having an altitude of around 1,000masl and the south eastern and south western rangelands rising up to 1,700masl (Gebremeskel, 1993). Climate in the lowlands includes arid (64%), semi-arid (21%) and sub humid (15%) zones mainly defined by rainfalls and temperature regimes. These zones vary decidedly in terms of number of plant growing days per year, forage production, common plant associations, livestock and human carrying capacities and incidence of important livestock diseases. Livestock depend upon rangelands containing of native vegetation, with crop residues increasing in importance as livestock feed as annual rainfall increases. According to (Coppock, 1994) calculated for the lowlands overall, roughly six people/km^2 are dependent on 11 Tropical Livestock Units

(TLUs), which are composed of cattle (49%), goats (16%), equines (16%), camels (12%) and sheep (7%). In contrast, the highlands support 72 people/km² and dependent on 44 TLUs/km² which are dominated by cattle (76%), equines (14%), sheep (8%) and goats (2%). Thus, although the lowlands comprise over 50% more land area than the highlands, the lowlands have only 40% as many TLUs at one-quarter the density.

2.7.1. Current Status of Ethiopian Rangeland Resources

Rangeland resources in Ethiopia are in risk of pleasurable extremely degrading due to natural and human-induced factors (Teshome Abate, Ebro, Nigatu, 2012 and Amaha, 2006). They are under pressure by several drivers of change and there are substantial difficulties in evaluating these changes and what they may mean for human use of rangeland resources (Desta, 2009). In arid and semi-arid rangelands, heavy grazing pressure and climatic factor such as elevation can influence forage production and shift composition (Gemedo *et al.,* 2006), soil erosion and rangeland degradation (Kassahun *et al.*, 2008), increase bush density (Angassa and Oba, 2008). Such deviations would influence the productivity, sustainable utilization and management of rangelands ecosystem (Abate and Ebro, 2009 and Alemayehu, 2006). The rangelands of Ethiopia are currently being extensively deteriorated both in quantity and quality (Belaynesh, 2006 and Tesfaye, 2008). Rangeland productivity hotspots need to be protected for pastoralists to ensure the viability and growth of the pastoral production system as a whole (Flinton and Cullis, 2010); Because of global climate change and the intensive human activities, desertification/land degradation has become the most serious problem in the modern society, particularly in the ecologically sensitive arid and semi-arid areas (Niguse and Gizachew, 2014). Rangeland degradation implies a reduction in rank or status, which includes a loss of topsoil, a change to a simple floral/ fauna composition or a change from organic form to a lower organic form and continuous reduction of productivity/biomass of the ecosystem (Tesfaye, 2008). In addition, on the view of ecology, degradation can be described as retrogression of an ecosystem (Niguse and Gizachew, 2014) are generally indicated that, a lower biological diversity is supposed to occur in a degraded rangeland.

2.7.2. Rangeland Degradation

Rangeland degradation is a decrease in plant species diversity, plant height, vegetation cover and plant productivity (Chen *et al.,* 2003). The joint effect of human and climatic factors on land degradation has led to reduced production of the rangelands (Jama and Zeila, 2005).The term rangeland degradation refers to both soil and vegetation and is commonly defined as the reduction of the economic or biological productivity of lands (FAO, 2011). Recently, degradation has also come to mean deterioration in ecosystem services and functions, such as decreased water and soil conservation, recreation values, carbon balance and so on. It also defined as the loss of provision or potential utility, loss or change of the features of rangeland ecosystem. In general, rangeland degradation is reduction in the status of natural vegetation. Loss of plant cover, undesirable change in herbaceous species composition (e.g. annual grasses replacing perennials), soil erosion of various types associated with intensification of grazing and woody encroachment have been dominant features in the Ethiopian rangelands which could have different implications for pastoral productivity (Chen *et al.,* 2003). Generally, a lower biological diversity is supposed to occur in a degraded rangeland.

2.7.3. Major Causes of Rangeland Degradation

Rangeland degradation, a worldwide problem, is serious in Ethiopia, especially in study area. In Tigray, Ethiopia, loss of perennial grass cover and increase in annuals, unpalatable forbs and bush cover are the leading cause and also conversion of rangeland to cropland and over-grazing by livestock are the major causes (Musa *et al.*, 2016). Climate change has serious the problem (Bai *et al.*, 2004). In general, natural and human induced with overlap between the two are identified in making rangeland degradation and the most common ones are discussed hereunder.

2.7.3.1. Climate Change

Ethiopia is already experiencing signs of climate change. According to (Chen *et al.*, 2003), increase in temperature and fall in rainfall have been measured since 1996 years with temperature increase has come more dry and increased erosion events. It is projected that rangelands will be negatively affected by climate change, with consequences such as change in water resources, change in rangeland productivity, change in land use systems and rangeland based livelihoods (Hoffman and Vogel, 2008). The country is also experiencing uncommon frequency and extensive droughts since recent decades (Kassahun, 2008). Dry lands of Ethiopia are exposed to climatic change and its variability, a problem that is affecting many sectors having biodiversity (flora and fauna), agriculture, human health and water. Climate change may also increase the spread of invasive species (McNeely, 2004) and can deterioration degradation of rangeland ecosystems and the people depending on these ecosystems.

2.7.3.2. Over-grazing

Overgrazing of rangelands is a problem worldwide and Ethiopia is no exception. Increase in human population demands increase in livestock population in rangelands in order to maintain survival. In pastoral areas of Ethiopia, the animal populations are growing at an increasing rate to encounter the need of increasing human populations, while the pasture resource is reduction in terms of grazing area and range productivity (Coppock 1994).These increases in livestock populations are developing the imbalances in the lowland range system and have already resulted in overgrazing and range degradation (Alemayehu, 2004; Amaha *et al.*, 2008; Gemado *et al.*, 2006; Solomon *et al.*, 2007and Teshome, 2016). According to the World Resource Institute (WRI, 1992), overgrazing is the most dominant cause of soil degradation.

According to (Dahmed and Yazman, 1994), the effect of grazing on the vegetation of grasslands is frequently measured by deviations in composition, cover and yield. Grazing beyond carrying capacity reduces the amount of regeneration and pushes the vegetation farther away from climax, while reduced grazing allows the system to move back along the succession pathway (Blench & Florian, 1999). Overgrazing can increase soil erosion, reduced soil depth, soil organic matter and soil fertility and also injured the land's productivity.

2.7.3.3. Population pressure

Demographic factors related to human population growth resulting from an increase in the number of communities themselves, settlements, immigrants from outside the pastoral area and from other pastoral areas are the underlying causes of rangeland degradation. A common result of increasing population is land degradation because of higher population involves increasing demand for forest products, space for settlement, grazing and farming areas (Mulugeta and Habtemariam, 2010). From this, it can be associated that increases in human population can aggravate pressure on the existing rangeland resources and lead to land degradation.

2.7.4. Impacts of Rangeland Degradation

Rangeland degradation in the pastoral communities has resulted in substantial declines in rangeland condition, water potential, soil status and animal performance, livestock holding at the household level, while communities in general have lost their livestock asset and become destitute. Another result of rangeland degradation is associated to food insecurity, poverty to the extent of food aid, expansion of aridity and the need for alternative livelihood income and diversification (Kassahun *et al.,* 2008 and Teshome, 2016). Moreover, it has increasingly become a threat to the pastoral production systems and has contributed towards increases in poverty and tribal conflicts over grazing land and water resources (Abule *et al.,* 2005 and Solomon *et al.,* 2007).

2.7.4.1. Rangeland rehabilitation techniques

Due to the shared effect of both human and climatic factors rangeland degradation spread fast and led to reduced production of the rangelands and reduced environmental quality (Jama and Zeila, 2005). According to (Schlesinger *et al.*, 1999), rangeland rehabilitation is becoming an increasingly important tool in humanity's attempt to manage, conserve and repair the degraded rangeland ecosystems. In order to rehabilitate the degraded rangeland in-depth understanding of how it worked before it was modified or degraded and then use this understanding to reassemble it and reestablish essential processes highly needed (Blench and Florian, 1999).

For effective rehabilitation of the rangeland we can take different techniques like reseeding or allowing the progression of natural regeneration, soil and water conservation measures and water harvesting and dry land forestry attention on the underlying causes of degradation and reverse the degradation process (Li *et al.,* 2011).

2.8. Biomass Estimation Methods

Biomass is a commonly measured vegetation features that refers to the weight of plant material within a given area. Other general expressions, such as 'yield' or 'production', are sometimes used interchangeably with biomass. Units to express biomass should be selected so that actual plant weight is easy to visualize, such as lb/acre, kg/ha or g/m^2 according to vegetation abundance and objectives of the inventory or monitoring program.

Biomass or standing crop usually refers to the weight of organisms present at one time (SRM 1999). Most estimates of plant biomass or standing crop include only that above the soil surface. This material is commonly available to larger herbivores. Below ground biomass is very important for plant functions, but is difficult to measure and generally not included in inventory or monitoring procedures. Direct harvesting is considered the most reliable method of determining above ground biomass. However, this method is to time consuming to be of practical value for inventory or monitoring of extensive range areas. Several weight estimate techniques have been developed for rapid and fairly reliable determination of herbage weight. These procedures involve estimating herbage weight by species from small quadrates in the field. Training of observers in the field is necessary. This can be done easily by checking the estimates with clipped quadrate (Mengistu, 2005b). The method is considered reliable enough to be used on detailed research studies. Weight estimates can be adjusted by clipping a portion of the quadrates that have been estimated.

3. MTERIALS AND METHODS

3.1. Descriptions of the Study Area

3.1.1. Area Coverage and Geographical Location

Alaje Woreda is geographically located between 39^{0}33'0" to 39^{0}37'0" East longitude and 12^{0}54'0" to 12^{0}58'0" North latitude and the altitude ranges between 1750 to 2350 meters above sea level. The study district is located about 88km south of Mekelle, regional capital. It is surrounded by Woreda Saharti Samre in the North, Endamokeni to the South, Raya Azebo and Hintallo Wojerat to the East and by the Amhara region to the west. The woreda comprises 20 kebelles and is dominated by two major agro ecologies –highlands and midlands.

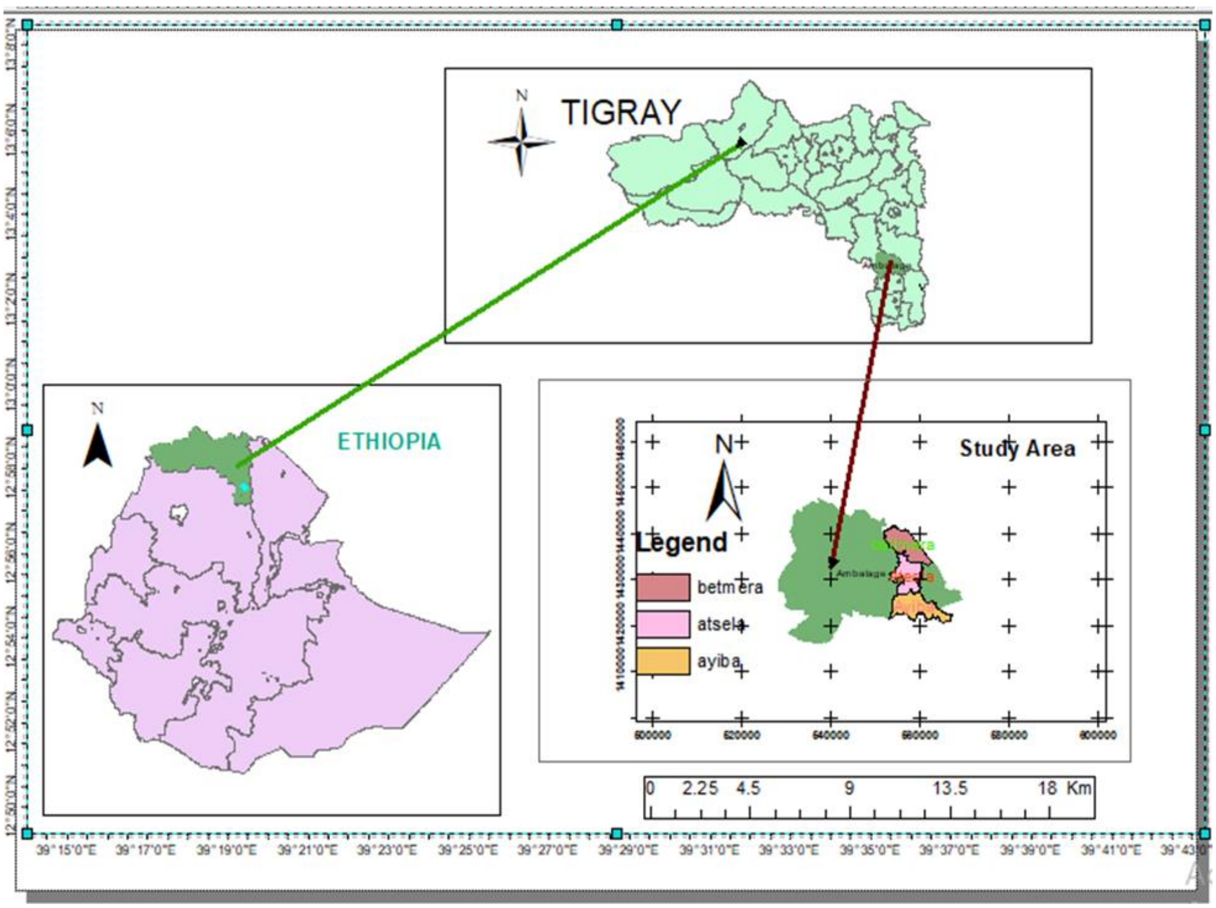

Figure 1: Location of study area

3.1.2. Climate and Topography

In Alaje long-term meteorological data indicate that the mean annual rainfall is between 700 - 912 mm with mean daily temperature ranging from 10 - 23^{0}C. Rainfall pattern is bimodal; short rain called Belg which rains from February to March and a main rain called Kremt that rains from end June to beginning of September, the most intense rainfall being between July and August. It is characterized by two major agro-ecologies; highlands and midlands.

3.1.3. Land Use and Farming Systems

The total land area in district is estimated at 76,722 hectares. There are about (35.6%) 27,327 hectares of arable land of which (3.4%) 2,618 hectares are under forest, (27%) 20,366.6 of the total land are grazing lands and (34.4%) 26,410.4 hectares fall under the category "others". The study district has human population of 140,157 from which 49% are female. The total household is 32,851 with 10,790 female and 22061male. Production system of the study area is mixed farming system (both livestock and crop production). The main livestock types are cattle, sheep and goats providing multiple benefits like draught power, food and income to the farm community. Major crops such as sorghum, Teff, Maize, wheat, barley, Faba bean, field pea, linseed, onion, pepper, cabbage, and fruits are grown in the study area (Girmay *et al.,* 2014).

3.1.4. Livestock Population

Livestock production is an integral part of the land use system in the study area. Production of cattle (as draft power, milk, and meat), shoat (income and meat), donkey (as Karoo and transport) and poultry (as source of meat, egg and income) are commonly practiced. (OoARD, 2018) shows that the livestock population of the district is composed of 126,890 cattle, 127472 sheep, 64054 goats, 18809 equines, 86932 poultry and 11810 beehives. The major feed resources in the area are natural pasture, crop residues (wheat, barley, sorghum, maize and teff straws) improved fodders (Elephant grass, Sesbania sesban, Tree lucerne, Oat-vetch and Dishograss).

3.2. Sample Size and Sampling Methods

The study district has 20 kebelles of which three kebelles were selected purposively based on accessibility, grazing land availability and climate change variability effect. For the sake of comparison of rangelands, three adjacent range sites were stratified into highland and midland based on agro-ecological zones topography and climatic conditions were selected from the pre-selected three peasant associations. The household sample sizes were determined by using the procedure of (Snodcor and Cochran, 1956) at 5% (0.05) level of precision. The sample size determination formula is:

$$n = \frac{NZ^2pq}{(N-1)e^2 + Z^2pq}$$

Where n=the sample size, N=the population size, Z^2 = Confidence level at 95% (Z=1.96), P= estimated population, q=estimation proportion (0.5) and e=the level of precision at 95% significance level.

Based on the above formula the minimum sample size required was 212 households. A total of 212 respondents were selected using simple random sampling technique for the purpose of household interview. Attempts were made to include female respondents to address gender related issues in relation to adaptation strategy rangeland degradation and climate change. In addition to this, three separate kebelles were selected systematically for the purpose of focus group discussions (FGD). The group discussion was including representative of the farm community with discussants involving of elder people, young people, female farmers and knowledgeable persons.

Table 1: Distribution of sampled households by selected Kebelle

Name of District	Kebeles	Agro-ecology	Total no of HH head	Sample size taken
Alaje	Atsela	High land Altitude	725	37
		Mid land Altitude	695	36
	Ayiba	High land Altitude	1425	75
	Betmera	Mid land Altitude	1386	64
Total			4568	212

Source: Alaje district Administrative Office, 2010 E.C).

3.3. Data Collection Methods

Both primary and secondary data were gathered using appropriate data collection techniques. Primary data were collected through household interviews, focus group discussions (FGDs) and personal observations. Secondary data were collected from different published and unpublished reading materials like books, journals, proceedings, thesis paper, and reports. A semi-structured questionnaire were prepared and translated into local language to undertake interview with the selected households. The questionnaire was administered to the randomly selected household heads by a team of enumerator recruited and trained for this purpose with close supervision by the researcher. In addition to interviews, three group discussions were held with development agents and key informant in three separated selected kebelles. Data were collected on the socio-economic characteristics (sex, age, education, family size, land size, animal number etc.), farmers' adaptation strategy on climate change; farmers' adaptation practices to reduce rangeland degradation and the effect of adaptation practices on livestock production, feeding practices, feed related problems, grazing land management and utilization system and other relevant once.

For rangeland degradation evaluation discussion were made with the community members, experts and development agents in the agricultural office to select the range sites. Short visits were made to these sites for evaluation. The number of sites was decided based on the proportions of the available grazing land in the kebelles. Categories of the grazing lands were further stratified into three sampling areas in each kebelles: free grazing, rotational grazing and enclosures (hill side protected areas) were selected using the stratified random sampling technique considered as parameters. The characteristics of the different grazing systems are given in Table 2 below.

Table 2: Characteristics of the difference grazing system

Grazing system	Characterization
Enclosure	Protected area and have guards from the community
Rotational grazing	Grazing area having different paddocks and freely grazed rotationally for the purpose of oxen and calved cows depending on body condition of the animal. Protected and have a legal body to manage the grazing land with rules and regulations of the community but violation of the rules and regulations are happened.
Free grazing	Not protected freely grazed the whole year

Questionnaire which focused adaptation strategy on rangeland degradation and effect climate change on animal feed production.

3.3.1. Estimation of Feed Supply from Each Source

The quantity of feed DM obtained annually from different land use types were calculated by multiplying the hectare of land under each land use types by its conversion factors. A Conversion factors of 2.0, 0.5 and 0.7 tons DM/ha/year were used for natural pasture, aftermath grazing and forest land, respectively (FAO, 1984). The quantity of available crop residues produced by farmers was estimated by converting crop yield to straw yield (Kossila, 1988), (Chenost and Kayouli, 1997); (De Leeuw and Tothill, 1990). Accordingly, for a tons of wheat, barley and teff straws, a multiplier of 1.5 will be used, for Faba bean and field pea a multiplier of 1.2 were used (Chenost and Kayouli, 1997), for noug seed and linseed a multiplier of 4.0 were used (Chenost and Kayouli, 1997). For maize a multiplier of 2.0(De Leeuw and Tothill, 1990) and for sorghum a multiplier of 2.5 were used (Kossila, 1988). The total quantity of potentially available crop residues for animal consumption were estimated by multiplying the crop residue yield by 90% assuming that 10% wastage of the feed mostly occurs during feeding and/or used for other purposes (Tolera and said, 1994). The size of private grazing land and hay collected were gathered through household interview. Dry matter yield from private grazing land were estimated by multiplying the average grazing land holding per household with the annual DM output of natural pastures which is estimated to be 2 t/ha based on (FAO, 1987). The DM outputs that can be available from hay were estimated with a formula recommended by the Fourth Livestock Development Project (MAO, 1989).

3.3.2. Biomass Measurements and Species Composition

A belt transect was measured up to 1.2km in each of the different grazing systems was demarcated. Along the transect line, three experimental quadrant measured (20m x 20m) the distance interval away 50m between quadrant to the nearest quadrant. In each of the sample site, the biomass yields of herbaceous species were measured using 1mx1m size quadrat were nested (four at the corners and one at the center) within the larger 20mx20m plots used. The herbages within the quadrat were cut off to ground level. The cut samples were immediately weighed using spring balance and transferred into properly labeled paper bags fastened at the top. The samples were kept under shade area until sampling for the day was completed. Each of the samples in the paper bag was weighed. Finally, the DM was determined in an oven (105^oC for 48 hours) at Mekelle University laboratory. In each $1m^2$ quadrates the grass species composition was estimated using cover pin plate by dropping pin method**.** When released pin hits plants, the species hit is recorded then the procedure repeated ten times at ten equal intervals in a quadrate (Elzinga et al., 2001). The percent cover for each cover category was calculated by dividing the number of hits for each category by the total number of hits for all categories, including hits on vegetation and multiplying the value by 100.

$$\text{Species composition} = \frac{\text{number of pins on species}}{\text{Total number of pin on vegetation}} * 100$$

3.3.3. Identification of Grass Species

3.3.3.1. Local criteria for evaluation of Indigenous fodder tree grass species

The criteria identified and used by locals of a given species were very diverse (N= 20), but can be categorized in to three groups; Animal-based: the numbers of criteria used were 5(fattening, health, milk letdown, palatability and rumen fill), Plant based: the numbers of criteria used were 4(browse biomass, drought resistance, early re-growth and termite resistance) and multipurpose: the numbers of criteria used were 11(charcoal, Ethno-medicine, farm implements, fencing, fiber or rope, fire wood, food, market value, Sanitation, Shading and shelter and Timber and construction. The farmers were asked which of the indigenous fodders, trees and shrub species of animal feed found around and in their household vicinity are grazed/browsed by their livestock so that compare and sorting of these indigenous fodders, trees and shrub species based on their local importance value (Balehegn *et al.*, 2015).

To identify and rank the locally preferred 10 top fodder species focus group discussions with purposively selected 20 experienced farmers, community elders and local development agents in the study area was held, in order to prepare an exhaustive list of all fodder species available in the study area. Then, farmers were asked to score all fodder species according to their local importance as outlined in (Balehegn et al., 2015). Here simple scoring 'was used for scoring species according to their different local criteria was used in (Balehegn et al., 2015). Respondents were asked to put 0–5 points to each of the 20 local fodder selection criteria. In order to develop scores based on their corresponding twenty criteria, each of the 20 criteria was first given different weights, because all of the twenty local criteria identified did not have the same level of importance. Therefore, the participants were asked to score the twenty different criteria according to their role or value as fodder criteria.

3.3.4. Palatability Composition

According to (Hardy and Hurt, 1989), for palatability composition three palatability classes is described for the purpose of classifying grassland species: classes 1, highly palatable, class 2-intermediate and class 3-unpalatable. Weightings of 3, 2 and 1 for classes 1, 2 and 3 respectively, are used to derive a palatability composition relating for each sample site.

$$PC= (N1*3+N2*2+N3*1)/ (total\ N*3)*100\%$$

Where N1=number of sample quadrant in class 1, N2= number of sample quadrant in class 2, N3=number of sample quadrant in class 3 and N= Total number of sample quadrants.

The palatability composition rating (PC) for each site was calculated as the sum of products of the relative abundance of each species and its weighting and is expressed as a percentage of the maximum PC to produce a scale ranging from 33.3 (all species in class 3) to 100 (all species in class 1).

3.3.5. Collection of Metrological data

Sample survey was selected to identify the current climatic condition of the area and help to show how the climate is changed over years. However, it is difficult to conclude only by using 30 years data but help me as a starting point and as accurate evidence for the information that I collect from the interviewees and studies. I used the sample of 20 years monthly rainfall data and monthly minimum and monthly maximum temperature data from Tigray metrological station. The data helped me to compare and contrast the climatic conditions of the area today and decade back. In addition, it helped me to easily see how various pressures or factors change the climate of the woreda data was calculated by using the procedure of Standardized Precipitation Index (SPI) (McKee *et al.*, 1993). Rainfall anomaly was computed as:

SPI= $\frac{xi - \overline{X}}{\sigma}$, where, Xi = the year rain fall, ($\overline{X}$) = mean of the year, (σ) =standard deviation

Subsequently, inter-annual rainfall variability was determined by the coefficient of variation (CV), which is obtained by dividing the standard deviation of the annual rainfall by the average long-term rainfall over the given period.

3.4. Data Analysis Methods

The collected household data were analyzed using Statistical Package for the Social Sciences (SPSS) software version 23. Descriptive statistical tools such as mean, percentage, minimum and maximum will be employed to analyze, describe and summarize respondents' socioeconomic, cultural, environmental and climate related variables were used to present the results. Moreover, One-way analysis of variance (ANOVA) was used for analysis of effect grazing land on species composition and dry matter biomass yield data, palatability composition rating of farmers to Indigenous fodder tree grass species mean of the measurements of reference quadrates $1x1m^2$ was the least significant difference was used for mean comparison

4. RESULTS AND DISCUSSIONS

4.1. Demographic Characteristics of Households

4.1.1. Household Characteristics of the Respondents

The overall average age of respondents was 46.0±10.15 years (Table 3). The average age was obtained to be 46.2±10.00 for highlanders while it was 45.8±10.36 for midlands with insignificant difference ($P>0.05$). This average age indicates the presence of active labor force, which can play a positive role in reducing the labor constraints faced in livestock production and climate change adaptation strategy. The family size of the respondents was generally higher than the mean value of 4.99 persons reported by (Hailemichael, 2013). The studied household had an average total size of 5.03. There is no variation in family size between highland (4.9±1.66) and midland (5.2±1.88) ($P>0.05$) (Table3). Larger family size is expected to allow farmers to take up labor intensive adaptation measures (Nyangena, 2007; Dolisca *et al.,* 2006; Anley, 2007 and Birungi, 2007). On the other hand (Gbetibouo, 2009) reported that household size enhances the farmers' adaptive capacity to respond to climate change.

4.1.2. Educational Level of Respondents

Out of the total respondents 37.3% attended elementary, 36.3% illiterates, 11.3% read and write, 9% junior school and 6.1% secondary school, respectively (Table3).This indicates the highest numbers of respondents were attended elementary school 47(41.96%) in the highland and 32(32%) midland. There was no significant difference between the altitude in literacy level ($P>0.05$). As indicated by (Ezeibe *et al.,* 2014), the low levels of education of the households have an influence on adoption of improved range land management practices. Other author stated that education is the main issue in agricultural development and adaptation to climate change (Bruna *et al.*, 2014).

Table 3: Sex, age, family size and Educational status of the respondents in the study areas

Variables		Highland(N=112)		Midland(N=100)		Overall(N=212)	
		N	%	N	%	N	%
Sex	Male	102	91.07	76	76	178	83.96
	Female	10	8.93	24	24	34	16.04
Age	24-35	20	17.86	21	21	41	19.34
	36-45	35	31.25	34	34	69	32.55
	46-60	48	42.86	36	36	84	39.62
	61-75	9	8.04	8	8	17	8.02
	>76	0	0.00	1	1	1	0.47
		112		100		212	100.0
	Total average Mean	46.21±10.0		45.79±10.35		46.01±10.15	
Family size	1-3 family size	34	30.36	40	40	74	34.91
	4-6 family size	74	66.07	59	59	133	62.74
	7-9 family size	4	3.57	1	1	5	2.36
	Total average mean	4.8±1.65		5.2±1.87		5.03±1.77	
Educational status	Illiterate	36	32.14	41	41	77	36.3
	read and write	14	12.50	10	10	24	11.3
	elementary school	47	41.96	32	32	79	37.3
	Junior school	9	8.04	10	10	19	9.0
	secondary school	6	5.36	7	7	13	6.1
	% of total	52.8		47.2		100	

4.1.3. Land Holding and Land Use Pattern Crop Land Owned in Hectare

The result indicating land is one of the most important resources required for any agricultural farming activities. The present results indicate the largest proportion of farm size was allocated for cultivation. There was similar land use pattern between both agro-ecological zones. In study area, the land allocated for private grazing areas and improved forage lands were very low. The overall average farmland size owned per respondent in the study area was 0.66±0.23 ha. This figure was less than 1.3 ha reported by (Yenesew *et al.*, 2013 and Abebe *et al.*, 2013) and 1.4ha in Ethiopia (World Bank, 2013). Similarly, the private grazing landing size (0.03±0.00 ha/HH) was less than 0.05 ha reported by (Alemu, 2015) and 0.23 and 0.27 ha reported by (Mekuriam *et al.*, 2011). The lower private grazing land ownership could be attributed to the lower land holding and high human population density. This may limit the contribution of grazing areas to the annual animal feed supply. This can be evidenced by the national (80-90%) and regional (30-35%) contributions of grazing areas (natural pastures) to the animal feed supply (BOANRD, 1987 and Mengistu, 2002).

The overall average total landholding varies among the respondents in study area. The average farmland size owned per household in study area was significantly higher (P<0.01) than the low average farm size owned. The higher the landholding, the more likely the farmer is to adopt adaptation strategies. The higher landholding of respondents may be due to rent of farm land from elder farmers and low population density of the area could have allowed individual farmer's larger landholding.

Table 4: Land size (ha/HH) and land use pattern of the study areas (Mean ± SE)

Land use pattern	High land (N=112)	Midland(N=100)	Overall (N=121)
Cultivated land owned	0.54±0.03	0.63±0.02	0.59±0.03
Grazing land owned	0.06±0.00	0.00±0.00	0.03±0.00
Other land owned (irrigation, forage)	0.05±0.01	0.03±0.07	0.04±0.20
Land holding total	0.65±0.04	0.66±0.09	0.66±0.23

4.1.4. Livestock population and utilization

According to the respondents (212 households) the major types of livestock in the study area were cattle, sheep, goats and donkeys in the order of their total population. 88.2% of the household owned cattle, 63.7% sheep, 63.2% donkeys' 62.3% poultry, 31.6% bee colony, and 14.6% had goats. Cattle, sheep, donkeys and poultry were the dominant species of livestock kept in the study area followed by bee colony and goats were least. The average size of livestock holdings per household were 1.35TLU/HH, 1.1TLU/HH,0.87TLU/HH, 0.69TLU/HH, 0.36 TLU/HH and 0.22TLU/HH for cattle, sheep, poultry, donkey, bee colony and goats, respectively (Figure 2). There was no much variation in livestock holding between highland and midland in all animal species (P>0.05). Most of the farmers in the study area kept more than one species of domestic animals. Farmers gave different reasons for this the farmers indicated that, having more number of animals is an indicator of wealth. Others responded that owning more livestock species, especially sheep and goats is the means of risk aversion in case of natural disaster or any incidence of disease outbreak. The higher sheep number is attributed to the ecological suitability of the areas for sheep production. Sheep prefer highland and midland areas while goats prefer lowland areas. The result is also similar with the findings reported by (Abera *et al.*, 2014, Birhan & Adugna, 2014 and Amsalu and Addissu, 2014) as cattle are contributing more to the total herd composition reported as cattle are contributing more to the total herd composition almost all farmers in the study area appreciate the importance of small ruminants indicating that keeping them is similar to saving cash in a bank. They can sale the animals to pay the credits for agricultural input (fertilizer and/or improved seeds) and also used to meet emergency cases, payment of taxes and school fees.

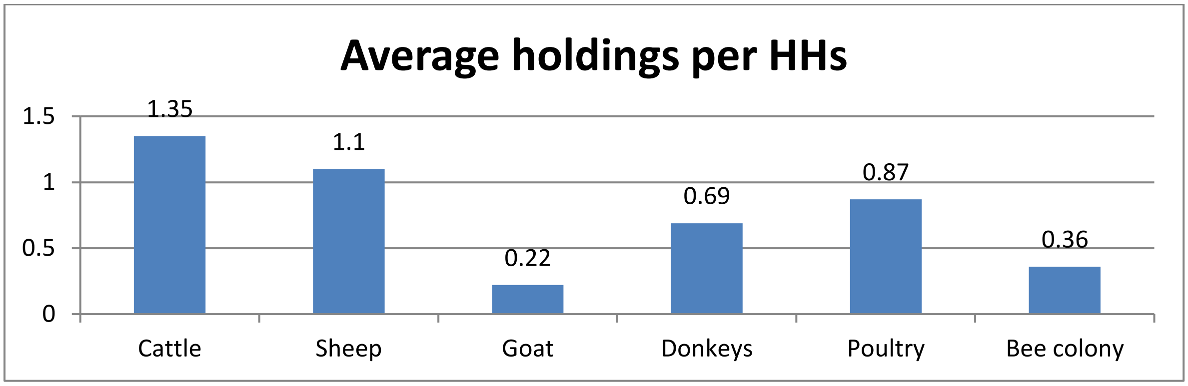

Figure 2: The average size of livestock holdings per household in the study area

As shown in Figure3, based on the regional livestock population data, the trend of livestock population was increasing annually. While during the questionnaire survey the respondents agreed that the livestock population was decreased due to decreasing the grazing land capacity, human population increasing and thus livestock population per house hold are decreasing may be shrinking rangelands due to high population growth, land degradation and reduced pasture land due to conversion into crop fields.

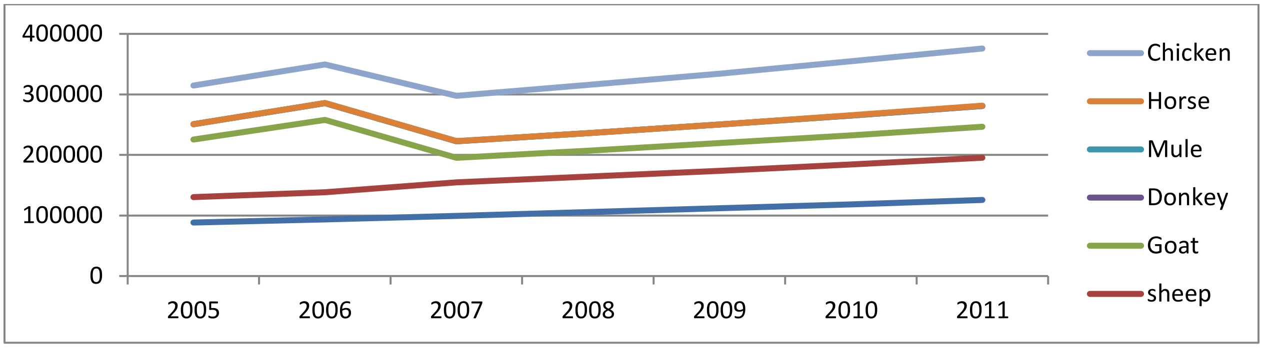

Figure 3: Trends of annually livestock population in study area (source: Regional BoA, 2011)

Table 5: Respondent's livestock herd size (Mean ±SE) in the study areas (N=212).

Animal spp.	Study area		
	Highland(N=112)	Midland (N=100)	Over all (N=212)
	Number	Number	Number
Cattle	1.5±0.0.73	1.14±0.65	1.35±0.72
Sheep	1.3±1.03	0.89±1.00	1.1±1.03
Goat	0.2±0.58	0.25±0.63	0.22±0.6
Donkeys	0.7±0.58	0.78±0.60	0.69±0.59
Poultry	0.78±0.74	0.98±1.05	0.87±0.91
Bee colony	0.38±0.59	0.34±0.55	0.36±0.57

4.2. Farmers Perception to Climate Change in Study Area

Farmers were asked to compare the current weather conditions with that of 10 years ago and the analysis results showed that the majority have perceived exciting differences of climatic condition over the years. As table 6 indicate that Farmers were asked about their perception whether climate is changing or not over the last 10 years. Most of the respondents acknowledged that there is rise in temperature and decline in rainfall amount. In line with this, (Deressa *et al.*, 2011, Mengistu, 2011, Taddesse, 2011 and Tessema *et al.*, 2013) reported that most of the farmers in Ethiopia are aware of the fact that temperature is increasing.

Hundred percent and Nighty-eight percent of the respondents from the high-land agro-ecological zone observed that the temperature was rising and the rainfall was declining in the last 10 years, respectively. A few respondents (2%) in this agro-ecological zone had reported that there is no change rainfall amount. Similar to the high-land agro ecological zone, respondents in midland consisted large proportion in reporting decline in rainfall amount (94%) and rise in temperature (31%). Farmers' response towards perception on climate change is consistent with other studies. Studies conducted in Ethiopia by (Deressa *et al.*, 2008 and Mengestu, 2011), reported that the temperature is rising and rainfall amount is decreasing due to climate change. Studies conducted in other African countries like South Africa (Mandleni and Anim 2011a), Ghana (Kemausuor *et al.,* 2011), and Nigeria (Apata, 2011 and Solomon and Rao, 2013) also documented similar findings with this study on farmers' perception about climate change. A significant number of farm households confirmed that early onset of rain fall, late onset of rain fall, early cessation of rain fall, poor distribution of rain fall, frequent and high volume flood and strong wind have become evident features of the climate and it is affecting rangeland production and Livestock production (Table 6)

Table 6**:** Respondent farmer's perception of climate change in the study area (N=212)

Climate change indicators	High land(N=112)				Midland(N=1`00)				Over all(N=212)			
	Yes		No		Yes		No		Yes		No	
	N	%	N	%	N	%	N	%	N	%	N	%
Rain fall amount has increased	25	22	87	78	25	25	75	75	50	23.6	162	76.4
Rain fall amount has decreased	110	98	2	2	94	94	6	6	204	96.2	8	3.8
Rain fall amount is the same	8	7	104	93	1	1	99	99	9	4.2	203	95.8
Early onset of rain fall	110	98	2	2	93	93	7	7	203	95.8	9	4.2
Late on set of rain fall	110	98	12	11	89	89	11	11	189	89.2	23	10.8
Early cessation of rain fall	104	93	8	7	72	72	28	28	176	83.0	36	17.0
Poor distribution of rain fall	109	97	3	3	89	89	11	11	198	93.4	14	6.6
Frequent high volume flood	88	79	24	21	62	62	38	38	150	70.8	62	29.2
High temperature	112	100	0	0	69	69	31	31	181	85.4	31	14.6
Strong wind	90	80	22	20	51	51	49	49	141	66.5	71	33.5

4.2.1. Farmers Perceptions towards Rangeland degradation in the Study Area

The results of the household survey indicated that the lands most frequently grazed by the animals of the district farmers were those near the villages the most important grazing areas. One potential way of studying the condition of the rangelands is through interviewed the farmers who have knowledge of their rangeland ecosystem. This in turn can be integrated with ecological approaches rangeland evaluation for a better understanding of rangeland ecosystem functioning and development of possible intervention mechanisms. Accordingly, 62.5% of the highlanders, 64% mainlanders indicated that the condition of their rangeland, based on their own subjective judgment, is poor (Table7). The main reasons given for this were respondents indicated recurrent drought (89.2%), increased settlement (71.2%), overgrazing (59%), bush encroachment (55.7%) and human population (51.7%), as the main forms of poor rangeland degradation (Table 8). The other problems of the study areas were the increase in human population creating pressure on the rangelands.

Table 7: farmers perception on rangeland degradation in the study area (N=212)

Agro ecology zone	farmers perception on rangeland degradation				
	Yes		No		
	N	%	N	%	Total HHs
High land	70	62.5	42	37.5	112
Midland	64	64	36	36	100
Overall	134	63.2	78	36.8	212

Source: Survey data 2019

Table 8: Possible causes rangeland degradation the responses of the sampled households in study area (n = 212).

Causes rangeland degradation	Overall			Study area			
				highland		Midland	
	%	yes	no	yes	no	yes	no
Recurrent drought	89.2	189	11	101	11	88	12
Shift to crop land	54.2	115	97	62	50	53	47
Overgrazing	58.5	124	88	67	45	57	43
Settlement	71.2	151	61	72	40	79	21
Population pressure	51.4	109	103	58	54	51	49
Bush encroachment	55.7	118	94	64	48	54	46
Limited knowledge of rangeland management	58.0	123	89	67	45	56	44
Reduced livestock mobility	74.1	157	55	80	32	77	23

4.2.2. Trends of Rainfall and Temperature of the Study Area

4.2.2.1. Analysis Trends of Temperature

The mean monthly temperature was analyzed using the data recorded over the years. The temperature data collected in Meteorological stations was computed and mean monthly temperature value was combined and representative single mean value was taken for this analysis. The analysis on the inter-annual variability of annually average minimum and maximum temperature showed that minimum temperature is highest in June and reaches its lowest value in December (Appendice table3).The maximum temperature in the study area is highest in 1998 and reaches its lowest in 2014. The mean of the maximum temperature is 23ºC and the mean of the minimum temperature is 10.3ºC. The temporal pattern of the maximum temperature is different to that of the minimum temperature with their lowest value occurring in December. The maximum temperature in the study area is highest in June and reaches its lowest in December. The temporal analysis indicates that temperature in Alaje has significantly increased over the period 1992-2017 (Appendices table4). There was the overall increasing annual maximum and minimum temperature change from 1992 to 2017. The trend line shows that the average annual maximum temperature increased about by a factor of 0.01^0C. This value is indicated by the slope equation given y= 0.0074x + 22.779. To the average, the annual maximum temperature is found to be 22.779 C^0, however; this value is not kept constant because of the climate change (Figure 5)

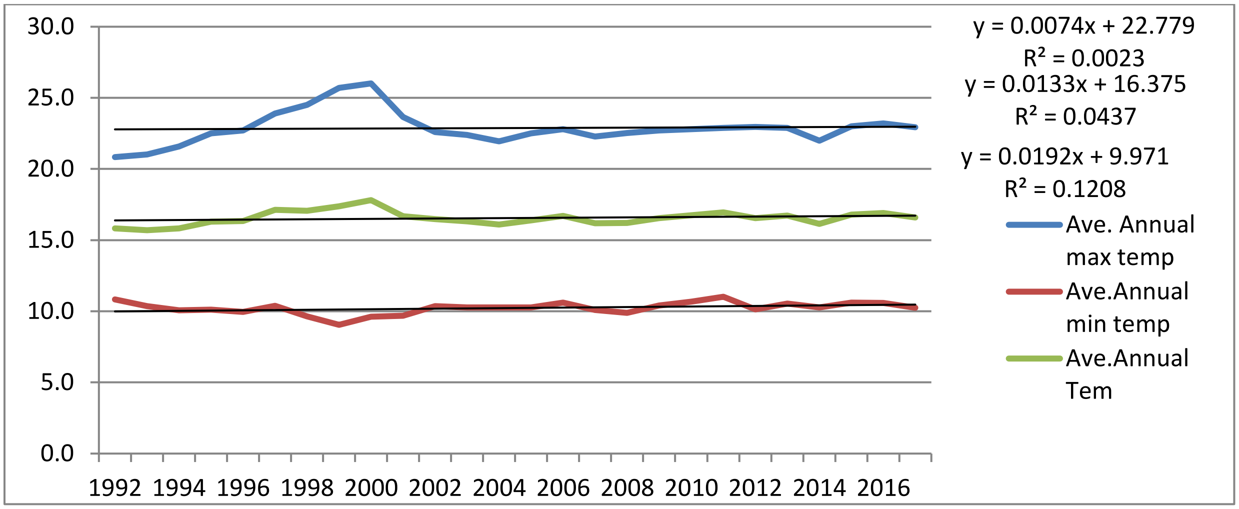

Figure 4: Trends Annual average temperature maximum and minimum temperature in the Study area

Source: Tigray metrological data of the study area 1992-2017.

Similarly, there is overall increasing annual minimum temperature change as indicated by the trend line. To the average, the annual minimum temperature is found to be 10^0**C**, however; this value is not kept constant as a result of the climate change by a factor of 0.02^0C.This value is also computed by using the slope equation, y=0.0192x + 9.971. The annual minimum temperature shows a great difference compared to the annual maximum temperature change.

4.2.2.2. Analysis Trends of Rainfall

The majority of the respondents (92.5%) mentioned a decline in rainfall as an indicator of climate change, suggesting that currently they have observed a bigger decline in rainfall and an increase in rainfall variability, duration and intensity. Estimates from the historical records of precipitation for the period 1998 - 2017 indicate that the mean annual rainfall is 548mm while the mean annual kiremt rainfall is 474.8mm, which is 86.6% of the annual rainfall. The temporal analysis indicated that rainfall pattern in the study area exhibited a very high variability over time and is quite often emphasized with positive and negative anomalies (Figure 8). Consequently, years like 2001, 2002, 2006, 2011, and 2015 can be described as agricultural drought years in statistical terms, where a period of negative rainfall anomalies in respect to the long-term mean is viewed as drought condition. In contrast, 1998, 1999, 2000, 2003, 2004, 2005, 2007, 2008, 2009, 2010, 2012, 2013, 2014, 2016 and 2017 were normal years. This result shows that the mean annual rainfall, based on 20 years of the rainfall recording stations was 548 mm. According to (Hare, 1983) annual rainfall variability greater than 30% is very severe, between 20 and 30% moderately severe and up to 20% is severe. Based on this classification, in the study area the coefficients of variation (CV) of rain fall 44% indicating that the variability in rainfall amounts is high. The finding indicates that the observed significance value for annual and seasonal rainfall (P< 0.01) in the study area. This is in line with the finding of (Hadgu et al., 2013).

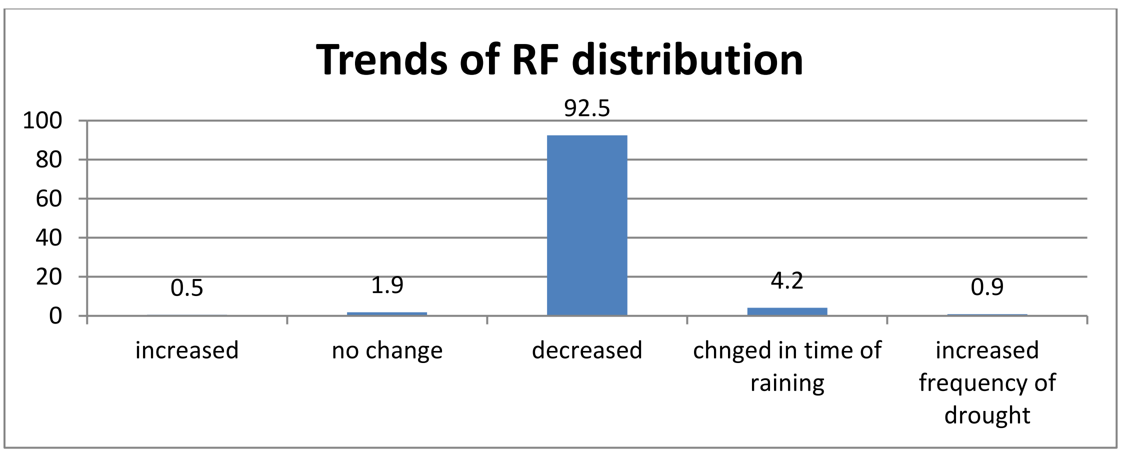

Figure 5: Trend of Annual rainfall distributions in Alaje district

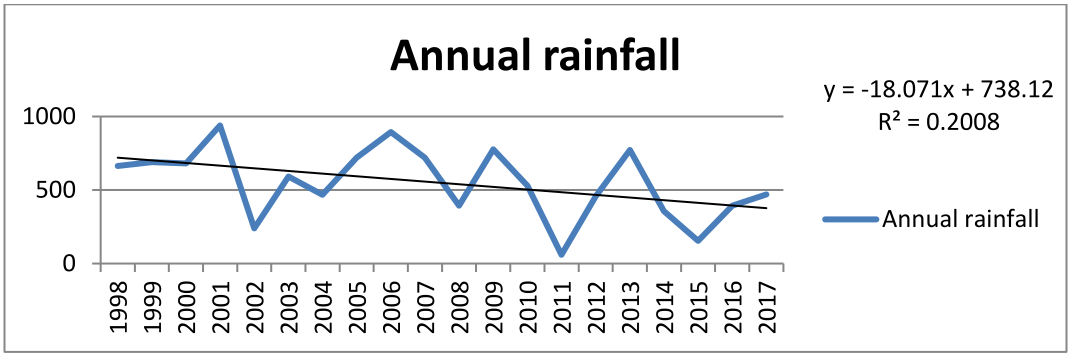

Figure 6: Annual rainfall distributions in Alaje district (1998-2017)

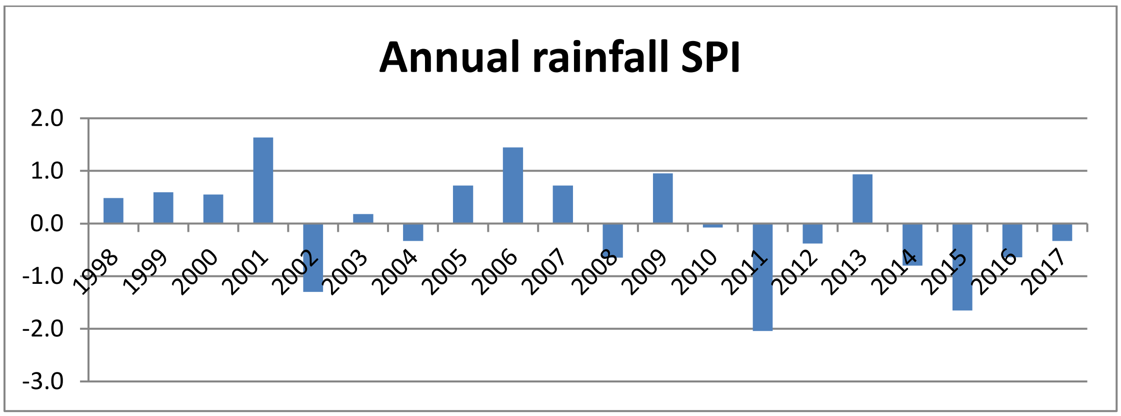

Figure 7: Annual rainfall distributions in Alaje district (1998-2017)

Based on the above result, it is significance to visualize the socio-economic and ecological impacts that could result if decreasing rainfall trends continue in the future. For rural farmers who are vulnerable to drought, water stress and erratic nature of rainfall, appropriate adaptation strategies have to be designed and implemented. The vulnerability of rural households might further be deteriorated if the rainfall continues showing drastic declining trend in the future as this incident results in drought and severe loss of the water resources due to evaporation and over exploitation.

4.2.3. Causes of Rangeland Degradation in the Study Area

Farmers in the study areas are aware of the range of rangeland degradation and the local indicators that have been used are showed in Table 8. In study area communities describe overgrazed lands which mean few or no grass cover, as well as short in height. Degraded areas described as that even if there was enough rainfall in the area, these degraded lands did not produce any grass and had a high number of livestock and bare ground patch's. There were different opinions on the rangeland as compared with ten years ago. Majority of respondents viewed the rangeland condition as poor and degraded (Table 8). Respondents indicated Shifting to crop land 189 (89.2%), human population growth 151(71.2%), overgrazing 124 (58.5%), bush encroachment 118(55.7%) and Limited knowledge of rangeland management 109(51.4%), this result was in line with the findings of (Coppock, 1994 and Beruk, 2003), as the main forms of degradation.

During FGD farmers evaluated condition of the rangelands, using mainly the following criteria: availability of grasses and water, freedom from animal and human disease, suitability to the different livestock species and security of the herders. The same finding was reported by (Mussa *et al.*, 2016).

Table 8: Possible causes rangeland degradation the responses of the sampled households.

	Overall			highland		Midland	
Causes rangeland degradation	%	yes	no	yes	no	yes	No
Shift to crop land	89.2	189	11	101	11	88	12
Recurrent drought	54.2	115	97	62	50	53	47
Settlement	58.5	124	88	67	45	57	43
Overgrazing	71.2	151	61	72	40	79	21
Reduced livestock mobility	51.4	109	103	58	54	51	49
Bush encroachment	55.7	118	94	64	48	54	46
Limited knowledge of rangeland management	58.0	123	89	67	45	56	44
Population pressure	74.1	157	55	80	32	77	23

Source: Survey data 2019

Local climate change indicators were evaluated among the households in all altitude. Among the major indicators, decreases in agricultural productivity, loss of pasture land, short planting/growing season, Increase in drought, deforestation, irregularity of rain fall patterns, decline of agriculture yield, and drought were highly perceived by most respondents (Table 9). These listed indicators were similar to the result of (Habtemichael, 2010), his study conducted in eastern zone of Tigray region.

Table 9: Perception of respondents on the local indicators of rangeland degradation

Local indicators of perceived climate change	Over all				Highland				Midland			
	yes		No		yes		No		yes		No	
	N	%	N	%	N	%	N	%	N	%	N	%
Increase in drought	161	75.9	51	24.1	86	76.8	26	23.2	75	75	25	25
Increase in temperature	149	70.3	63	29.7	80	71.4	32	28.6	69	69	31	31
Feed shortage	159	75	53	25	80	71.4	32	28.6	79	79	21	21
Decreases animal Productivity	165	77.8	47	22.2	88	78.6	24	21.4	77	77	23	23
Loss of pasture land	164	77.4	48	22.6	89	79.5	23	20.5	75	75	25	25
Increase in animal diseases	162	76.4	50	23.6	84	75	28	25	78	78	22	22
Short planting/growing season	161	75.9	51	24.1	86	76.8	26	23.2	75	75	25	25
Loss of agricultural land	158	74.5	54	25.5	80	71.4	32	28.6	78	78	22	22
Sever soil erosion	158	74.5	54	25.5	82	73.2	30	26.8	76	76	24	24
Loss income	162	76.4	50	23.6	81	72.3	31	27.7	81	81	19	19
Deforestation	164	77.4	48	22.6	88	78.6	24	21.4	76	76	24	24
decline rain fall	155	73.1	57	26.9	80	71.4	32	28.6	75	75	25	25

Source: Survey data 2019

4.3. Farmers Adaptation Strategies to Climate Change in Study Area

Farmers observed variability in the climate over the period of 10 years were further asked to describe the Farmers adaptation strategy undertaken in response to rangeland degradation and effect of climate change on livestock feed resources. The overall adaptation strategies used farmers in response to climate change is shown in Table 10. The most common adaptation strategy is Change in crop variety (71.2%), reduce number of livestock (70.3%) and diversification of farm enterprise (67.9 %), respectively were the predominant means by which the farmers adapted to long-term changes in climate. Similarly, (Gebre *et al.,* 2015) also reported climate change adaptation practices by communities. This practice allowed farmers to sell their animals (especially, small ruminants) during extreme weather events because animals were unable to resist long dry periods due to deficiency of feed and water. However, this has its own drawback, as animals will not be fetching good prices; ideally it is recommended that farmers participate in the normal time market. The second most commonly used adaptation strategy by the farmers is home feeding. As reported by key informants and group discussants, this was mainly because of the introduction of area enclosures in almost all communal lands of villages by which farmers were appreciative to feed their animals at home. The same finding was reported by (Weldlul , 2016). As shown in Table 10, Change from livestock to crops, was the least practiced adaptation option to cope with climate change effects. This may be because of shortage of cultivated land.

Table 10: Farmers' adaptation strategies to climate change in the study area (N=212)

	Overall(N=212)				Highland(N=112)				Midland(N=100)			
	Yes		No		Yes		No		Yes		No	
farmers adaptation strategy	N	%	N	%	N	%	N	%	N	%	N	%
Changes crop variety	151	71.2	61	28.8	85	75.9	27	24.1	66	66	34	34
Reduce number of livestock	149	70.3	63	29.7	85	75.9	27	24.1	64	64	36	36
Diversification of farm enterprise	144	67.9	68	32.1	83	74.1	29	25.9	61	61	39	39
Changes livestock breeds	142	67.0	70	33	76	67.9	36	32.1	66	66	34	34
Find off-farm job	38	17.9	174	82.1	21	18.8	91	81.3	17	17	83	83
Water harvesting	38	17.9	174	82.1	22	19.6	90	80.4	16	16	84	84
Animals home feeding	69	32.5	143	67.5	37	33	75	67	32	32	68	68

Source: Survey data 2019

Reduction in number of livestock (70.3 %) and change of local breeds (67 %) were the main livestock specific farmers' responses to unpredictable weather conditions and unfavorable farming conditions. Erratic and insufficient rainfall had reduced the quantity of pastures, thereby exciting most farmers to reduce their herd sizes and undertake measures to improve their local breeds to ensure that production was not adversely affected. The cross breed was found to be the most preferred for milk production. Diversification of farm enterprises (67.9 %) was yet another adaptation strategy used to spread the risk of climate change and variability on agricultural production. Seeking off-farm jobs (17.9 %) mainly in the informal sector was another adaptation strategy that the farmers used in response to the declining income from agricultural activities caused by poor weather and farming conditions. Examples of the off-farm jobs included the business, selling of food and clothing items at local markets and participation in the cattle sale business, mainly as brokers. Water harvesting (17.9 %) were the other adaptation strategies to climate change and variability. Land was commonly leased for a single cropping season while rain water was harvested mainly for domestic and livestock use and for small-scale irrigation activities.

4.4. Availability of Feed Resources

The main feed resources to livestock in both agro-ecological zones were natural pasture, crop residues and crop stubbles, which agreed with earlier reports (Yeshambel *et al.,* 2011: Mergia *et al.,* 2014 and Alemu, 2015). According to the responses of respondents, in the study area, the availability of feed resources varied in seasons with respect to quantity. The principal dry season feed resources available to livestock were crop residues, natural pastures, fodder trees, stubble grazing and grass hay in their downward order of magnitude. Whereas, during the wet season, the principal feed resources are natural pastures, stubbles grazing, fodder trees, hay and crop residues in their downward order of strength of use by producers. However, types of feed resources were not different among the altitude (Tables 11). This due to mixed crop livestock production system is more practiced in the study area. This could be due to the poor practices of feed conservation of the feed resources during the dry season. Other studies have reported similar results (Alemu, 2015).

Table 11: Farmers Response the Major Feed Resources in Dry and Wet Season

Season	Feed resources	High land					Midland					Over all				
Dry	**Rank**	**1st**	**2n**	**3rd**	**4th**	**5th**	**1st**	**2nd**	**3rd**	**4th**	**5th**	**1st**	**2nd**	**3rd**	**4th**	**5th**
	NP	27.7	13.4	29.5	26.8	2	31	3	0	0	4	29.4	8	14.8	13	3.0
	CR	96.7	3.4	0	0	0.4	100	0	0	0	0	98.3	2	0.0	0	0.2
	SG	3.5	23.2	23.2	29.5	16	5	1	49	31	9	4.3	12	36.1	30	12.5
	FT	0.0	36.8	6	4	40.2	0	29	32	33	2	0.0	33	19.0	19	21.1
	Hay	20.5	14.3	27.7	0.05	14.3	0	59	0	0	13	10.3	37	13.9	0	13.7
	Con.	0	1.7	0	17.8	23.2	1	3	0	15	63	0.5	2	0.0	16	43.1
Wet	**Rank**	**1st**	**2nd**	**3rd**	**4th**	**5th**	**1st**	**2nd**	**3rd**	**4th**	**5th**	**1st**	**2nd**	**3rd**	**4th**	**5th**
	NP	95.5	3.6	0	0	0	72	22	2	0	0	83.8	12.8	1.0	0.0	0.0
	CR	0	0	0	16.1	51.8	0	1	21	19	34	0.0	0.5	10.5	17.6	42.9
	SG	0	4.5	68.8	12.5	13.4	21	0	52	14	7	10.5	2.3	60.4	13.3	10.2
	FT	0	85.7	7	5	0.9	2	79	10	5	0	1.0	82.4	8.5	5.0	0.5
	Hay	0.9	26.8	33.9	2.7	1	0	0	13	32	36	0.5	13.4	23.5	17.4	18.5
	Con.	0	0	2	3.6	9.8	1	0	3	20	21	0.5	0.0	2.5	11.8	15.4

NP = Natural pastures; CR = crop residues; SG = stubble grazing; FG=Fodder tree; Con=concentrate

According to the reports of group discussions, feed was sufficiently available from November to February (crop residues and stubbles) and May to October (natural pasture), severely short supply from March to May. The sufficient available of feed from November to February was in line with the reports of (Yeshambel *et al.,* 2011). The availability of crop residue in study area disagreed with the reports of (Mesay *et al.,* 2013) on which crop residues dominant from December to July in highland of Ethiopia. This difference may be due to the use of irrigation to produce crops and the length of rainfall seasons.

The major feed resources of livestock are presented in (Table 11) by season of the year. In the wet season natural pasture, fodder tree, Stubble grazing, grass hay and crop residue are sources of livestock feed, respectively. While in the dry season, crop residues (98.3%), stubble grazing, grass hay, fodder tree feed and natural pasture are the major feed resources, respectively. Among the major feed resources described above, crop residues and stubble grazing rank as the first and second largest source of livestock feed. Natural pastures provision animal productivity in the wet season, while in the dry season these pastures can just maintain the animals as most of the feed resources are less available and poor nutritional quality. This could be due to the poor practices of feed conservation of the feed resources during the dry season. Other studies have reported similar results (Simbaya, 1998; Alemayehu, 2006; Sisay 2006 and Elias *et al.,* 2007).

The availability of feed resources varied in seasons with respect to quality, quantity and type of feed. The principal feed resources available to livestock both in the wet and dry seasons include crop residues, stubble grazing, natural pasture, weeds and improved fodder crops through cut and carry system. The main feed resources were both cereal and pulse crop residue, private grazing land and stubble grazing were the most important principal dry season feed resources of livestock respectively. However, communal grazing land, cereal crop residue and pulse crop residues were year round feed resources the study area, respectively. Crop residues and green grass from natural pasture are major feed resources. Crop residues and green grass from natural pasture are major feed resources in the highlands of the Blue Nile basin (Bedesa, 2012). Similar to the present finding (Belay, 2009), reported that the principal dry season feed resources available to livestock in Bure district Amhara Region include crop residue, stubble grazing, natural pasture and hay in their downward order of magnitude. While the principal feed resources during the wet season were natural pasture, stubble grazing, hay and crop residue in their descending order of strength of use by producers. In contrast (Negesse *et al.,* 2010), reported that over 86% of the crop residues are fed between November and February which is higher than the current study (70.05%) and 83% of the farmers graze their animals on crop stubbles which are lower than the current finding. This variation might be due the difference in the availability of other feed resources in the respective study areas. According to (Alemayehu, 2003), this variation is expected, as livestock feeding season varies according to availability of feed resources in different months of the year. Livestock feeding season is an essential livestock management practice to use the available feed resources efficiently and to supply the livestock with required quantity and quality feed and to overcome feed shortage (Alemayehu, 2003). On the other hand the reason that crop residue becomes the main feed resource at dry period is that; the time of sufficient crop residues is the time when the amount of natural pasture, crop thinning and weed used is minimum, which indicates that it is the period when there is some kind of substitution effect of these feeds with crop residues (Negesse *et al.,* 2010).

Many researchers and development workers said that before the last decades natural pasture involved the main proportion of feed resource. According to (Alemayehu, 1998), 80–85% of all animal feed comes from natural pasture while some estimates also indicate the natural pasture to provide 88–90%; these values are higher than the current finding. This variation might be due to the rapidly increasing of human population and increasing demand for food, grazing lands are shrinking by converted to croplands and are restricted to areas that have little value or farming potential such as hilltops, swampy areas, roadsides and other marginal land (FAO, 2006).

According to (Bogale *et al.,* 2008 and Tsegaye *et al.,* 2008), reported in central and southern highlands of Ethiopia also indicated that there is increasing importance of crop residues as a livestock feed Shortage of grazing lands due to conversion into crop fields and the absence of alternative feed resources attributed to underline the increased dependence on crop residues in the central highlands of Ethiopia (Tsegaye *et al.,* 2008). According to (Bogale *et al.,* 2008), exercises of feeding livestock with crop residues around homesteads has been reported to increase in the recent years in the Bale highlands of Ethiopia due to the reduction of the herbage obtained from natural pasture because communal grazing areas are overgrazed and degraded due to recurrent drought. Farmers also provide improved fodder crops to their animal through cut and carry system. Accordingly, of the total interviewed farmers 64.2% free grazing, 25.5% rotational grazing and 10.4% of the respondents practiced cut-and-carry feeding system of fodder crops in the wet and dry seasons, respectively, while 10% of the livestock owners practiced cut and carry feeding of animals year round (Table 12). This practice has led to extensive overgrazing of the grazing lands.

Table 12: Farmers' response major livestock feed resources and feeding systems in study areas

Agro ecology	Types of grazing system we use							
	free grazing		cut and carrying		rotational		Total	
	N	%	N	%	N	%	N	%
Highland	72	64.3	13	11.6	27	24.1	112	100.0
Midland	64	64	9	9	27	27	100	100.0
Over all Total	136	64.2	22	10.4	54	25.5	212	100.0

Source: Survey data 2019

Among the interviewed farmers have asked own livestock Number increase, decrease or no change in the study area among the total respondents about 89.2% of farmers own livestock number decreased in the altitude (Table 13). However, the trend of livestock numbers is not different between altitudes.

Table 13: Number of animals increase decrease or no change in the study area (N=212)

	no change		increase		decrease		Total	
Agro ecology	N	%	N	%	N	%	N	%
Highland	4	3.6	9	8.0	99	88.4	112	100.0
Midland	7	7	3	3	90	90	100	100.0
Total	11	5.2	12	5.7	189	89.2	212	100.0

Source: Survey data 2019

The main reasons associated with livestock number decreased as perceived by the respondents are presented in (Table 20) Shortage of feed (52.4%), shortage of grazing area (23.1%), shortage of land (16%), and others (8.5%) like of Livestock diseases were listed constraints in both the altitude respondents response, respectively (Table 21).During the group discussion, Farmers also reported that the productivity of communal grazing area is declining at an alarming rate due to conversion to crop land; loss of soil fertility, over grazing this could contribute to feed shortage during the long dry season.

Table 14: Farmers response reasons for number of animals decreased in the study area

	shortage of feed		shortage of grazing area		shortage of land		others	
Agroecologyzone	N	%	N	%	N	%	N	%
Highland	71	63.4	14	12.5	12	10.7	15	13.4
Midland	40	40	35	35	22	22	3	3.0
Total	111	52.4	49	23.1	34	16.0	18	8.5

Source: Survey data 2019

4.4.1. Storage of Feed and Feeding System

This result indicated that almost all interviewed farmers had experience of feed shortage to their animals. Due to the shortage and seasonality of availability of livestock feed; they established a practice of storing crop residues for feeding to livestock during the times of feed shortage. Stacked under shade and outside shade were the two ways of crop residue storage in this study. Accordingly, majority Stacked outside 35.4%, Stacked under shade 33.5% and baled outside 30.2% of the respondents stored their crop residue (Table 15). During the group discussions, it was mentioned that hay making is not common in the study areas for the reason that the grazing lands are communally owned and free grazing is the common grazing system being practiced in the areas. In the highlands and midlands most of the respondents (35.4%) in both areas store hay and crop residues Stacked outside (under open air). This was similar result of (Mekonnen *et al.*, 2013). Proper preservation of hay (like baling) is uncommon in both altitudes.

Table 15: Farmers response store hay or crop residue in the study area (N=212)

Agro ecology zone	Stacked outside		Stacked under shade		Baled outside		baled under shade	
	N	%	N	%	N	%	N	%
highland	30	26.8	39	34.8	41	36.6	2	1.8
midland	45	45	32	32	23	23	0	0
Total	75	35.4	71	33.5	64	30.2	2	0.9

Source: Survey data 2019

The interviewed farmers had experience of using different crop residue for feeding animals. The respondents feed crop residue to treating and mixing it with other feeds 2.4%, respectively (Table 16). However, 70.8% of the respondents feed as a whole and 24.5% of the respondents practice chopping maize Stover prior to feeding. Similarly, (Bedesa, 2012) in the highlands of the Blue Nile basin reported that 35.5% of respondents experienced with mixed straw feeding practice provide to animals. Feeds can be treated chemically, physically and biologically. Feeding of urea treated feeds increases feed intake, digestibility and body weight gain of animals (Aregawi *et al.*, 2014 and Shrivastava *et al.*, 2014).

Table 16: Feeding methods of crop residues to animals in both areas (N=212)

Methods to feed crop residue	Agro-ecological zones					
	Highland(N=112)		Midland (N=100)		Overall (N=212)	
	N	%	N	%	N	%
Whole	88	78.6	62	62	150	70.8
Chopped	21	18.8	31	31	52	24.5
Urea treated	1	0.9	4	4	5	2.4
Mixed with other	2	1.8	3	3	5	2.4
Total	112	100	100	100	212	100

Source: Survey data 2019

Number of practices are guided and to some extent studied in Ethiopia to treat crop residues to improve its palatability and digestibility. (Descheemaeker *et al.,* 2011) at present demonstrated that crop residues management like chopping and urea treatment improves the feed quality. According to (Smith, 1993) also listed chopping, grinding and urea treatment with the most appropriate methods of improving the feed value of crop residues at the smallholder level. Hence, untreated crop residues may reduce the quality of available feed for livestock. In this regard, physical treatment of such residues, either to reduce their size (e.g chopping) or to soften them (e.g., by soaking or wetting) is important to improve palatability leading to efficient utilization of the residues (Tesfaye, 1999).This shows that improved feeding technologies have been introduced extensively in the study areas. This implies that more efforts should be exercised to promote such important feeding technologies to enhance livestock productivity through improved local feed utilization. The low utilization/adoption of improved feed technologies is related with poor education, awareness and knowledge of the farmers. Capacity building is needed for the extension workers and farmers with practical supported training.

4.4.2. Crop Residues

The major crop residues available for livestock feeding in the study areas are straws of cereals (maize, wheat, barley and sorghum) and pulses (Faba bean). The annual total dry matter (DM) feed produced from crop residues was estimated to be 4.89 tons per household. This number was lower than 8.74 t DM at Adami Tullu Jiddo Kombolcha District which was reported by (Assefa *et al.*, 2013). Wheatstraws(21.54±1.35QDM/HH), maize Stover (11.62±1.2QDM/HH) and sorghum Stover (5.40±1.15QDM/HH) contributed the largest DM related to other crop residues. The overall average yield of crop residues varies between the two agro-ecological zones. The overall average crop residue yield was significant higher in midlands (5.43 t DM/HH) than highlands (4.39 t DM/HH) ($P>0.05$). This seems to be related with the cultivated land holding size which was relatively higher for mainlanders than that of highlanders even though it was insignificance difference ($P>0.05$).

The average yield of wheat straw in the mid altitude (2.085 t DM/HH) was significantly lower ($P<0.01$) than that of high altitudes (2.23 t DM/HH). Similarly, the average yield of sorghum Stover owned per household in high altitude (0.18 t DM/HH) was significantly higher ($P<0.01$) than its counterpart mid altitudes (0.9 t DM/HH). However, there was no significant difference in yields of maize Stover and barley straw ($p>0.05$) between them. The variation of yield of crop residues between altitudes may be associated with the size of crop lands, yields of crops and altitudinal difference. As obtained from the group discussions and development agents, crop residues are mainly used as source of livestock feed. There is a condition also to use crop residues as income source (through sales), as fuel and home construction (Table 17).

Table 17: Crop grain and Crop residue yield (Mean ± SE tone DM/HH) of the study areas

Type of crop residues	Highland		Midland		Overall		CF*
	Grain yield (Q/HH)	Crop residues (Q DM/HH)	Grain yield (Q/HH)	Crop residues (QDM/HH)	Grain yield (Q/HH)	Crop Residues (QDM/HH)	
Maize	5.67±1.20	11.34±2.40[a]	5.95±0.10	11.9±0.20[a]	5.81±0.60	11.62±1.2	2
Sorghum	0.72±0.41	1.8±1.03[a]	3.60±0.78	9.00±1.95[b]	2.16±0.46	5.40±1.15	2.5
Teff	0.06±0.05	0.09 ±0.08[a]	0.04±0.01	0.06±0.02[b]	0.05±0.03	0.08±.05	1.5
wheat	14.82±1.23	22.23±1.85[a]	13.9±1.46	20.85±2.2[b]	14.36±0.96	21.54±1.35	1.5
Barely	2.46±0.56	3.69±0.84[a]	3.18±0.58	4.78±0.87[b]	2.82±0.40	4.23±0.6	1.5
Faba bean	2.32±1.93	2.78±2.32[a]	3.25±1.26	3.9±1.51[b]	2.57±1.78	3.08±2.13	1.2
Field pea	1.64±1.14	1.97±1.37[a]	3.19±1.22	3.83±1.46[b]	2.42±1.18	2.90±1.42	1.2
Total	27.69±5.27	43.9±9.89	33.11±5.41	54.32±8.21	27.77±5.41	48.85±5.33	

ab = means values with different superscripts within a row are significantly different ($P < 0.05$); SE = standard error;* CF = Conversion factor of grain yield to crop residues for respective crop type (Kossila, 1984; FAO, 1987).

As shown table 18 the majority of the respondents (61.8%) uses of crop residues in the study area is of course as a feed value but significant households surveyed alternatively use crop residues for fuel, roof shatter, fences and any of their combinations as the need arises and this puts maximum pressure on the dry matter yield obtained from crop residues further of failure to collect, store, treat and conserve it properly. Crop residue as fuel source is one which highly competes more since the practice is a daily consumption and an alternative way has to be found to minimize this competition through awareness creation of the farmers.

Table 18: Farmers Responses Use of Crop Residue for Other Purposes in Study Area

	Yes		No		Overall(N=212)	
Agro ecological zone	N	%	N	%	N	%
Highland	76	67.9	36	32.1	112	52.8
Midland	55	55.0	45	45	100	47.2
Total	131	61.8	81	38.2	212	100.0

Source: Survey data 2019

4.4.3. Private Grazing Lands

The findings of this study showed that farmers respond only (50%) own private grazing lands in highlanders and 26% own private grazing lands in mainlanders. This was less than 94% (Mekuriaw *et al.,* 2011). This difference could be attributed to the limited availability of grazing lands and grazing land tenure system (use of communal grazing lands).There was no privately owned grazing lands in the highlands and midlands. The size of private grazing land per household was seen to be very small (0.01ha) (Table 4). This was comparable to 0.04 ha which reported by (Yenesew *et al.,* 2013).

Table 19: grazing land owned in hectare in the study area

	Have not owned		0.125_0.25 ha owned		0.26_0.5ha owned		0.76_1.0 ha owned	
Agro ecological zone	N	%	N	%	N	%	N	%
Highland	56	50	54	48.2	1	0.9	1	0.9
Midland	74	74	26	26	0	0	0	0
Total	130	61.3	80	37.7	1	0.5	1	0.5

Source: Survey data 2019

4.4.4. Stubble Grazing Lands

Crop stubble of different cereal crops (wheat, maize, barley, sorghum and teff) is one of the important feed resources in the study areas from November to February. Animals are made to graze on the crop stubble for 2-3 months. The same finding was reported by (Amsalu and Addisu, 2014, Birhan and Adugna, 2014 and Alemu, 2015), on which livestock in mixed crop-livestock farming systems graze two to three months on stubbles. The length of feeding on crop stubble was longer in midlands than highlands. The possible reason for this may be the ratio of livestock population to the size of crop stubbles may be lower in mid altitude than in high altitudes. The annual dry matter yield obtained from stubble grazing is estimated to be 0.5 tone DM/ha according to (FAo, 1987). Based on this calculation, about 0.54 and 0.65 tone DM/ha yield is estimated to be obtained from stubble grazing lands in highlands and midlands, respectively (Appendix table.1).

4.4.5. Improved Forage and Pasture

Overall the number of respondents use improved forage as animal feed sources was very low (9.4 %) which is below ten percent (Table 20). This was lower than 75% of respondents reported by (Assefa *et al.*, 2014) and 17.5% of respondents reported (Alemu, 2015) in other parts of Ethiopia. This implies that less attention is given to forage production which could be occurred from limited land availability and poor awareness of farmers. Only eleven farmers in highland areas was observed growing alfalfa forage in his vicinity while others yet not. The overall percentages of respondents growing improved forage were low in both altitudes. The main reasons for this could be attributed to the shortage of land, lack of awareness and lack of forage seed supply. Moreover, the educational background of the respondents (with 36.1% illiteracy level) may influence the adoption of improved agricultural technologies including forage plants. In an attempt to solve animal feed problem, forage production has been promoted for more than two decades in Ethiopia including the study areas. However, the success was not to the required level for many reasons among which poor adoption of improved forage is the main one. This can be evidenced by the less inclusion of improved forages in the livestock feeding system. The annual dry matter yield obtained from improved forage is estimated to be 0.32 tone DM/ha according to (FAo, 1987). Based on this calculation, about 0.24 and 0.0.08 tone DM/ha yield is estimated to be obtained from improved forage lands in highlands and midlands, respectively (Appendix table.1).

Table 20: farmers response use improved forage in the study area

Agro ecological zone	Yes		No	
	N	%	N	%
Highland	11	9.82	101	90.2
Midland	3	3	97	97
Total	20	9.4	192	90.6

Source: Survey data 2019

4.5. Availability of Communal Grazing Land

Communal grazing lands are a land use system in which livestock are fed to sustain their feed requirements. As its name indicates, these lands belong to the community and extensively used by animals using the traditional free grazing system. Communal grazing lands are available in both areas (Personal observations). The local farmers and elders were asked to talk about the size of the communal grazing lands in comparison with the previous periods. As per the farmers, 75% of them agreed with the decreasing trend of the grazing lands while 25% of them observed no change in the last 10 years. But no one challenges to say increasing trend in size. Similar to the current study, (Yenesew *et al.,* 2013 and Solomon, 2016) reported that communal grazing areas are increasingly being converted into cropland due to rapid population growth. This has led to massive pressure on the little remaining grazing land, through overstocking of animals and thus overgrazing, resulting in considerably decreased productivity of communal grazing land (Table 23). Generally, the size of communal grazing land in the study area is decreasing from time to time and this indicates that the quantity of livestock feed obtained from this source is also decreasing. Respondents in the study area reported that, allocation of communal grazing lands for landless youths for settlement and expansion of crop lands are the major reasons for decreasing the size of communal grazing land (Table 22).

Table 21: Farmers response reasons for decreasing the size of communal grazing land

Reasons to decrease	Highland(N=112)		Midland (N=100)		Overall(N=212)	
	N	%	N	%	N	%
Expansion of cropland	66	58.9	45	45	111	52.4
Settlement	6	5.4	4	4	10	4.7
Both expansion of crop and human settlements	40	35.7	51	51	91	42.9
Total	112	100.0	100	100	212	100.0

Source: Survey data 2019

Table 22: Farmers response trends of grazing land productivity in study area

grazing land status	Highland (N=112)		Midland(N=100)		Overall (N=212)	
	N	%	N	%	N	%
Increasing	0	0	0	0	0	0
Decreasing	70	62.5	89	89	159	75.0
Steady	42	37.5	11	11	53	25.0
Total	112	100	100	100	212	100.0

Source: Survey data 2019

4.5.1. Farmers Introduction of Improved Forage Species in the Study Area

The majority of the respondents introduced multi-purpose woody and herb species have been in backyard forage development strategies 56 (26.4%) in the study area (Table 24). A variety of exotic grasses and legumes have been stressed in farmers' private fields back yard and gullies (10.8%), alley cropping and integrated cropping (10.4%), backyard, alley cropping and gullies (9.9%), enclosure area (9.9%), alley cropping (9.9%), communal grazing land (9%), pasture land (6.1%), respectively farmers introduced improved forage species (Table24). According to respondents, the reason for not using cultivated forage crops in the study area in order of shortage of land, lack of awareness of farmers on benefits of cultivating forage crops and shortage of availability of forage seed and planting material in decreasing order of importance.

Except in a few cases, the success rate of introducing improved forage crops into the farming community is generally not to one's expectation and a lot needs to be done to expand the adoption of different forage species by the farmers. This is particularly true in irrigated fields where the part of improved forage crops is generally low, although the highland is a better position than the midland. In principle, in each study area imposes a certain quota for growing improved forage species in the irrigable land of smallholder farmers. In convert, field observations are far from achieving a desired level of integration of forage into irrigation and farmers do not seem to follow such imposed prescriptions. One of the key factors that determine farmers' choice of crops to be planted in irrigated areas is current commodity market value. Thus, it is not surprising that most of the irrigable lands found across districts are covered with marketable crop commodities and the share of improved forage crops is generally lower than desired by the extension system.

During the FGDs, the elders reported that majority of respondents have no trends of growing improved forage species. This is due to shortages of land, lack of knowledge, lack of forage seeds, cuttings and splitting. (Mekoya *et al.,* 2008), reported that improved forage species are not well developed under the current Ethiopian conditions which are agreed with current study.

Forage development strategies include backyard, alley cropping and along watersheds. Backyard and alley cropping are the commonest strategies across the study area (Table23).

Table 23: Farmers forage development strategies practiced in the study area

Agro ecological zone	Farmers introduce the fodder species									
	B	G	CGL	PL	EN	AL	ALIN	BG	BALG	Total
Highland	30	7	10	10	8	11	10	15	11	112
Midland	26	9	9	3	13	8	14	8	10	100
Total	56	16	19	13	21	19	24	23	21	212
%	26.4	7.5	9.0	6.1	9.9	9.0	11.3	10.8	9.9	100.0

*Forage development strategies: B=Backyard; G=Gullies; CGL=communal grazing land, PL= pasture land, EN=enclosure area, AL= alley cropping, ALIN= alley cropping and integrated cropping, BG= back yard and gullies and BAlG= back yard, alley cropping and gullies.

4.5.2. Herbaceous Species Composition

From a total of 33 grass species recorded in study area, 45.5 % are different grass species. On the other hand, 18.2% and 36.3% are the legume species and sedges respectively (Appendix Table2). Though the proportion of grass species seemed to be high with respect to the legumes and sedges species in the grazing system, the desirability of the species by livestock was very low. Therefore, of the total grass species identified in this grazing system, 25% were identified as highly desirable, 33.33% and 41.67% as desirable and less desirable, respectively. This might be due to the gradual disappearance of highly desirable species through over use and disturbance by livestock and human beings. During focus group discussion held with the farmers, it was understood that the major factors that cause the decline in the abundance of highly desirable species were drought followed by overgrazing. Furthermore, overgrazing reduces ground cover, plant height, forage quality and productivity, changes are induced in the dominant growth forms of herbaceous plants; tall perennial bunch grass species give way to shorter rhizomatous and sotoloniferous perennial grasses which are replaced by annual grass and forbs species (Desalew *et al.*, 2010). Besides, overgrazing tends to reduce perennial grassland vegetation types and allows invasion by annual forbs and grasses.

The majority of grass species identified were *Melinis repens*, *Cynodon dactylon*, *Eleusine floccifolia*, *Eragrostis tenella*, *Cymbopagon commutatus*, *Andropogon distachyos*, *Harpachena schimperi*, *Chloris gayana* and *Pennisetum schimpri* and the legumes that were identified include *Trifolium tembense*, *Trifolium rueppellianum*, *Trifolium campestre*, *Bidens prestinarta* and *Trifolium dubium*. This studies had similarities with (Adane, 2003 and Yihalem, 2004) reported on forage species composition in the highlands of Ethiopia.

The enclosed areas have a relatively higher percentage of highly desirable grass species than the free grazing and rotational grazing areas. That is to say, *Melinis repens*, *Cynodon dactylon*, *Eleusine floccifolia*, *Eragrostis tenella*, *Cymbopagon commutatus*, *Andropogon distachyos*, *Harpachena schimperi*, *Chloris gayana* and *Pennisetum schimpri* are the common species. This could be attributed to the results of good management practice by the communities and to lesser intensity in the grazing pressure which the livestock can exercise in the enclosed areas. This finding supports some of the findings that focused on similar issues (e.g. Amaha, 2006; Admasu, 2006 and Teshome, 2006).

4.5.3. Rating of Indigenous Fodder Trees and Grass Species Based on Animal, Plant and Multipurpose based.

Rating of IFTGS based on animal average criteria (fattening, health, milk letdown and palatability).There was a significance difference ($p<0.05$) between IFTGS. The highest feed preference by the respondents was *Cynodon dactylon,* respondents gave the highest mean value 4.3 and second highest preferred species was *Adropogon distachyas* in the mean value 3.80. *Cynodon dactylon* and *Adropogon distachyas* are grass species which utilized the species in ruminant feeding. Among the other IFTG species such as Randa, *Chloris gayana*, *Eleusine floccifolia*, *Melinis repens*, *Carissa spinarum*, *Eragrostis tenelle* and *Acacia seyal* have no significance difference (p>0.05) in the mean value of 3.63, 3.50, 3.45, 3.37, 3.30, 3.27 and 3.27 respectively. From those species Randa, *Chloris gayana*, *Eleusine floccifolia*, *Melinis repens* and *Eragrostis tenelle* are indigenous fodder grass species which utilized for cattle and sheep feeding whereas *Acacia seyal* and *Carissa spinarum* are indigenous fodder tree species utilized for goat browsing. Accordingly, *Cynodon dactylon* and *Adropogon distachyas* species were highly preferred from the rest of the 8 IFTGS. However, the lowest preferences for feed mean value 2.95 was given to *Maytenu sundata* species. Little or no overlap was observed between IFTGS highly ranked for their animal based average.

Rating on plant based criteria (Browse biomass, drought resistance, early re-growth, Termite resistance).There was a significance difference (p<0.05) among IFTGS. *Chloris gayana* and *Carissa spinarum* was the first and second most preferred species in all types of household securing the score of highest mean 2.95 and second highest mean 2.72 respectively; because of their browse biomass, drought resistance, and early re-growth and Termite resistance. *Acacia seyal* and *Cynodon dactylon* was the third and fourth most preferred species in all respondents in the mean score of 2.60 and 2.55 respectively. Species of Randa, *Adropogon distachyas*, *Eleusine floccifolia*, *Maytenu sundata* and *Melinis repens* have no significance difference (p>0.05) in the mean score of 2.47, 2.32, 2.23, 2.23 and 2.22 respectively. However, the lowest preferences for plant based criteria mean value 1.90 was given to *Eragrostis tenelle* species. Little or no overlap was observed between IFTGS highly ranked for their plant based average.

Rating of IFTGS on Multipurpose based criteria (Charcoal, Ethno-medicine, Farm implements, Fencing, Fiber or rope, Fire wood, Food, Market value, Sanitation, Shading and shelter, Timber and construction).There was a significance difference ($p<0.05$) between IFTGS. *Carissa spinarum* and *Acacia seyal* was the first and second most preferred fodder tree species in all types of household securing the score of highest mean 1.33 and second highest mean 1.17 respectively; because of their multipurpose criteria. *Maytenu sundata* was the third most preferred fodder tree species in the mean score 0.93±0.25. However, the indigenous fodder grasses species have lowest preferences for multipurpose based criteria in mean value 0.00±0.00 was given to all grass species. Mean that all the indigenous fodder grass species are used for feeding of animals but not used for other multipurpose uses.

Based on total average of animal, plant and multipurpose based criteria there is a significance difference ($p<0.05$) between IFTGS. *Carissa spinarum*, *Acacia seyal*, *Cynodon dactylon* and *Chloris gayana* was the first most preferred species by the household respondents. The score of highest mean 2.38, 2.35, 2.28 and 2.27 respectively. *Maytenu sundata*, *Adropogon distachyas*, *Melinis repens*, randa and *Eleusine floccifolia* was the second most preferred species of the house hold respondents in the mean score value 2.12, 2.05, 2.00, 1.98 and 1.95 respectively. However, the lowest preference for total average was given to *Eragrosti stenell* species, in the mean value score of 1.73.

Table 24: Farmers rating on the top 10 IFTGS based on animal, plant and multipurpose average (Mean ±SD).

Scientific name	Local name	ABA	PBA	MPA	TA
1.	Randa	3.63±.61[a]	2.47±.50[a]	.00±.00[a]	1.98±.22[a]
2. Chloris gayana	Hitsehitse	3.50±.87[a]	2.95±.75[b]	.00±.00[a]	2.27±.51[b]
3. Cynodon dactyion	Tahage	4.32±.62[b]	2.55±.75[ab]	.00±.00[a]	2.28±.49[b]
4. Eleusine floccifolia	Regahe	3.45±.99[a]	2.23±.76[a]	.00±.00[a]	1.95±.62[a]
5. Melinis repens	Keyhesaeri	3.37±.78[a]	2.22±.49[a]	.00±.00[a]	2.00±.41[a]
6. Eragrosti sttenella	Taftafo	3.27±.71[a]	1.90±.47[ba]	.00±.00[a]	1.73±.44[a]
7. Carissa spinarum	Agame	3.30±80[a]	2.72±.95[ab]	1.33±.47[bc]	2.38±.55[b]
8, Acacia seyal	Chea	3.27±.63[a]	2.60±.86[ab]	1.17±.37[bd]	2.35±.57[b]
9. Maytenu sundata	Ateat	2.95±.67[ba]	2.23±.62[a]	.93±.25[b]	2.12±.45[ab]
10.Andropogon distachyas	Saerbala	3.80±.77[ab]	2.32±.72[a]	.00±.00[a]	2.05±.22[ab]
TOTAL		3.49±0.83	2.42±0.75	0.34±0.57	2.11±0.50

Values down column with different superscripts are significantly different ($p<0.05$) ABA=Animal based average PBA= plant based average MBA=Multipurpose based average TA= Total average

4.5.4. Effect of Different Grazing Systems on Grass Biomass Measurements

The mean aboveground biomass yield measured in enclosure areas was more than the adjacent free grazed areas and rotational grazed. The total dry matter biomass value obtained in enclosure has no significance difference with communal rotational grazing but a little bit higher biomass in enclosure. This was in line with the findings of (Tadesse and Peden, 2002,Kasmau and Change 2004, Rogers *et al.,* 2005, Terefe *et al.,* 2010, Angassa *et al.,* 2010; Tegegn *et al.,* 2011, and Haider *et al.,* 2011), who reported higher biomass in enclosure. The higher biomass enclosure area might be due to proper grazing management aids recruitment and persistence of species whereas poor management (communal free grazing) can cause the degradation of grazing lands causing loss of species and their biomass. High grazing the continuous grazing pressure resulted in decreased biomass Production.

Dry matter yield of grasses in the current study was within the range of 625 Kg/ ha up to 4834.67 Kg/ ha (Table25). The results in the current study suggest that with continuous higher stocking rates and grazing pressure on communal free grazing lands, the above ground biomass grass production is low, both because of heavy utilization and destruction of grass by trampling livestock (Guo *et al.,* 1999). Consequently, the production capacity of grasses and their ultimate contribution to the total dry matter yield were reduced. The impact of management factors may be the main reasons for the significant differences in the grass biomass production of the different grazing areas in the study area. Generally therefore, there was more accumulation of biomass or organic matter in ex-closures compared to the freely grazed site. Previous studies in the western part of Ethiopia confirmed that biomass in the enclosures was accumulated more than in the open grazed plots (Tadesse and Peden, 2002). The dry matter percentage was no significantly difference in enclosure and free grazed communal lands sites where as significantly difference ($p<0.01$) lower DM% in rotational communal grazing. The possible reason for variation of this might be associated with climate change, grazing pressure and soil type which affect the plant growth.

Table 25: Indicates DM biomass in different grazing land types (Mean ± SD)

GLTS	DM g/m^2	DM%	DM tons/ha
Enclosure	483.46±164.32^a	44.39±9.83^a	4.85±1.60^a
Rotational	448.19±159.88^a	32.59±8.03^b	4.48±1.6^a
Free grazing	62.54±19.29^b	42.09±11.41^a	0.63±1.92^b
Total	392.15±240.81	40.18±10.19	3.92±2.41

Values down column with different superscripts are significantly different ($p<0.01$)

4.5.5. Palatability composition

Palatability composition of species was significantly difference ($p<0.01$) among GLTS. Highly palatable species was significantly higher in the enclosure and rotational grazing sites than in the free grazed seems more Dm content and disappearance of palatable species (Table 27). About 71.76 the mean value score of the recorded species at the enclosure site were highly palatable compared to 66.72 at the free grazed site. The current results (Table 27) demonstrated difference between free grazed and enclosure sites and a shift in species composition from palatable species to less palatable species under free grazing areas.

Table 26: Palatability composition among different grazing land systems (Mean ± SD)

Grazing Land Systems	Palatability composition of species
1. Enclosure	71.7 ± 7.5^{a}
2. Rotational	69.9 ± 9.78^{a}
3. Free grazing	66.72 ± 10.14^{b}
Total	69.80 ± 9.85

Values down column with different superscripts are significantly different ($p<0.01$)

5. CONCLUSION AND RECOMMENDATIONS

This chapter concludes the study by summarizing its findings and recommendations. The contribution of the study and its limitations are also presented along with areas for further research.

5. 1. CONCLUSION

In this study area, almost all of the respondents were aware about the change in the level of precipitation and temperature during the last 10 years. Majority of the respondents' perceived increase in temperature and decline in rainfall over the last 10 years. The increasing climate variability and reduction in precipitation we have seen effects of population pressure, overgrazing and feed production in study area.

In spite of this difference in the perceived direction of changes in these elements of climatic change, the adaptation strategies such as different Change in crop variety, reduce number of livestock, change livestock breed, diversification of farm enterprise, sell their animals and home feeding, respectively were the predominant means by which the farmers adapted to long-term changes in climate are the most commonly practiced adaptation strategies by the households. In general, based on the respondents' majority of the farmers have taken at least one adaptation measure in response to rangeland degradation.

The main sources of livestock feed in all altitudes were natural pasture, crop residues and stubbles during wet and dry seasons. Crop residues contributed the highest dry matter of the total feed sources. However, chemical treatment of these feeds was not accomplished in all altitudes even physical method was low. In the study area, natural pasture was available during wet season in all altitudes. But, most of the respondents did not conserve livestock feeds in the form of hay to feed livestock during dry season. Moreover, most of respondent's did not planted and cultivated improved forages as livestock feed in the study areas. The total annual estimated available feed supply to maintain the livestock in the area fulfilled only 67.4%. The total dry matter produced from different feed resources was not enough to satisfy the dry matter requirement of livestock. The climate change, population pressure, expansion of cropping land, settlements were identified as rangeland degradation on livestock feed production constraints in to study areas.

Rangeland resources in study area are currently in risk of becoming seriously degrading due to natural and human induced factors. Due to human population growth and global climate variability and changes, overgrazing and recurrent drought; rangeland resource is under degradation (a reduction in rank or status).

Appreciative the likely knowledge on preference of IFTGS of the farmers is very interesting and understanding how IFTGS provide based on different perspectives of animal, plant and multipurpose criteria for the farmers in the study area. Grazing had effect on grass species composition and biomass at different altitudes. The total biomass was higher in enclosed area than communal grazing areas in all altitudes.

Above ground dry matter biomass and species composition was higher recorded in enclosure site plots showed a higher herbaceous species composition, palatability composition compared with the communal free grazing and rotational grazing areas. These indicate grazing had an effect on dry matter biomass and palatability composition. Thus implies that there are challenges on management and utilization of free grazing lands.

5.2. RECOMMENDATION

The study revealed that the rangeland of the area is declining. Therefore, should be reversed through rangeland rehabilitation, proper management and demarcation of the natural grazing lands.

Provision of integrated extension services regarding Climate change adaptation strategy, feed resources management and training on basic principles of feed collection, storage, proper feeding systems and amounts of supplementation of the feed resources should be made.

Attention should be given rangeland resource and its conservation for forage development strategies like backyard, alley cropping and along watersheds in the study areas.

The average dry matter yield of herbaceous species in enclosed grazing areas was higher than in communal grazing areas in all altitudes. Thus, to increase the productivity of communal grazing land which is found in large coverage in altitudes efficient grazing land management systems should be considered. Among these adjusting stocking rate, use of rotational grazing, promoting area closures and over sowing with locally adaptable of leguminous feed species. To improve livestock feed supply by using different climate smart interventions; it is also upgrading farmers' skill through the provisions of training on proper feed resource management, feed conservation techniques and feed quality improvements techniques.

Forage development: Introduction of forage development activities, rehabilitation of grazing lands through over sowing, reseeding and weeding and closing and enriching hill sides and degraded gullies with forages that are adaptable to the specific conditions and provide high biomass production.

Awareness creation: Awareness creation to farmers and experts at different levels through provision of intensive training, experience sharing and visits for the success of communal resource management, strengthening farmers training centers and development of pilot learning sites as demonstration plots in potential areas is a key for the successful implementation of zero grazing. The livestock development planning should be implemented in a manner that environmental friendly and sustainably through participation of all the responsible stakeholders.

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Appendices

Table 1: Annual DM supply per households from different feed sources in both highland and midland agro-ecological zones

Feed resource	Highland Ha	(tDM) content /HH	%	Midland Ha	(tDM) content /HH	%	Over all Ha	(tDM content) /HH	%	CF
Crop residues		3.54	44.1		4.799	51.8		4.17	48.2	
Maize	0.135	0.27	15	0.153	0.31	12.9	0.143	0.29	13.9	2
Sorghum	0.03	0.1	2.2	0.075	0.2	9.7	0.033	0.83	6.2	2.5
Teff	0.023	0.04	0.1	0.34	0.51	0	0.303	0.46	0	1.5
Wheat	0.354	0.54	22.2	0.264	0.4	23.9	0.303	0.46	23.1	1.5
Barely	0.26	0.39	4.6	0.203	0.31	5.2	0.235	0.35	4.9	1.5
Faba bean	0.295	0.35	0	0.255	0.31	0.1	0.282	0.34	0.1	1.2
Crop stubbles	1.097	0.549	3.2	1.29	0.65	3.1	1.299	0.65	3.1	0.5
Communal grazing land	0.69	1.38	17.2	0.67	1.34	14.5	0.68	1.36	15.7	2
Forest land	1.58	2.84	35.5	1.576	2.837	30.6	1.58	2.84	32.9	1.8
Improved forage	0.03	0.24	0	0.01	0.08	0	0.04	0.32	0.03	8.0
Total		8.02	100		9.267	100		8.65	100	

Table 2: Common and dominant grass species identified by farming systems and different grazing types

SNo	Scientific Name	Local Name (Tigrigna)	Desirability	Plant type	Life form
1	*Pennisetum schimpri*	*Ayder*	DS	Grass	Perennial
2	*Eleusine floccifolia*	*Reghe*	LD	Grass	Perennial
3	*Eragrostis tenella*	*Taftafo*	DS	Grass	Annual
4	*Cymbopagon commutatus*	*Chegursaeri*	DS	Grass	Annual
5	*Andropogon distachyos*	*Saeribala*	HD	Grass	Annual
6	*Harpachena schimperi*	Cheguar-Sa'eri	HD	Grasses	Annual
7	Cynodon dactylon	Tihag	DS	Grasses	Perennial
8	*Chloris gayana*	Hitse-hitse	HD	Grasses	Perennial
9	*Digitaria abysinica*	*Saeri tseba*	DS	Grass	Perennial
10	*Melinis repens*	Keyh saeri	DS	Grasses	Annual
11	*Trifolium rueppellianum*	*Chewchawe*	HD	Legume	Annual
12	*Trifolium tembense*	*Gurdimakuya*	DS	Legumes	Annual
13	*Trifolium campestre*	*Effel/Messi*	LD	Legumes	Annual
14	*Trifolium dubium*	*Shimbera eff*	HD	Legumes	Annual
15	*Bidens prestinarta*	*Embabayohanse*	DS	Legumes	Annual
16	*Solanumincanum*	*Engule*	LD	Shrub	Perennial
17	*Rumexnervosus*	*Hahot*	LD	Shrub	Perennial
18	*Berciumgrandiflorum*	*Tebeb*	LD	Shrub	Annual
19	*Hypostusariculatal*	Engirbiala	LD	Herb	Annual

20	Sidaschimperiana	Teferaria	LD	Herbs	Perennial
21	Trifolium species	Mesi	LD	Herbs	Perennial
22	*Conyza hypoleuca*	Tsaedakotsli	LD	Herbs	Annual
23	*Lippie javanica*	Kusehe	LD		
24	*Echinops hispidus*	Dander	LD	Weeds	Perennial
25	Cyprus schimperianus	Seti	LD	Grass	Perennial
26	*Fallopia convolvulus*	Shehita	LD	grass	Perennial
27	*Sonchus oleraceus*	Tiseba dimu	LD	Weeds	Annual
28	*Xanthium strumariaum*	Deha neqel	LD	Weeds	Annual
29	*Albuca abyssinica*	*Shegurty zebey*	LD	Weeds	Annual
30	*Cyperus rotundus*	*Saeri my*	LD	Grass	Annual
31	*Satureja punctate*	*Tesena*	DS	legume	Annual
32	*Snowdenia polystachya*	*Muguya*	LD	Grass	Annual
33	*Kniphofia foliosa*	*Ashenda*	LD	Grass	Annual

Table 3: Trends Average Monthly Temperature in the Study Area (1992-2017)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ave monthly max temp	21.2	22.2	23.4	24.0	25.9	26.1	23.5	23.0	23.8	23.0	21.9	21.1
Ave monthly min temp	7.4	8.0	10.0	11.2	12.1	13.8	13.9	12.9	10.8	8.7	7.5	6.7
Aver monthly temp	14.3	15.1	16.7	17.6	19.0	20.0	18.7	17.9	17.3	15.8	14.7	13.9

Table 4: Trends Annual average temperature, maximum and minimum temperature (1992-2017)

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Ann ave max temp	21.7	21.8	21.7	26.8	27.1	27.2	27.6	27.0	26.3	23.5	23.0	22.2	21.9	22.5	22.9	22.8	22.8	23.3	22.6	22.7	23.5	22.8	20.0	23.4	23.1	23.3
Ann min tem	11.4	10.4	10.1	10.1	10.0	10.4	9.4	9.0	9.6	9.7	10.3	10.3	10.3	10.3	10.6	10.1	9.9	10.4	10.7	11.0	10.5	10.5	10.3	10.6	10.6	10.3
Ann ave temp	16.5	16.1	15.9	18.4	18.5	18.8	18.5	18.0	17.9	16.6	16.7	16.2	16.1	16.4	16.8	16.4	16.4	16.8	16.6	16.9	17.0	16.6	15.1	17.0	16.8	16.8

Source: Tigray metrological data of the study area (1992-2017)