THE EFFECT OF FREE GRAZING ON FORAGE QUALITY AND INVITRO METHANE EMISSION IN CHANGING CLIMATE OF CATTLE IN CHANGING CLIMATE, THE CASE OF SULULTA DISTRICT, OROMIA, ETHIOPIA

MSc THESIS

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THESIS SUBMITTED TO THE DEPARTMENT OF FORESTRY WONDO GENET COLLEGE OF FORESTRY AND NATURAL REOURCE GRADUATE STUDIES HAWASSA UNIVERSITY, HAWASSA, ETHIOPIA

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN CLIMATE SMART GRICULTURAL LANDS CAPE ASSESSMENT.

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Approval Sheet

This is to certify that the thesis entitled: **“THE EFFECT OF FREE GRAZING ON FORAGE QUALITY AND INVITRO METHANE EMISSIONS IN CHANGING CLIMATE, IN SULULTA DISTRICT, OROMIA, ETHIOPIA”** and submitted in partial fulfillment of the requirements with specialization in Climate Smart Agriculture landscape assessment, the Graduate Program of the Department of MRV, and has been carried out by **Gemechu Bekele Kitil, I`d. No CSA/R009/09,** under our supervision. Therefore, we recommended that the student has fulfilled the requirements and “hence” here by can submit the thesis to the department.

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Name of Co-advisor	Signature	Date

Approval Sheet - II

As members of the Examining Board of the final MSc. Thesis Open Defense, we certify that We have read and evaluated the thesis prepared by Gemechu Bekele Kitil and recommend that it be Accepted as fulfilling the thesis requirement for the degree of Master of Science in climate smart agricultural landscape assessment (MRV).

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Statement of the Author

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Dedication

This thesis is dedicated to my families in thanks for their endless love, Support and encouragement throughout my lifetime.

List of Abbreviations and Acronyms

ADF	Acid detergent fiber
ADL	Acid detergent lignin
AOAC	Association of Official Analytical Chemists
CH_4	Methane
CO_2e	Carbon dioxide emission
CP	Crude protein
CRGE	Climate resilient, green economy
CSA	Central Statistics Agency
DM	Dry matter
FGD	Farmers group discussion
GDP	Gross domestic product
GHG,	Green House gases
GP	Gas production
GPS	Geographical positioning system
GWP	Global warming potential
HH	House Hold
Hrs.	Hours
IPCC	Intergovernmental panels climate change
IVME	In vitro metabolisable energy
LDCs	Least Developed Countries
MOA	Ministry of Agriculture
Mt	Metric ton
NDF	Neutral detergent fiber
NMA	Nono mana Abichu kebele
NMSA	National Meteorological services agency
OBLA	Oromia Bureau of land administration

OMD	Organic matter digestibility
OSZSF	Oromia special zone surrounding finfinne
P/km^2	Population per kilometer square
SCFA	Short chain fatty acid
SDAO	Sululta District Agriculture Office
SPSS	Statistical Package for Social Science
WG	Weserbi Guto kebele
WL	Wale lube kebele

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The effect of free grazing on Forage quality and Enteric Methane emissions of local cattle, the case of Sululta District, Oromia, Ethiopia

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ABSTRACTS

In the central Ethiopian highlands, the success or failure of livestock production was determined by livestock-environment interaction impacts which are mainly associated with overgrazing and land degradation (Endale, 2015). However, the differences of in vitro methane emission from free grazing and area closure is not studded & well documented. This study was conducted with the objective of assessing the effect of free grazing on forage quality and in vitro methane emission to fill this gap in sululta district. The research followed mixed approach collecting data both primary (HH survey, FGD, KII and biomass survey) data, secondary data and 30 year RF and temperature data form metrological agency The data obtained from field survey of 139 HH respondents, 30 year RF and Temp data from meteorological agency and 90 sample biomass measurements collected from three kebeles (NMA, WL and WG). The data analysis employed survey data were analyzed by descriptive statistics using SPSS 21 version, metrological data analyzed in time serious using Minitab 17 version, farming system characterized using importance index and methane emission determined through laboratory at end of 24 incubation in which 1N Na $(OH)_2$ was added to the substrate of each syringes. Result showed, the mean annual rainfall of the study area was 1038.9mm and showed a decreasing trend with (1.251mm/year) with coefficient variation CV 29.48%. The mean minimum temperature of the study areas was 12.4^0C & showed an increasing trend by 0.1497^0C/decades. The farming system of the study area was characterized by mixed livestock-crop production system. Livestock feed balance of the study area was showed -36,000.45 ton deficit. The chemical analysis of animal feed was made according to Menke and Steingass as described by Abdulrazak and Fujihara, 2000 methods of analysis. The chemical composition of grass form area closure result was showed, OM 79.4%, CP 13.99%, ME 9.5Mj/kg DM, GP 42.78% and OMD 78.9 and DM 89.4%, Ash 15.3%, NDF61.73%, ADF29.38 %, ADL 2.98, and CH_4 9.61%. The chemical composition of grass from free grazing result was showed OM 72.92%, CP 8.04%, ME 6.95 mg/kg DM, GP 37.56% and OMD 69.32 and DM 96.97%, Ash 19.15%, NDF78.51%, ADF45.33%, ADL7.79%, CH_4 15.4%. This indicated that potential of methane production, higher in free grazing due to low forage quality caused by overgrazing/land degradation. To alleviate feed shortage different development options such as climate-smart technology such as development of improved forages with the use of irrigation and rain fed, Destocking to decrease the number of livestock down to the carrying capacity of the land, to control land degradation due to overgrazing and regional government give a value equal to community-based water shade management strategy.

Keywords: *Climate change, Digestibility, Dry matter, Metabolize energy,*

1. Introduction

1.1. Background and Justification

According to the Intergovernmental panels of climate change (IPCC, 2007), climate change, is defined as long-term and significant changes in the expected patterns of specific region's average weather for an appropriately significant period of time, and it is rapidly emerging as one of the most serious threats that humanity may ever face. Changes in the patterns of rainfall and ranges of temperature are affecting livestock production by affecting feed availability, grazing ranges, feed quality and disease incidence (Shunkute, 2012).

The agricultural sector in Ethiopia is the driving force of economic growth and transformation of the country's economy and its contributions to achieving food security, create job opportunity and reducing poverty at the national, regional and household levels. Livestock is an integral part of the predominant smallholder's livestock-crop mixed farming system in highlands of the country.

Livestock production was considered as one of the strategic economic resource to livelihood in which about 80-85% of rural community on agriculture and 51% contribute to the total GDP (Admasu, 2017). Ethiopia has with 50 million heads, the largest cattle herd in Africa and its economy is based mainly on its agriculture sector (CIA 2009; Demeke, 2006). In Ethiopia, Agriculture generates more than 85% of the farm cash income. In terms of contribution to the national economy, livestock contributes about 13-16% of total Growth Domestic Product (GDP) and the share to total exports are about 16% (Yayneshet, 2010). In the mixed crop-livestock systems of the Ethiopian highlands, the total feed resources available for livestock production come from free grazing and area closure, crop residues and crop aftermath grazing are a common practice.

Feeding of livestock in different places differs depending on forage availability, climatic variability of a given location or region to mitigate feed shortage problems during worst Conditions, the season of the year and the type of animal the owner prioritizes to feed (Beyene *et al*., 2011). The feeding systems in Ethiopia include communal or private natural grazing and Area closure or cut and carry feeding, hay and crop residues (Tesfaye, 2008).

Inadequate feed supply, both in terms of quantity and quality, is the major constraint affecting Livestock production in Ethiopia. Feed scarcity is indicated as a factor responsible for the Lower reproductive and growth performance of animals, especially during the dry season (Legesse, 2008). Methane was important contributing factor towards global warming (IPCC, 2007). Global Methane emission (CH_4) from enteric fermentation by ruminants is estimated to be in the range of 76 to 92 million tonnes per year (Dlugokenky *et al*., 2011), approximately 16% of the total from anthropogenic sources, while those originating from animal manures are estimated 25 million tons of CH_4 per year (Mosier et al., 2004), approximately 5% of the total from anthropogenic sources.

The current cattle population in Ethiopia is more than 50 million and together with other livestock nearly 100 million. Livestock generates methane, mainly in the form of methane emissions arising from digestion processes and nitrous oxide emissions released from excretions (FAO, 2013). In this regard, livestock production could be considered as one of the strategic economic concerns since the majority of the rural people keep livestock as a means of livelihood. The livestock feed sources are becoming declining due to the excessive conversion of grazing lands into settlement and other land use system. Therefore, grazing land degradation need attention for the sustainability and healthy livestock productivity. The overall livestock productivity is a function of high human and animal population, which in turn results in a shortage of pasture land. Moreover, most of the communal grazing/browsing lands are degraded lands providing only limited feed. In general, feed shortage and poor performance of local breed affect the productivity of livestock (Amsulu, 2014).

According to Ethiopian CRGE, 2011 (climate resilient, green economy) document, as principle of "Business as usual", GHG emissions will be more than double from 150 Mt CO_2e in 2010 to 400 Mt CO_2e in 2030. Livestock emissions are estimated to 65 Mt CO_2e in 2010 to more than 40% of total emissions today. The vulnerability of smallholder farming communities and their responses to climatic changes are therefore critical for the future sustainability of Livestock production and development in Ethiopia. This will require strong public and scientific commitment, increased investments and financial resources, and enhanced local, national capacity and land use policy. Focusing on the feed of livestock production systems the study was conducted in sululta district of Oromia regional state.

1.2. Statement of the problem

In the central Ethiopian highlands, the success or failure of livestock production is intimately tied to negative livestock-environment interaction impacts are mainly associated with overgrazing and land degradation (Endale, 2015). Overgrazing causes chemical and physical soil degradation (Endale, 2015). Socio-economic changes in the rural areas such as population growth, has led to a decline in household land size, forcing people to turn to livestock grazing on steep mountain slopes and pushing to marginal areas, which enhanced land degradation even further (FAO, 2006). The active social and economic changes in rural areas contributed to gradual changes in traditional livestock practices in mixed livestock-crop production systems (Nigatu, 2013). The effect of livestock on land degradation is a serious problem unless proper stocking rates, management and proper land uses are enforced. In spite of the economic importance of livestock production in Ethiopia, there is very little or no information about the interactions of livestock feed and environment in relation to climate change and the effect of free grazing on forage quality and to produce enteric methane emission.

The Ethiopia cattle population is estimated to increase from close to 50 million today to more than 90 million in 2030. This will increase emissions from 65 Mt CO_2e today to almost 125 Mt in 2030 (CRGE, 2011). Forage quality has an important influence on enteric methane emissions through digestible organic matter intake were formed from cattle consuming the quality forages. Enteric methane emission contributes 30-40% of total methane production from agricultural sources (Moss *et al.*, 2000).

This study is anticipated to fill the gap by analyzing collected different data from the study area to determine the effect of free grazing and area closure on forage quality and in vitro methane emission. Using household socio-economic survey, main farming system, constraints of livestock production, source of feed, annual feed requirement and analyzing climate variability of the study area from 30-year data of temperature and Rainfall from national metrological agency (NMA). Finally, enteric methane emission & forage quality through determination of laboratory analysis using biomass data collected through survey of the study area to avail information of the study area.

Sululta district was selected for this study because of a wide range of free grazing and area closure system. The availability of these two grazing systems able to link key parameters of free grazing and enclosure areas. Moreover, there is a better road access to study areas, which help to timely complete field research within the limited time and budget. This study intended to assess the effect of free grazing to produce enteric methane emission and to come up with recommendations that could assist in forming environmentally friendly livestock production systems. It also proposed generating future research topics that could be used by the scientific community to minimize the contribution of enteric methane emission to climate change.

1.3. Objectives

1.3.1. General objectives

The aim of this study was to assess the effect of free grazing on forage quality and enteric methane emission from local cattle in Sululta districts of Oromia national regional state Ethiopia.

1.3.2. Specific objectives

1. Characterizing the main farming system, source of livestock feed and feeding system in the study area.
2. Analyzing the effect of free grazing and area enclosure on yield and quality of forage production in the study area.
3. Assessing the potential of free grazing to produce enteric methane emission from local cattle of sululta districts.
4. Assessing trend of rainfall and temperature and farmers coping strategy.
5. Assessing major constraints of livestock production

1.3.3. Research Questions

This study was conducted to answer the following research questions:

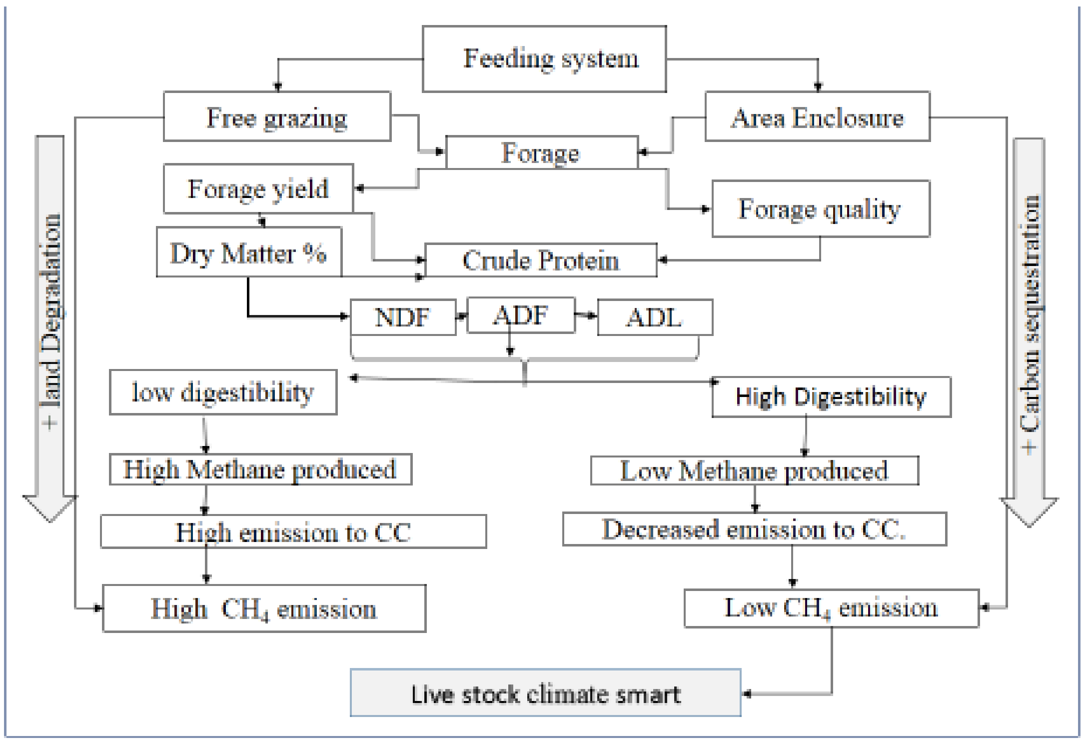
1. What are the main farming systems and source of feed in the study area?
2. What is the effect of free grazing and area closure on yield and quality of forage in the study area?
3. What are the effects of forage from free grazing and area closure on enteric methane emission in the study area?
4. What are the trend of rainfall and temperature and farmers coping strategy in the study area?
5. What are the major constraints of livestock production in the study area?

1.3.4. Hypothesis

1. Free grazing produces higher quantity and quality forage than the area enclosed in the study area.
2. In vitro methane emission % higher in free grazing than area closure in the study area.

1.4. A conceptual framework

Free grazing and closed grass area of the study area were established from similar conditions in portions of the degraded communal grazing and private lands that were used for ruminant livestock grazing. Finding the effect of free grazing on forage quality and enteric methane emissions from local cattle depends on the digestive system and ruminant livestock enables them to utilize plant material that humans and other non-ruminant animals cannot digest. The dissimilarities in Methane emissions resulting from differences in forage quality, dry matter consumption and Neutral detergent fiber (NDF) The insoluble portion of the forage which is negatively correlated with dry-matter intake, acid detergent fiber (ADF) the portion of the forage that remains after treatment with a detergent under acid conditions which is negatively correlated with how digestible a forage may be when fed and acid detergent lignin (ADL). Methane is produced as a by-product of the normal livestock digestive process, understanding the amount and quality of feed consumed are the principal drivers affecting emissions which are base for livestock climate-smart agriculture.



Source: own frame work of the study

Fig 1. A conceptual framework to produce enteric methane emission in the study area

1.5. The Significance of the Study

The study focused on assessing the effect of free grazing on forage quality and enteric methane emission in sululta, district of the Oromia special zone surrounding finfinne, Ethiopia. The study provides important information about the effect of free grazing to produce enteric methane emission from cattle and it also serves as baseline information to facilitate an exchange of ideas among the local community, researchers, policymakers, development actors, etc. And to make available data for the districts to other researchers who are interested to undertake further related study on a wider scope.

2. LITERATURE REVIEW

2.1. Definitions of terms and Concepts

2.1.1. Definitions

Climate change: According to (IPCC 2007), the term 'Climate change' refers to 'a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period.

Livestock production: it is production of farm animals for the beneficial of human being.

Mixed crop-livestock production: it is the land use system in which crops and livestock husbandry practice in association with each other on the same plot of land.

Vulnerability: is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2001).

Adaptation: Adjustment or preparation of natural or human systems to a new or changing environment which moderates harm or exploits beneficial opportunities.

Grass hay: Hay is forage harvested during the growing period and preserved by drying (Assefu, 2012). Hay in central highland of Ethiopia is usually harvested after the crude protein (CP) of the pasture passed peak production and the protein content of hay on DM basis was usually less than 5%, which is below the level of maintenance required for ruminants (Solomon *et al.*, 2008a). According to (FAO, 1997) annual and perennial grass from natural pastures consumed during the dry season and often at late stage of maturity together with the straw and stalk from cereal crops constitutes low quality forages, with high lignified cell wall and poor nitrogen. The quality of hay prepared varies with grass legume proportion, leaf to stem ratio and physiological development of the forage upon harvest (Assefu, 2012).

Crop residues: Crop residues are the fibrous by-products which result from the cultivation of cereals, pulses, Oil plants, roots and tubers and represent an important feed resource (Yayneshet, 2010). They are important in fulfilling feed gaps during periods of acute shortage of other feed resources. A report by (Tolera *et al*., 2012) indicated that crop residues contribute to about 50% of the total feed supplied in Ethiopia. The amount of crop residue produced is closely related to grain production, farming system, the type of crops produced and intensity of cultivation.

Agro-industrial by-products

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

Dry matter: Dry matter (DM) is the portion (weight) of forage other than water. Nutrients are typically reported on a DM basis to eliminate the dilution effect of moisture and to allow more direct comparison of feeds and easier formulation of diets. According to Proximate 2000, for hay, excessive low moisture (less than 10%) could indicate low palatability or excessive leaf loss (linked with lowered forage quality), while high moisture (greater than 14 to 18%) indicates a risk of growth.

Protein: Protein is a key nutrient that must be considered both in amount and type for various animal diets. According to proximate 1990, crude protein (CP), which is 6.25 times the nitrogen content of forage. Crude protein is used because rumen microbes can convert non-protein nitrogen to microbial protein, which can then be used by the animal.

Crude protein (CP): This value is 6.25 times the nitrogen content to forage or 5.7 times the nitrogen content of grain.

Dry matter digestibility (DMD): The portion of the dry matter in a feed that is digested by animals at a specified level of feed intake. Called DMD if determined by feeding animals in a digestion trial. There is no laboratory method for measuring DMD directly; it is often estimated by measuring in vitro digestibility, in situ digestibility, near infrared reflectance analysis, or calculated from acid detergent fiber.

Organic matter (OM): The portion of the dry matter that is not ash (mineral).

Organic matter digestibility (OMD): The portion of the organic matter that is digestible.

Digestibility How much of the forage will be digested? Digestibility (the extent to which forage is absorbed as it passes through an animal's digestive tract) varies greatly. Immature, leafy plant tissues may be 80 to 90% digested, while less than 50% of mature, steamy material is digested.

Ash: A measure of the total mineral content; the residue remaining after burning a sample. Values above 10% for grasses or 14% for legumes usually indicate soil contamination of forage. Ash, ADF-ash, and NDF-ash will be different values because ADF and NDF procedures remove some minerals.

Neutral Detergent Fiber (NDF): The insoluble portion of the forage (neutral detergent fiber) contains the cellulose, hemicellulose, lignin and silica. Neutral detergent fiber has been shown to be negatively correlated with dry matter intake. In other words, as the NDF in forages increases, animals will be able to consume less forage. NDF increases with the advancing maturity of forages.

Acid Detergent Fiber (ADF): Acid detergent fiber is the portion of the forage that remains after treatment with a detergent under acid conditions. It includes the cellulose, lignin and silica negatively correlated with how digestible a forage may be when fed. As the ADF increases, the forage becomes less digestible. Acid detergent fiber is sometimes misinterpreted as indicating the acid content of fermented forages.

Acid Detergent Lignin (ADL): Lignin, the indigestible non-carbohydrate component that decreases cellulose and hemicellulose availability, can be determined by further treatment with a stronger acid.

Enteric fermentation: is fermentation that takes place in the digestive systems of animals. In particular, ruminant animals (cattle, sheep, goats, and camels) have a large "fore-stomach," or rumen, within which microbial fermentation breaks down food into soluble products that can be utilized by the animal. Approximately 200 species and strains of microorganisms are present in the anaerobic rumen environment, although only a small portion, about 10 to 20 species, are believed to play an important role in ruminant digestion Crutzen, *et al.*, (1986). The microbial fermentation that occurs in the rumen enables ruminant animals to digest coarse plant material that mono gastric animals cannot digest. The climate change has negative impact on livestock production in different ways (reproductive and productive performance, as it has been stated by several researchers Mckee *et al.,* (1993). Therefore, it needs an immediate action to implement climate smart Livestock development strategies which enables livestock to adapt climate change. If the climates change continues as the present it will have devastating effect on livestock and communities who overwhelmingly depend on livestock.

2.1.2. Concepts

The Livestock development priority issues are fed and water to increase productivity and play roles in alleviating poverty and helping households to deal with climate change and to fill Considerable gaps in our knowledge. Assessment of localized impacts and the importance of identifying appropriate options that can help livestock keepers adapt to climate change (Philip Thornton, 2007**)**.

Knowledge about methods used in the quantification of greenhouse gasses is currently needed due to international commitments to reduce the emissions and in the agricultural sector one important task source of emissions is enteric methane emissions from ruminants. For scientist and other persons working with the topic it is very important to understand the enteric methane production through feeding system of different land use system (Jorgen Madsen, 2012).

2.1.2.1. Types of Livestock Feeds

Livestock production has been a traditional practice in the area since long before other farming system experienced and the major source of family assets and forms a central part of the mixed farming systems in the study area. Normally the main feed resource for livestock in the study area are natural pasture (open and enclosed). Animal feeds were classified as natural pasture, crop residue, crop aftermath and agro industrial byproducts of which the first two contribute the largest share in livestock production (Tolera *et al*., 2012). Marginal fallow lands are also serving as source of feed. Though the potential of this sub sector is very high, the contribution made towards the community income and food security is highly limited. This is mainly due to feed shortage in quality and quantity. Natural pasture is also used the whole year round without rest and thus the sustainability of sward and high composition of decreases will no longer exist. On the other hand, insignificant quantities of agricultural by-products are fed to livestock mainly in the dry season when it is at high traction time and for fattening. The concern of my study towards forage quality because the result of already consumed by ruminants produce methane through enteric fermentation. So, study the quality of forage was the most important part of the livestock production system.

2.1.2.2. Grazing Systems

Grazing is the predominant form of livestock feeding system in most part of the extensive and stallholders crop-livestock farming system in central high land areas of Ethiopia (Getachew, 2004). Natural pasture could be utilized as a grazing or green feed in the form of cut and carry system. Continues grazing and stall-feeding of mostly oxen with crop residues are the common feeding system in the highlands of Ethiopia. Free grazing, sometimes under the control of herders, is also practiced with natural pastureland, fallow and stubble grazing. Zinash *et al.*, (1995), and Alemayehu (2004) reported that livestock in the central highlands graze on communal, fallow and after harvest. Grazing impacts on forage quality have been dependent on grazing intensity. Enclosures and the open grazing lands had similar conditions because the enclosures were established on parts of the degraded communal grazing lands that will be used for livestock grazing. In area closures, grass harvesting (using a cut-and-carry system) is allowed and is conducted once a year, typically after seeding stage (GIZ Ethiopia, 2014).

2.1.2.3 Forage quality

The digestive system of ruminant livestock enables them to utilize coarse plant material that humans and other non-ruminant animals cannot digest. The differences in Methane emissions resulting from variations in forage quality, dry matter consumption and average daily gain (Chagunda, 2016). Systems based on forages increase the quality of animal feed and reduce methane emissions, particularly from enteric fermentation. Carbon foot printing of livestock systems should, therefore, account for the variation in forage quality (Chagunda, 2010).

The main constraint to productivity was lack of fodder (quantitative and qualitative) having a negative repercussion on fertility, milk productivity, immunity, and mortality, thus impacting negatively on the economy at household level. This problem remains neglected and not addressed by most agricultural organizations whose main focuses often remain on market access, and genetic improvements of dairy animals (Aseffa, 2014).

2.1.2.4. Feed availability and sources in Ethiopia

Inadequate feed supply, both in terms of quantity and quality, is the major constraint affecting Livestock production in Ethiopia. Feed scarcity is indicated as a factor responsible for the Lower reproductive and growth performance of animals, especially during the dry season (Endale, 2015). The dry season is characterized by the inadequacy of grazing resources as the result of which animals are not able to meet even their maintenance requirements and laws Substantial amount of their weight. The use of communal grazing lands, private pastures and forest areas as feed resources have declined while the use of crop residues and purchased feed have generally increased (Endale, 2015).

2.1.2.5. Animal feeding practices in Ethiopia

Feeding of livestock in different places differs depending on forage availability and season of the year and the type of animal the owner prioritizes to feed (Beyene *et al.,* 2011). The feeding systems in the study area include communal or private natural grazing cut and carry feeding and crop residues. At present, in the country stock are feed almost entirely on natural pasture and crop residues. Grazing is on permanent grazing areas, fallow land and cropland after harvest (Tesfaye, 2008). In the mixed crop-livestock systems of the Ethiopian highlands, the major feed resources available for livestock production come from permanent pastures and transient pastures between cropping cycles, crop residues and crop aftermath grazing (Taye, 2004). Agro-industrial by product (like molasses, furshika, nug-cake etc. are used during dry season to fill feed gap their animals and for fattening purposes.

2.1.2.6. Emission of gases from livestock

Animal husbandry results in CH_4 emissions from two main sources: enteric fermentation (the digestive processes of animals) and waste management. According to (NMSA, 2001), the estimated total amount of CH_4 emissions from enteric fermentation in 1994 was about 1337 Gg, accounting for 80% of the total national emissions, which dung 25 used as a fuel released 49.5 Gg CH_4 per annum. Global livestock and waste management contribute about 16% of total annual CH_4 production (FAO, 2007).

2.1.2.7. Climate-related risks faced by crop-livestock production systems in Ethiopia

Mixed farming systems, in which crops and livestock are integrated on the same farm, are the backbone of smallholder production in the developing countries of the tropics (Herrero *et al.*, 2010). Mixed crop-livestock systems produce over 90 percent of the world's milk supply and 80 percent of the meat from ruminants (Herrero *et al.*, 2013). It is practiced nearly all agro-ecological zones in developing countries under widely disparate climatic and soil conditions. Except for the lowlands and pastoralist areas of Ethiopia, the mixed crop-livestock farming is the dominant farming type in the country (CSA, 2008). In these systems, climate induced change in rainfall and temperature affects both crop and livestock production systems.

Climate change will impact the crop, animal and grazing resources of mixed farming systems in different ways, by altering interactions and resource flows between the crop and animal.

Climate change will affect the livestock component of mixed farming systems through impacts on primary forage biomass production, and on grass suitability. Furthermore, changes in temperature and rainfall affect biomass production through their effects on transpiration and water stress (Asseng *et al.*, 2011).

2.1.2.8. Effects of Climate Change on Water Resources.

The impact of climate change is not only on the water resource, but also at the same time affect availability of feed resources, particularly for the pastoral community who depend mostly on rainfall. According to (IPCC, 2008b), stated that the overall net impact of climate change on water resources and freshwater ecosystem is negative due to diminished quantity and availability of water. Droughts are more likely to become widespread, while increases in heavy rainfall events would produce lower temperature resulting from climate change may flooding. If the present food production and environmental trends continue into the future, the genetic diversity among crops and farm animals; will lead to crises in many parts of the world. The response of increased temperature on water demand by livestock is well known. According to (kassahun, 2016), studies show that for bos indicus (Zebu cattle), water intake increases from about 3kg/kg dry matter intake at 10°c ambient temperature to 5kg/kg DM at 35°c.

2.1.2.9. Enteric methane emission

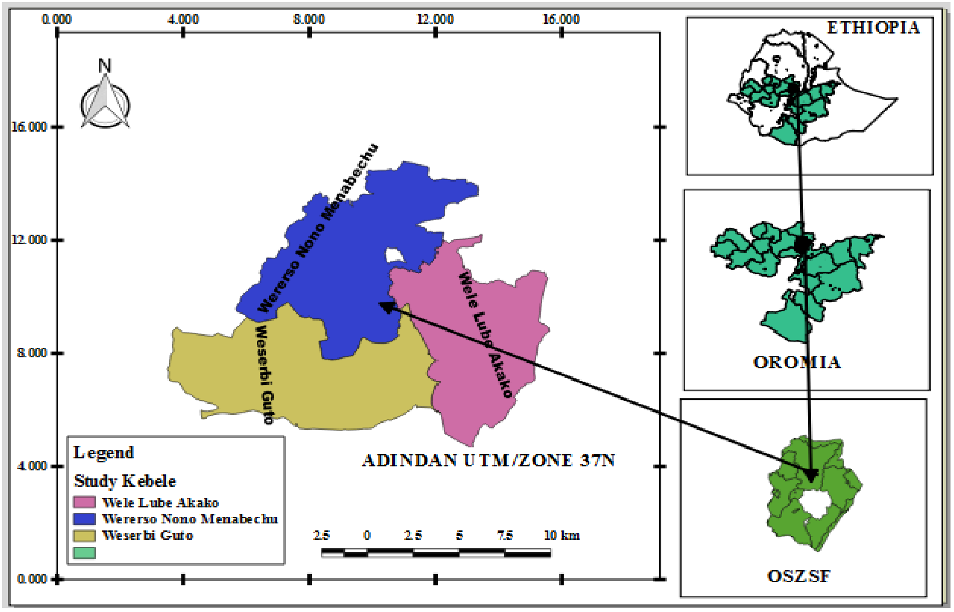
Based on its Global warming potential (GWP), CH_4 is 28 times more potent as a GHG than CO_2 (IPCC, 2007). Methane is emitted as a by-product of the normal livestock digestive process, in which residing in the animal's digestive system ferments the feed consumed by the animal. This fermentation process, also known as enteric fermentation, produces methane as a by-product. The number of animals and the type and amount of feed consumed are the primary drivers affecting emissions (Jelgava, 2015).

3. Materials and Methods

3.1. Description of the Study area

The study was conducted in sululta, district of Oromia special zone surrounding Finfinne, Ethiopia. Sululta is 23 km far from Addis Ababa and located at 9° 10′ 0″ -8° 47′ 1″ N latitude and 38° 45′ 0″ -37° 51′ 59″ E longitude and found at an altitude of 2635m above sea level (SDAO, 2017).

According to the information from (SDAO, 2017), the average annual rainfall ranging from 900 to 1400 mm, having a bimodal pattern. Approximately 70 % of the total annual rainfall is received during the main rainy season, which lasts from June to September. The short rainy season extends from March to May. The dry season lasts from October to February. The mean annual temperature of the Special Zone was in the ranges of 11-20 0^{C} and this temperature is within the ranges of the physiological requirement for agricultural production. The Special Zone has an estimated total area of 4,300 km^2 and sululta district has a 23, 300.94 ha. It consists of four kebeles in sululta district (Nono mana abichu, Wele lube, Guto weserbi and Wererso weserbi).



Source: Own result

Fig 2. Map of Specific study area

3.1.1. Farming System

The overall farming system of sululta district is characterized by mixed livestock-crop production system and the systems are highly integrated. In the mixed livestock-crop production system, Livestock production is the major source of cash income for the household.

3.1.2. Land use type

Land cover or vegetation cover of Sululta district from secondary data of suluta office of land administration (OBLA 2010 E.C), Open grassland 5466.67 ha 23.46% , Forest land 4255.66 ha 18.26%, degraded land 3887.16 ha 16.68%, cultivated land 3540.45 ha 15.19 %, area closure 3061 ha 13.14%, settlement ha 2807 12.05%, flower farm ha 283 1.21%, total ha 23300.94 100% was analyzed.

3.1.3. Population

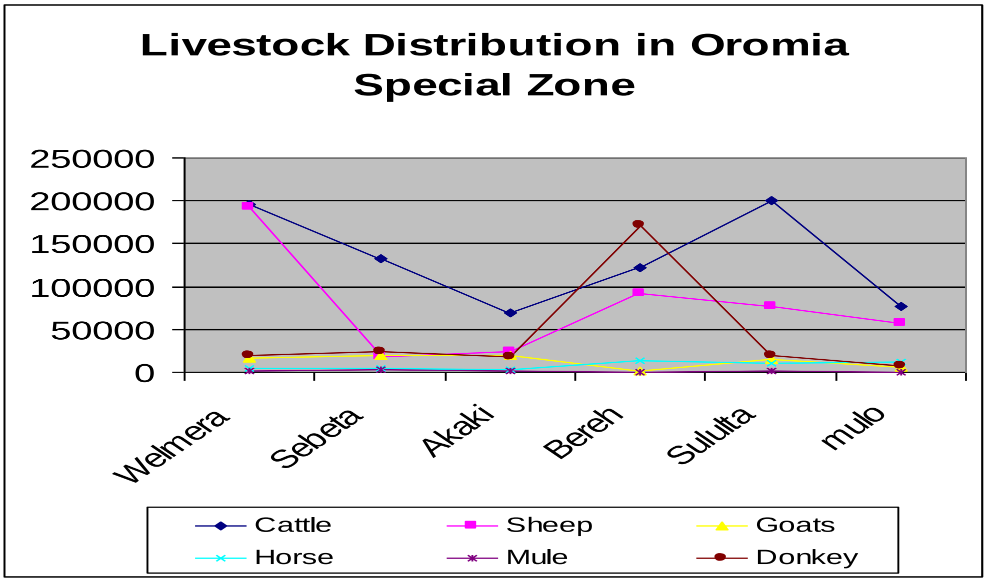
The 2007 national census reported a total population for this district of 129,000, of whom 64,516 were men and 64,484 was women; 15,145 or 11.74% of its population were urban dwellers. In terms of population density, the Special Zone can be characterized as densely populated, which is 163 persons per kilometer square (163 p/km^2). The national (federal) population density is 59 p/km^2, whereas the regional population density is 76 p/km^2 (OBLA, 2010 E.C).

3.1.5. Water

Regarding livestock drinking water, in the study area there are rivers, springs, ponds and swampy areas. Major rivers are permanent throughout the year. Water intermittent areas and ponds are used for only some period in the year (Oromia land use plan 2011).

3.1.6. Livestock population

According to sululta district agriculture and natural resource office of 2010 data shows that, the livestock population of the Oromia Special Zone indicates 797,054 Cattle, 458,645 Sheep, 80,233 Goats and 317,816 Equines. Livestock are mainly of indigenous type 99.1 percent, whose characteristics and potential are not well established. The good merits of the local animals are their potential to survive in situation of low feed and water and their ability to resist diseases; however, their productivity is very low (SDAO, 2009).



Source: Sululta district Agricultural and natural resource Office.

3.1.7. Soil type

Major Soils type in the Study Area is Vertisols (clay to silt clay), Cambisols (sandy clay silty clay loam), Luvisols (clay to clay loam), Fluvisols (clay loam soil texture) and Leptosols clay texture respectively information from sululta district agriculture office (SDAO, 2009 E.C).

3.1.8. Vegetation type

Dominant type vegetation in the study area was Tid (Juniperus procera), Baharzaf (Eucalyptus globule) and Waira (Olea africana), are tree species grown in the area and grasses such as trifolium species, setaria species, Hyparrhenia and Sedge species. (Lafto) Acacia albida is common in some parts of the district (SDAO, 2009 E.C).

3.2. Data type and sources

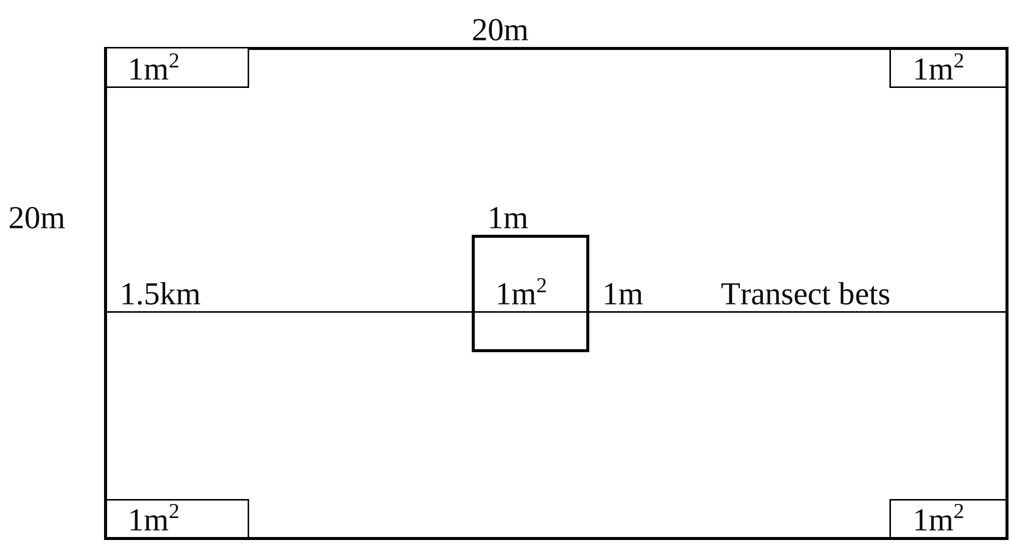
The study encompasses survey and laboratory data to explore appropriate information and address the research objectives. By using survey data a great range of data includes main farming system, the source of livestock feed and feeding system. The trend of climate change and its impact on livestock production and adaptation strategies that the farmer`s practice related to climate change were collected. In addition, the climate data of the study area were collected from the suluta and chancho stations of Ethiopian meteorology agency. The survey data study focused on the production of dry matter determination using primary (biomass survey) and secondary data (land use as source feed) from the district office. The trend of rainfall and temperature and its impact on livestock population trend by farm households over a period of ten-years (2006–2015) was collected from the district office. Similar previous study 10 year time-frame has been adopted for other studies in Ethiopia (Deressa *et al.*, 2011). The study used both primary and secondary data sources. In addition to these, demographic data of household was collected and analyzed, To analyze the trend of climate change both rainfall and temperature data (30 years data) were collected from Ethiopian meteorology Agency, Finally, the adaptation mechanism of farmers to respond climate change adaptation strategies of farmers in the study area was assessed and Laboratory data were used to explore appropriate information to address forage quality issues such as dry matter contents, forage digestibility, organic matter, protein and fiber contents as well as methane emission from biomasses of free grazing and area closure.

3.3. Sampling techniques and size

Cross-sectional survey was conducted with selected household using the semi-structured pretested questionnaire in three kebeles (Nono mena abichu, wale lube and weserbi guto) selected purposively based on the presence of both free grazing and area closure. Data on the trend of free grazing, forage production, the trends of livestock population from the community was collected and yield calculated from grass land using (FAO 1978) conversion factor. The boundary of the study site, both closed and open grazing land was delineated by taking geographic coordinates with GPS at each turning point. The recorded GPS points taken from the study sites were used to indicate each sample plots.

3.3.1. The Sampling of forage biomass

Forage Biomass: Forage biomass in the study areas was measured by constructing two transect bets of 1.5 km each in two grazing systems of the selected kebeles on which three quadrants of 20 m x 20 m size at each 50 m interval was used for sample collection. In each big quadrant has five small quadrant, of 1mx1m size were also be constructed for measurement of above ground forage biomass estimation. Thus, from a total of 90 sampling pilots 1 kg from each samples design 18 kg sampling was used for measurements of biomass yield parameters and collections of grass samples for laboratory analysis. The sample harvested was oven dried at 100 ^{0}c overnight for DM determination. But samples for chemical analysis was partially dried at 65 ^{0}c which was followed by grinding at 1mm particle size (Yimer, 2015).



Source: Own result

Fig 3. Sampling design in each kebele

3.3.2. . Site selection

Sululta is one of the 6 districts of Oromia special zones of surrounding finfine (OSZSF) and three kebeles were selected purposely based on the presence of both free grazing and area closure in each selected kebeles. The study district was 100% high land. Data on forage production, livestock feed type, trends of livestock and livestock**.**

3.3.3. Selection of Respondents

The total human population number of three kebeles was assessed from the office of kebele manager. Out of the total 1240 of household heads residing in the study area 139 sample household heads were selected by using the following formula (OSMAN, 2015). It is used to calculate the sample size for the study.

n=N/1+N (e) 2

Where, n = the required sample size

N= total households

e= expectation error (0.08)

N=1240

e = 0.08, $n=1240/1+1240(0.08)^2$

1240 /1+1240(0.0064)

1240/8.936

n= 139

n= 139 sample size with 8%.expectation error.

A total of 139 household heads was selected purposively for the interview from the three kebeles. In addition to the household survey, three key informants and two focus group discussions were conducted in each kebele with representative of the community, who have lived for long time in the study area and well understand in depth of historical trend of free grazing, forage production, trends of livestock population, yield and quality of forage, rainfall and temperature variability and can remember climate-induced risks in the study area.

3.4. Methods of Data Collection

In order to improve the validity of the findings, semi-structured and/or open-ended interviews, consisting of discussion topics and checklist were used in a complementary manner. This approach helps to build a comprehensive picture of the livelihood system and the resource base in the study area.

3.4.1. Focused group discussion and key informant interview

The Semi-structured interview was held with local community representative used to gather information regarding socio-economic status (land size, livestock number, literacy, sex, gender, and age), the trend of free grazing, and trends of forage availability. After having purposively selected the kebeles, discussions using Focus Group Discussions (FGDs) and Key Informant Interview (KII) with the experienced household in the selected kebeles was conducted. In addition, FGD with a representative from elders, extension agents, farmers and kebeles officers was interviewed and 20.9% of HH was female.

3.4.2. Household's survey

Questionnaire format were used for data collection purpose were managed by researcher and trained enumerators. The researcher prepared closed-ended questionnaires on the basis of the objectives of the study. The questionnaires were translated into afaan Oromo. Since farmers speak afaan Oromo language; the enumerators were used on the base of fluency in speaking afaan Oromo as well. Before the implementation of the survey, enumerators were trained and tested for their clarity and understanding the questions. The survey questionnaire covered a wide range of information which includes household characteristics, household livelihood, feed insecurity and farmer's coping strategies issues. Questionnaire-based formal survey was administered to 139 household heads from the three kebeles. Detailed information was drawn through the survey from sample household heads.

3.4.3. Secondary data

Relevant documents and harvest data was obtained from the district and zonal Agriculture and natural resource office, land administration, forest and climate change and Livestock development office. Also, 30-year temperature and rainfall data of the study area are collected from national metrological service agencies (NMSA) Addis Ababa, Ethiopia.

3.5. Forage quality determined at laboratory

To determine the potential forage biomass yield and dry matter production in the high land, representative samples of grass species were taken from free grazing and enclosure. In each quadrant (1m x 1m), harvesting was done at the ground level. From each quadrant fresh weight of harvested samples was taken immediately by using a spring balance of 18 kg precision. For further chemical analysis, a composite sample was taken from the bulk samples. A composite sample was transported to Hawassa University, school of Animal and range sciences, nutrition laboratory and dried in an oven at 105^{O}C overnight for dry matter determination. For chemical analysis, the same feed samples were dried in an oven at $60^{O}C$ for 48hrs to a constant weight. Oven dried feed samples were thoroughly mixed by feed type and ground to pass through 1 mm sieve. Then the ground sample was used for chemical analysis. DM and ash contents of feed samples were determined by oven drying at $105^{O}C$ overnight and by igniting in a muffle furnace at $600^{O}C$ for 6 hour, respectively (AOAC, 1990). Nitrogen (N) content was determined by Kjeldahl method and Crude Protein (CP) was calculated as N*6.25 (AOAC, 1995). Neutral detergent fiber (NDF) was analyzed according to (Van Soest *et al*, 1991) while acid detergent fiber (ADF) and acid detergent lignin (ADL) were based on Van Soest and Roberson, 1985. Digestible Organic Matter in the Dry Matter (DOM) was calculated from gas production (Menke and Steingass, 1988). *OMD=Organic matter digestibility, ME=Metabolisable energy, OMD (%): OMD (%) = 18.53+ 0.9239 *Gas production (48 hrs) + 0.0540 *Crude protein (Menke & Steingass, 1988), ME (KJ/gDM): ME (KJ/gDM) = 2.20+0.136 *Gas production (24 hrs) +0.0057* Crude protein*

3.6. Data Analysis

The duplicated sample data results were analyzed by multi ANOVA (Analysis of Variance) using statistical tools of SPSS version 21 and Minitab 17 software.

3.6.1. Statistical data analysis

The collected data, both qualitative and quantitative were statistically processed, summarized and analyzed. Objectives one, were analyzed by using Microsoft Excel and presented in the form of tables and graphs. Editing will be done to detect error and omissions and to correct these when possible.

Metrological data, such as, trend of temperature and rainfall were analyzed using Minitab version 17. Finally, the output was interpreted.

The Standardized Precipitation Index (SPI-n) is a statistical indicator comparing the total Precipitation received at a particular location during a period of n months with the long-term rainfall distribution for the same period of time at that location. SPI is calculated on a monthly basis for a moving window of n months, where n indicates the rainfall accumulation period, which is typically 1, 3, 6, 9, 12, 24 or 48 months. The corresponding SPIs are denoted as SPI-1, SPI-3, SPI-6, etc.

In order to allow for the statistical comparison of wetter and drier climates, SPI is based on a transformation of the accumulated precipitation into a standard normal variable with zero mean and variance equal to one. SPI results are given in units of standard deviation from the long-term mean of the standardized distribution.

Since the SPI can be calculated over different rainfall accumulation periods, different SPIs allow for estimating different potential impacts of a meteorological drought:

- ✓ SPIs for short accumulation periods (e.g., SPI-1 to SPI-3) are indicators for immediate impacts such as reduced soil moisture, snowpack, and flow in smaller creeks;
- ✓ SPIs for medium accumulation periods (e.g., SPI-3 to SPI-12) are indicators for reduced stream flow and reservoir storage; and
- ✓ SPIs for long accumulation periods (SPI-12 to SPI-48) are indicators for reduced reservoir and groundwater recharge, for example.

In priority index formula for abundances of feed availability, constraints for livestock production according to their severity, farming system and purpose of rearing livestock according to their priority were also calculated with the similar following formula using priority index:

$$PI=\frac{(6xF1)+(5xF2)+(4xF3)+(3xF4)+(2xF5)+(1xF6)}{F\ total}$$

No 6-1 listed purpose of variable

F1=Frequency of the first rank

F2=Frequency of second rank

F3=Frequency of third rank

Fe=Frequency of the fourth rank

Finally, the focus group discussion and key informant data were analyzed by using narration

3.6.2. Laboratory analysis

Representative feed samples were collected and allowed to lose moisture under shade after measuring initial weight before transportation. The air dried samples were taken to Hawassa University Nutrition Laboratory for chemical composition analysis. Up on arrival at the laboratory, the feed samples were allowed to dry at $65^{O}C$ for 48hr to a constant weight in a forced draft oven. Oven dried and air dried samples were ground to pass through 1mm sieve and analyzed for DM and ash contents according to the standard methods of (AOAC, 2005). The ground samples were kept in air-tight containers until used for analysis. Nitrogen (N) content was determined by Kjeldahl method and crude protein (CP) was calculated as N*6.25. The neutral detergent fiber (NDF) was analyzed following the procedure of (Van Soest et al. 1991) and acid detergent fiber (ADF) and acid detergent lignin (ADL) were based on Van (Soest and Robertson 1985) The gas production technique of Menke and Steingass as described by (Abdulrazak and Fujihara, 2000) was used in the in-vitro gas production assessment.

Objective three was analyzed by using statistical package Minitab version 17 after laboratory chemical composition result. The Chemical content of the forage was determined as follows:

I. Organic matter digestibility (OMD) was calculated from the equation:

OMD (%) = 18.53 + 0. 9239 gas production (at 48 hrs.) + 0.0540 CP (Menke and Steingass, 1988).

Where: OMD= organic matter digestibility at 48 hours and CP=crude protein (%DM).

II. Metabolisable energy (ME) was calculated from equation:

ME (KJ/gDM) =2.20+0.136GP+0.0057CP (Menke and Steingass 1988).

Where: GP=Gas production over 24rs of incubation; CP=Crude protein content.

III. Methane production from the samples of both free grazing pilots and controlled sites was measured at the end of 24 hr incubation in which 4ml of 1N $Na(OH)_2$ was added to the substrate in each syringes to determine the methane production (Fievez *et al.*, 2005).

4. RESULTS AND DISCUSSION

4.1. Demographic Characteristics of Respondents

As indicated in Table 1, about 79.1% of the respondents were male-headed, while only 20.9% were female-headed. With regards to the marital status of the respondents, the results of the present survey showed that most of the household heads were married (87.8%) and the remaining 12.2% were widowed. About 11.4%, 24.1%, 24.5%, 27% and 13% of the respondents had attained Illiterate, Primary school, junior school, Secondary school and College diploma and above, are shown respectively.

Table 1. Sex, marital status and education level of the respondents in the study area

Sex of the HH	Frequency	Percent (%)
Male	110	79.1
Female	29	20.9
Total	139	100
Marital status of the HH		
Married	122	87.8
Widowed	17	12.2
Total	139	100
The Education level of the HH		
Illiterate	16	11.4
Read and write	33	24.1
Primary school	34	24.5
Junior school	38	27
Secondary school	18	13
College diploma and above	0	0
Total	139	100

4.2. Purpose of keeping cattle and their importance in the study area

Cattle production is one of the most important agricultural subsectors for rural and urban communities. These are cash (sale income), meat and saving. In both study kebeles the purpose of cattle rearing was the same but the index values are different. The survey indicated that the respondents were kept their cattle for different purposes. In both kebeles, when there is importance of cattle by the respondents were ranked as milk (100%), as dung cake (92.1%), as fertilizer 91.4%, direct selling 89.2 %, and for traction (89%), were used for three kebeles of study area with different index values respectively (Table2).

Purpose of Cattle	Nono mena Abbichu (N=45)		Wale Lube (N=57)		Wesrbi Guto (N=37)		Total	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank
Milk	0.12	1st	0.15	1st	0.09	1st	0.36	1st
Direct selling	0.06	3rd	0.05	4th	0.03	4th	0.13	4th
Fertilizer	0.04	4th	0.08	3rd	0.05	3rd	0.2	3rd
Traction	0.02	5th	0.01	5th	0.01	5th	0.05	5th
Dung cake	0.09	2rd	0.11	2rd	0.07	2rd	0.28	2nd

Index= [(5x number of households ranking as first+4 x number of households ranking as second+3 x number of households ranking as third+2x number of households ranking as fourth+1x number of households ranking as sixth) for each importance]/[(5x number of households ranking as first+4 x number of households ranking as second+3 x number of households ranking as third+2x number of households ranking as fourth+1x number of households ranking as sixth) for all keeping livestock].

Table 2. The purpose of keeping cattle in the study area.

4.3. The Trends of Rainfall and Temperature of the Study Area

4.3.1. Analysis of rainfall

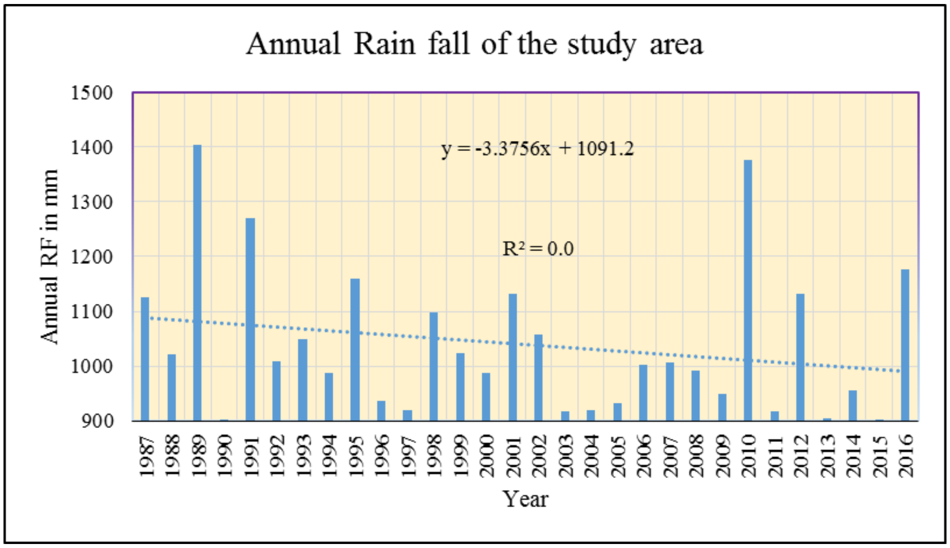
The table presents the mean annual rainfall and coefficient of variation in the study area.

Rainfall	Mean rainfall(mm)	CV (%)	r^2
Annual	1038.9	29.48	0.0

Source: Field survey result

Table 4. The Coefficient of variation for rainfall of the study area (1987-2016 G.C)

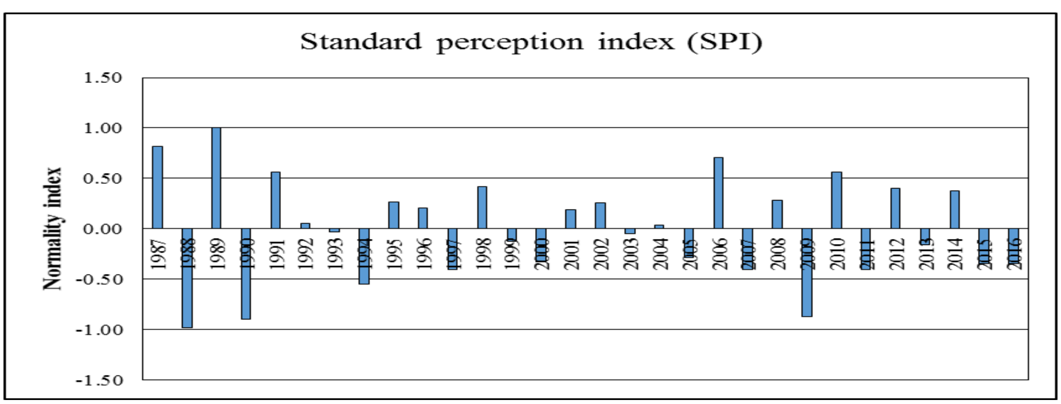
Annual Rain fall analyzed of the study area



Source: Ethiopian Metrological data of the study area. 2018

Fig 3. Trend of annual rainfall in study area (1987-2016)

The 30-year rainfall data of the study area indicate that the total amount of rainfall for the last three decades shows decreasing trend with high variability. According to trend analysis, the annual rainfall shows decreasing trend by (1.251 mm/year) with the high annual variability of rainfall with coefficient variation CV 29.48% (Fig 4). Previous study were shows 2.095mm/year with CV 23.8% (Samuel 2018).



Source: Ethiopian Metrological data of the study area. 2018

Fig 5. Standard precipitation index of the study area (1987-2016)

According to the McKee *et al.*, (1993), the annual rainfall of the district during the period 1987-2016 years shows normality (1 up to -1), moderate wet (1 up to 1.5) and moderately dry (-1 up to -1.5), severely wet (>1.5) and severely dry (<-1.5) in the district. Accordingly, the figure below indicates that in most part of the year, the district has been receiving normal rainfall. However, both positive and negative anomaly has a significant impact on crop production and livestock production in the study area (Fig5.). In this area, drought occurrences caused serious problems in 1988, 1990, 1994, 1997, 1999, 2007, and 2009, which caused failure of crop production and livestock deaths which affected the livelihoods of the farming community.

4.3.2. Analysis of Temperature

Over the last three decades of the study area, 2001-2016 were the warmest year with >20°C annual average temperature and With regards to yearly temperature variability. The drier months (March-April) experienced higher temperature than wetter months. Similarly, the previous studies by (NMA, 2001 and NMA, 2007) have reported that the average annual maximum and minimum temperature of the country has increased by 0.37°Cper decade.

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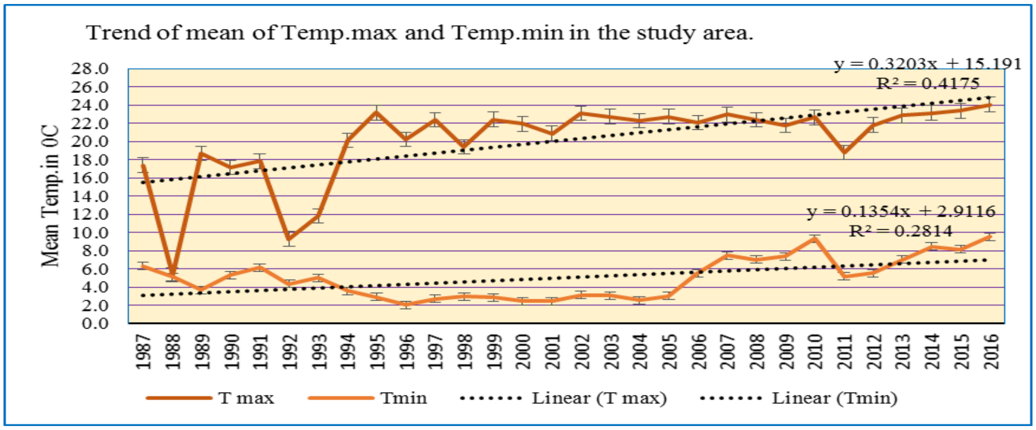


Source: Ethiopian Metrological data of the study area, Sululta. 2018

Fig 6. Average temperature max and min in the study area (1987-2016)

4.3.3. Temperature Variability and Trend

The analysis of the result of 30 years (1987-2016) temperature of the study area indicated that annual average Temperature decreased by 0.1497 °C over the last 30 years in the study area (Fig 6). The current finding of temperature data less than (NMSA 2007).In Ethiopia the temperature has been increasing about 0.37°C per decades. In this area, in the year 1988, 1994, 2007, 2009, 2012 analyzed data showed minimum temperature increasing by 0.1497^{0}C in the study area.

4.4. Effect of Climate Change on Livestock in the Study Area

4.4.1. Effect of climate change on size of livestock population

Livestock production was the major sources of livelihood for the farmers in the study area. The major livestock species reared in the study area were cattle, sheep, horse, donkey, and mule (Table 6). The average mean herd size of the household in the study area for both kebeles of similar agro-ecology was 7.6 TLU, The mean herd size per household was lower than that reported (11.8TLU) for the sululta district (Feyissa, 2013.).

Tropical Livestock units (TLU) Conversion factor used to estimate (ILCA, 1990) (appendix 8).

The reasons for the decline in livestock number at HH level were due to the decline in feed availability and quality with the delay in the occurrence of rainfall in terms of timing, amount and distribution

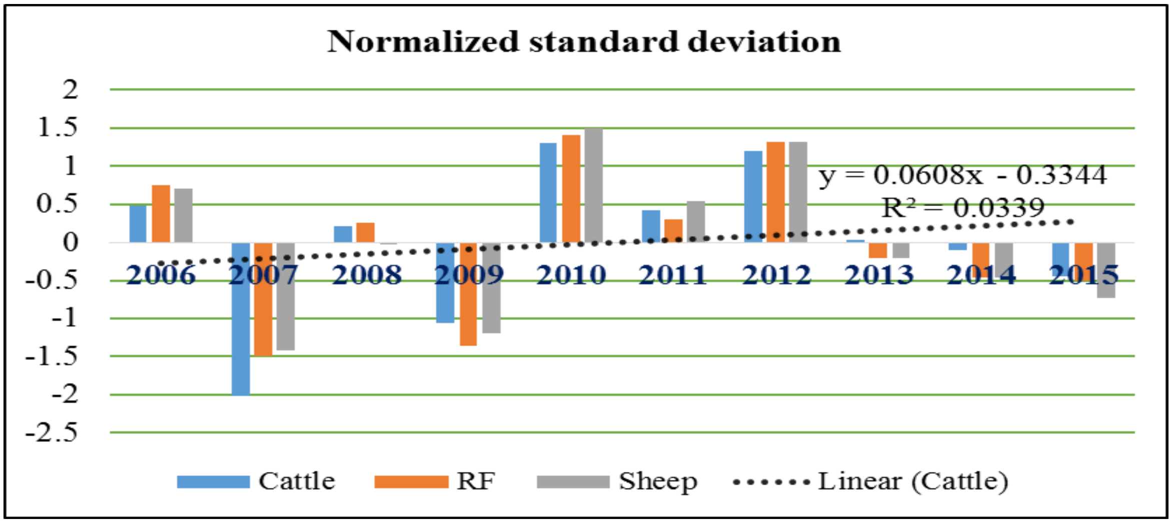
variables	NMA (mean±SD)	WL (mean±SD)	WG (mean±SD)	Average (mean±SD)
Cattle	8.23±1.79	7.28±1.66	9.23±1.89	8.25±4.08
Sheep	1.62±0.98	1.32±0.77	1.42±0.88	1.45±0.88
Horse	0.55±0.30	0.60±0.32	0.53±0.29	0.56±0.30
Donkey	1.93±1.48	1.79±1.45	1.89±1.46	1.87±1.46
Mule	0.04±0.04	0.03±0.02	0.04±0.03	0.04±0.03
TLU	7.5	7.13	8.14	7.6

Source: Field survey report, *(NMA-Nono mena abichu, WL-wale lube and WG-weserbi guto kebeles)*

Table 4. Mean livestock holdings per household in the study area.

As indicated in Table 6, the average herd size per households in three kebele was almost similar because of they were found in the same agro-ecology since the availability of pasture and feed production was similar in the same climate.

4.4.2.**Variability of the mean annual rainfall and major livestock species**



Source: National metrological agency and sululta livestock development office 2017.

Fig 7. Standardized deviation of mean annual rainfall and major livestock no in TLU.

According to the 10 years (2006-2015) livestock data collected and analyzed showed most of the deviation of mean annual rainfall showed similarity trend with mean deviation of the major livestock species. When the amount of rainfall increased in the study area the number of cattle and sheep herd also increase and vice versa (Fig 10), This is because of decline in amount of rainfall which in turn caused drought, which had negatively affected the productivity and production of cattle and sheep through affecting feed availability, drinking water for animals and aggravated the outbreaks of new animal diseases that caused the death of the animals. Similarly (Abdeta and Oba 2007) reported that cattle herd dynamics was strongly determined by rainfall variability in southern Ethiopia. The population of sheep also showed the decreasing trend in 2007, 2009, 2013, 2014 and the increasing trend in 2010 and 2012 when the rainfall decreased below the mean value the population of cattle and sheep also decreases (Fig 7). These tell that when the amount of total annual rainfall tends to decreases the population of cattle and sheep shows decreasing trend. Similarly, (NAPA 2007), studies indicated that the year-to-year variation of rainfall over the country expressed in terms of normalized deviation of rainfall average.

4.4.3. Trends of feed availability in the study area

Farmers perceived that access and availability to livestock feed resources were largely affected by the distribution and amount of rainfall in the study area. These, in turn, affect the number and type of livestock holding at a household level in rural areas. The majority of the respondents (94.3%) perceived that the condition of natural pastures was deteriorating due to overgrazing. The conversion of grazing land into different land use system was mainly accelerated as a result of population increase. Respondents also mentioned that due to the delay in the timing of rainfall beyond expected time this condition can destroy grasses and result in feed shortage for livestock. Furthermore, farmers in the study area had associated the decline in livestock production with land degradation and depletion of pasture resources induced by heavy flooding and moisture stress linked to the failure of rain and drying of watering points.

Type of feed resources	Rank in terms of availability	Trends of size of land as a source of feed in last 20 years		
		Increased (%)	Decreased (%)	No change (%)
Natural pasture/free grazing	1st	5.7	94.3	0
Area closure/cut &carry	2 nd	47.1	50.6	2.3
Crop residue	4th	13.4	86.6	0

Agro-by product	3rd	53.7	46.3	0
Crop after math	5th	17.4	80.7	1.9

Source: Field survey result, 2018

Table 5. Major feed type and their availability in the study area.

As perceived by 94.3 % of the respondents mentioned that they use free grazing of natural pasture become decreased throughout the year. About 86.6% of the respondents reported that the cropping potential of the area become decreased gradually which reduces the Crop residue yield amount because the livestock production demand of the livelihood increasing in the study area and 80.7 they use crop after math because of high rate of land conversion to settlement area. On the other hand, 50.6 % of respondents stated that the land used for area closure become decreased because of expansion of other land use system and increased by 47.1 because there is establishment of new area closure they used to cut and curry feeding system, while few farmers stated that they use additionally 46.3% of respondents use supplementary/concentrate feed to their animals during feed shortage and previous study concedes with these result (Gashaw *et al*. 2017; Stegaye *et al.* 2015).

4.5. Major constraints that affect livestock production in the study area

Respondents mentioned that scarcity of grazing resources or pasture and land degradation as a result of overgrazing and rainfall failures, were among the major factors causing the decline in livestock productivity. The respondents ranked that livestock feed scarcity was problem number one followed by land degradation. In addition to the problem of feeds and land degradation, lack of using seasonal feed utilization plan for their livestock and water scarcity during dry season followed by the frequent occurrence of livestock disease and low performance of livestock was another major constraint in affecting livestock production in the study area. Similarly, (Zelalem *et al.*2009) have reported a decline in livestock productivity as a result of feed scarcity, shortage of water and high prevalence of diseases in north shewa zone , Southern Ethiopia.

Type of feed resources	Index	Rank
Feed Shortage	2.1	1st
Land degradation	0.8	2nd
Lack of seasonal feed utilization plan	0.6	3th
Water scarcity during dry season	0.4	4rd
Diseases Occurrence	0.2	5th
Low performance of livestock	0.1	6th

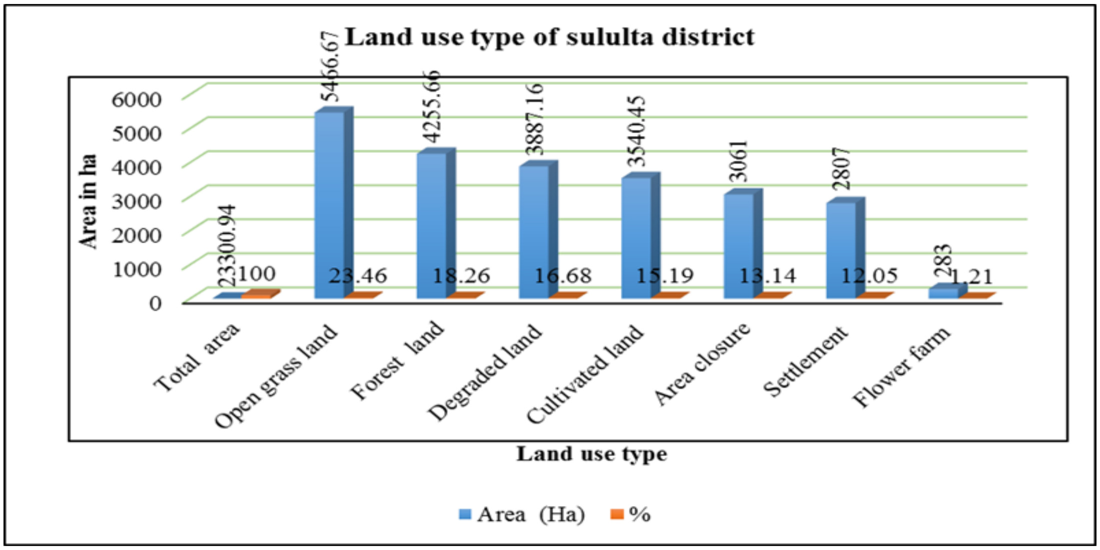
Index= [(6x number of households ranking as first+5x number of households ranking as first+4 x number of households ranking as second+3 x number of households ranking as third+2x number of households ranking as fourth+1x number of households ranking as sixth) for each importance]/[(6x number of households ranking as first+5x number of households ranking as first+4 x number of households ranking as second+3 x number of households ranking as third+2x number of households ranking as fourth+1x number of households ranking as sixth) for all keeping livestock].

Table 6. Major Constraints of livestock production in the study area.

4.6. Type of Livestock Feed and Vegetation

Livestock is a major source of farm family assets and forms a central part of the mixed farming systems in the study area. Feed and Feeding is the most important part of livestock production system. Normally livestock feed resources are classified as natural pastures (free grazing and area closure), crop residues, agro industrial by-products (concentrates), other by-products. These feed resources must provide essential nutrients such as energy, protein, vitamins and minerals for all classes of animals in order to fulfill maintenance, production and reproduction requirements.

Among the above-mentioned livestock feed, the main sources of feed resource to livestock in the study area was natural pasture, and crop residue, an industrial by-product. Fallow lands are also serving as grazing lands. The major constraints affecting the utilization of natural pasture in the study areas were reduction in size and quality of grazing land due to land degradation, conversion of grazing land to agricultural land, intrusion of settlement center in to grazing lands, and land alienation for other purposes (investment). The contribution of crop residues to the feed resource base is significant (Solomon, 2004). The quantity of different crop residues produced depends on the total area cultivated. In addition to these problems, the quality of pasture is low while that of crop residue is very low. Out of the total land of the study area, land under free grazing is 23.46 percent and this indicates that grass obtained from this land type is very high and good management of this resource is very imperative. Cultivated land is less than open grass the feed a resource of crop residue about 15.19 percent which is very low in size and still most part of it is decreasing to other land type or bare land.



Source: District agriculture office. 2018

Figs 8. Land use cover or vegetation cover of sululta district

4.6.1. Trends of Feed Quantity Assessment

As it is well known, livestock feed is the first important and the highest contribution among the above-mentioned feed resource was natural pasture followed by crop residue. The various feed resources are available and used in different seasons of the year. Since grass from area closure is collected and conserved very well, used almost throughout the year. Even, used as source of income through selling grasses during the dry season. Natural pasture is used the whole year round without rest and thus the sustainability of grassland and high composition of organic matter digestibility was no longer exist. In all areas as general observation has been made, there is a declining trend in livestock feed availability. The feed shortage is mainly attributed to the shrinkage of the grazing land and Existing Situation for the negative trend is increased Population growth, expansion of settlement, overgrazing and land degradation /deforestation.

The quantity of feed dry matter obtainable from natural pastures was determined by multiplying the hectare under each land use category by their respective total area covered by a crop i.e. 2.0 t/ha (FAO, 1987). The Similar study by Oromia land use plan feed sources and DM production converted in ton shows that Grass land 2ton/ha, Crop residues 3.577ton/ha, forest land 0.7ton/ha, wood/shrub land 1.2ton/ha, crop aftermath grazing 0.5ton/ha was used. The amount of grain yield obtained from the respective crops was quantified from recorded data of sululta animal development office and cross-checking it with the data recorded by development workers for any deviation used (Zawide, 2010).

Feed sources	Area(ha)	DM Production (Ton)
Grass land	5466.67	10933.34
Forest land	4255.66	5106.79
Crop residues	3540.45	1770.23
Aftermath grazing	3540.45	1770.23
Woodland, Shruband Bush land	2160	1512
Total	18963.23	31986.55

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Table 7: Feed sources and DM production in ton in the study area

4.6.2. Feed Requirement in the sululta district

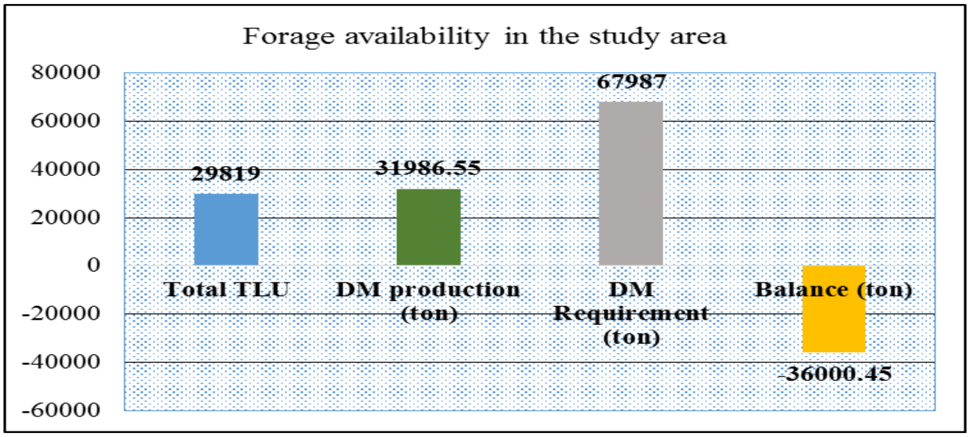
Feed requirement on the average, an animal requires daily feed equivalent to 2.5 percent of its body weight, which is 2.28 tones per tropical livestock unit /TLU/ per annum (OBLA, 2016). The total dry matter required for 29,819 Tropical Livestock Unit /TLU/ is 67,987 ton but the amount of dry matter existing now is 31,986.55 ton, which is 47.05 percent of the total feed required annually and this is calculated only for maintenance. Needed it been for production and reproduction too, the deficit might have increased much higher than this. Out of the feed resources available, the highest feed comes from natural pasture. Similarly, previous studies challenges in Ethiopia show that the dry season is characterized by the 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).

Livestock Species	TLU	DM Requirement(Ton)
Cattle	15561	35479
Sheep	10657	24298
Horse	1567	3573
Mule	1972	4496
Donkey	62	141
Total	29,819	67,987

Source: OZSF integrated land use planning project, (2011)

Table 8. DM Requirement for Livestock in study area (Ton)

The total maintenance DM of feed requirement of the animals per year was 67,987 tons while the actual DM of feed production was 31,986.55 tons and feed balance -36,000.45 per year (Fig 9).



Source: Field survey Result. 2018

Figs 9. Livestock feed balance of the sululta district

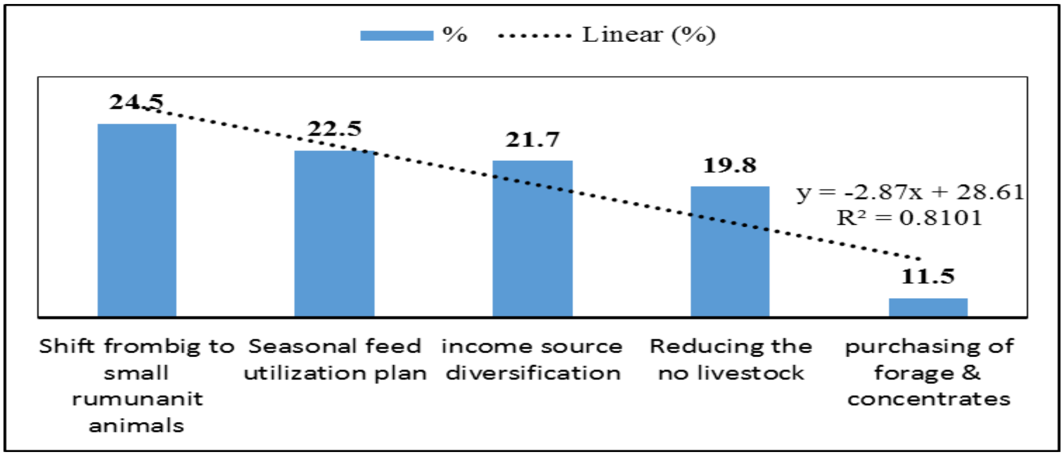
Similarly, previous studies show that the total maintenance DM of feed requirement of the animals per year was 388,859.8 tons while the actual DM of feed production was 212,047.15 tons. The total DM of feed produced per year shows the balance -176,812.65 ton per year Meta Robi district, west Shewa zone (Endale Y, 2015).

Forage Biomass estimated from feed sample of the study area showed that forage yield from free grazing 29.673 ton/ha and yield from area closure 130.991 ton/ha. This indicated that the effect of free grazing on forage yield and on environment become a critical problem.

4.7. Coping strategies practiced in response to climate change in the study area

4.7.1. Farmers coping Strategies to Climate Change in the Study Area

Most of the farmers in the study area were depended on rain-fed agriculture for their subsistence. As a result, change in the amount and seasonality of rainfall can cause a significant impact on livestock production or both agricultural production in the district under changing the climate. Respondents believed that they had affected considerably by the impact of climate change in terms of the obstacles they encountered in livestock production. As indicated in (Fig12) below, farmers in the study area practiced the different type of adaption measures for livestock to cope up the impact of climate change.



Source: Field survey result.2018

Figs 10: Choice of coping strategies in response to climate change.

Respondents' observations showed that the local communities in the study area had extensive knowledge and experience about their environment that could help them to adapt to the changing environmental conditions. Among others, the local communities had their own adaptation mechanism that had been transmitted from generation to generation in terms of livestock production and adaptation to their local environment. Respondents shared their experience that they also used to store grasses (i.e. area closure and wheat straws) to feed their animals in times of feed shortage.

4.7.2. Coping strategies related to livestock production

Respondents reported that different type of coping mechanism in response to effect of climate change on livestock production in the study area. About 24.5 and 22.5% of respondents indicated that they used to shift from big to small ruminant animals and arranging seasonal feed utilization plan to feed their livestock in the dry season. About 21.7% of respondents indicated that income source diversification during prolonged dry periods (petty trade, water harvesting for irrigation, small ruminant fattening and etc.) (Fig12.). About 11.5% of the respondents mentioned that purchasing forage and agro-industrial by product and feed during the dry period (Fig12). Through these strategies of adjusting the number of livestock to the available feed resources, farmers in the study area minimize risks of climate change. Furthermore, diversification strategy towards drought tolerant livestock type such as indigenous animal is another opportunity that will support farmers in mitigating the impact of climate change.

4.8. Chemical Composition result

The major chemical elements indicating forage quality were dry matter (DM), ash, organic matter (OM),crude protein (CP), neutral detergent fiber (NDF) , acid detergent fiber (ADF), and lignin (Acid detergent lignin) (ADL) mean value content in the grass was determined.

	Types of grazing system						
Nutrient	Free grazing			Area closure			
Composition (%)	mean	N	SE mean	Mean	N	SE Mean	
DM	96.97	18	0.175	89.4	18	0.245	p-value= 0.000
Ash	19.15	18	0.904	15.3	18	0.760	
OM	72.92	18	0.900	79.84	18	0.836	
CP	8.04	18	0.848	13.99	18	2.11	
ME	6.95	18	0.76	9.5	18	2.31	
GP	37.56	18	0.56	42.78	18	0.78	
NDF	78.51	18	0.924	61.73	18	1.05	
ADF	45.33	18	1.18	29.38	18	1.09	
ADL	7.79	18	0.324	2.98	18	0.489	
OMD	69.32	18	0.912	79.9	18	0.921	

Source. Field data lab result

Table 9. Chemical composition of grazing forage biomass

DM=dry matter; OM=organic matter; CP=crude protein; NDF=neutral detergent fiber; ADF=acid detergent fiber; ADL=acid detergent lignin

4.8.1. Dry matter (DM)

The mean dry matter content of the analyzed grass from free grazing was 96.97 and area closure 89.4%. This small differences in DM content % might be attributed to the different times at which grass samples were collected, fertility of the soil due to overgrazing, differences in species of grass, stage of harvest as noted by (Gworgwor et al. 2006).

In this case, free grazing had the highest DM content followed by Area closure. The current finding is agreed with the result of (Beyene *et al.* 2010) who evaluated the grass species for their chemical composition in west showa zone meta robi district where the figure was 96.02% and the one reported by (Megersa *et a.* 2017) who indicated that the mean DM content of the analyzed grass samples was 93.53 in Abol and Lare districts of Gambella region.

4.8.2. Ash

The average ash content of the free grazing grass samples evaluated was 19.56% and area closure grass 15.3%. Ash contents of grass from free grazing were relatively higher because of high DM content. The present finding is almost higher than earlier report of (Belete *et al.*, 2012), (Bruh and Destalem, 2015) who showed that the examined browse species ranges from 23.4 to 34.5 in the central and north western zones of Tigray. The variation in the ash content of the browse plants may be due to certain factors like differences climatic zone, soil type, species maturity and season of harvest as well.

4.8.3. Organic matter

The average OM content of free grazing grass species studied was 78.88% and the highest 79.84 % was recorded by area closure. This result is in agreement with the finding of (Bruh

Weldemariam and Destalem Gebremichael, 2015) who showed that the examined browse species ranges from 80.0 to 94.5 in the central and north western zones of Tigray. The variation in part might be attributed to soil type and season of harvest.

4.8.4. Crude protein (CP)

The mean crude protein content of the grass from free grazing studied was 8.045 and grass from area closure 13.99%. The result shows that between the acceptable ranges (7-14%) for ruminant diets as noted by (Gidado OG *et al.* 2013). For varied range between 8.04 and 13.99 of free grazing and area closure, respectively. The difference plant part (leaves, pods, and petiole), maturity level, season and location (Solomon, 2001). Thus, the high CP content in the evaluated grazing type in this study area suggested that these grass species have a potential for use as protein supplement to poor quality feeds.

4.8.5. Neutral detergent fiber (NDF)

The average NDF value for the grazing system analyzed in the current study value grass from free grazing 78.51% and 61.73% grass from area closure respectively. The observed differences in NDF content between grazing system is probably due to the effect of species variability, ability of the soil to supply nutrients to the plant, maturity of the plant, (Upreti and Shrestha, 2006), as well as the proportion of different grass components in the harvested samples. In other words, as the NDF in forages increases, animals will be able to consume less forage.

4.8.6. Acid detergent fiber (ADF)

The mean ADF values for the grass samples from free grazing analyzed was 45.33% and grass from area closure was observed 29.38%. The observed ADF content for both grass from free grazing and area closure in the study area was found within the range 17-61%

documented for forages used in ruminant feeding (Budi T, 1995). As the ADF increases, the forage becomes less digestible.

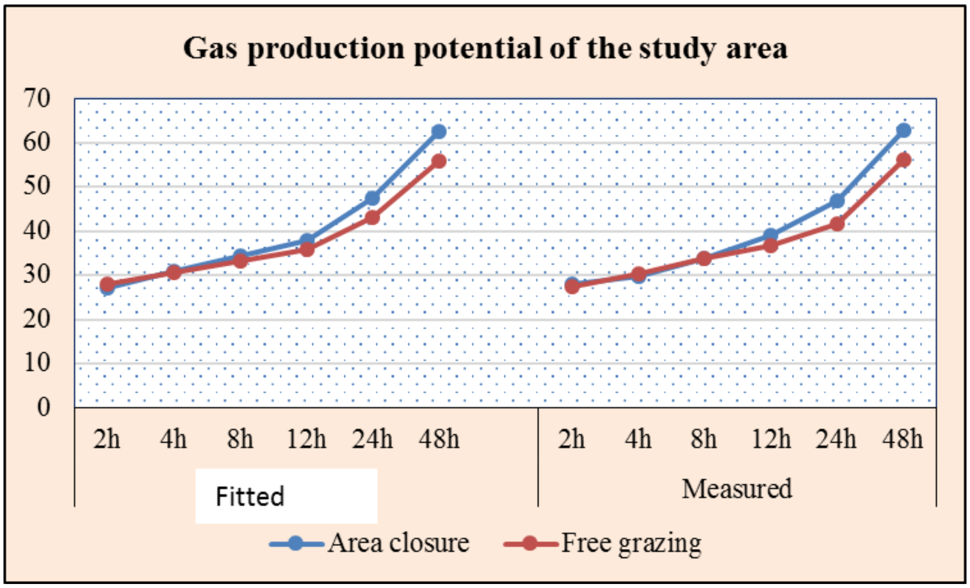
4.8.7. Acid detergent lignin (ADL)

The mean value for lignin grass from area closure were analyzed as 2.97% and the mean value grass from free grazing was 7.795%. The high value obtained in lignin were grass from free grazing because of the low digestibility resulted from low quality of forages. Also we can understand from the definition of **Lignin,** Lignin is indigestible non-carbohydrate component that decreases cellulose and hemicellulose availability and Lignin is the indigestible fraction of the plant cell wall (Norton 19940).

4.8.8. The total Volume and Gas production

The gas production at various incubation time (ml/200mg DM) of the grazing type examined. Variations in gas production were observed among grasses from free grazing 37.56% were examined and grass from area closure gas production value observed was 42.78%. In due regard, free grazing and area closure had the highest gas production after 48 hrs. According to, (Mebrahtu and Tenaye, 1997) pointed out that the amount of gas produced when feeds are incubated in vitro has been reported to be closely associated with the digestibility of feed for ruminants. In the light of this, the gas produced can be considered a good indication of substrate fermentation to an estimate of potential digestibility in the rumen. The higher gas production observed for area closure 78.88 % and the value of grass from free grazing was 69.32%. Therefore suggested that a higher digestibility of these grass species.

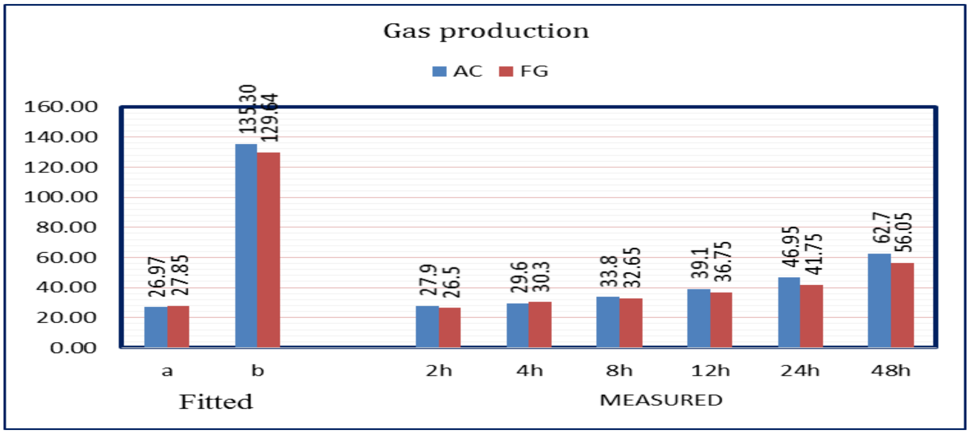
This variation could be the differences in the location, maturity harvest and season of the collection as well. (Babayemi *et al.* 2004) further stated that the variation in gas production may probably be due to the variability in nature and level of fiber, the part might be attributed soil type, maturity of harvest and season of harvest. But the variation between grazing type (free grazing and area closure) are low potential of soil to produce quality forage due to intensive over grazing which aggravate land degradation and lowering quality of forage.



Source. Standard and field data lab result of sululta district.

Figs 11. Gas production from potentially soluble component of the study area

The gas produced at different incubation time of area closure is higher than free grazing. This was due to forage quality/ digestibility effect. This variation is due to land degradation resulted by over grazing. The mean gas production from the soluble fraction of area closure (a) 28.97 % DM. The mean gas production from the insoluble but rumen degradable portion (b) 135.3% DM. The mean gas production from the soluble fraction of Area closure (a) 27.8% DM. The mean gas production from the insoluble but rumen degradable portion of free grazing (b) 129.6% DM. This indicates that the gas production of area closure from immediately soluble fit component and gas production potentially soluble component was higher than free grazing. This was resulted from low potential of soil to produce quality forage due to intensive over grazing which aggravate land degradation and lowering quality of forage



Source: standard fitted and measured result

a- gas production from immediately soluble fit component

b- gas production from potentially soluble component

Fig 12. Standard fitted and measured gas production from soluble (a) (ml/200mg DM) at different incubation time

Gas volume after 24 hrs of incubation ranged from 29.4-51.2 ml /200 mg DM while at 48 hrs of it ranged from 39.0- 56.6 ml/ 200 mg DM.

The gas production from the soluble fraction (a) ranged from 13.8-24.3 % DM, gas production from the insoluble but rumen degradable portion (b) 50.0-78.5 % DM, rate of gas production (c) 0.012-0.043 /hr and potential gas production (a+b) 67.0-93.7 % DM.

4.8.9. Organic matter digestibility

Metabolisable energy (ME) and organic matter digestibility (OMD) of the grazing type are presented in fig 21. Organic matter digestibility (OMD 69.32%) of the free grazing grass examined ranged between 55.926 and 78.934%. In this case, area closure had the highest

OMD 78.88(%) which ranges between 71.24 to 92.51% and the lowest was recorded for free grazing grass type. This finding is was above documented value range (42.2 - 58.08) obtained by (Merga *et al.*, 2016) for browse species from Borana rangeland. May be this was due to climatic factor.

This finding clear show that metabolize energy, organic matter digestibility are higher in area closure were as ch_4 (methane) are lower and the opposite true for the free grazing.

4.8.10. DETERMINED METHANE (CH4)

The gas production of area closure from immediately soluble fit component and gas production potentially soluble component resulted the residue remains in the syringe was enteric methane product. Methane production from the samples of both free grazing pilots and area closure sites was measured at the end of 24 hr incubation in which 4ml of 1N $Na(OH)_2$ was added to the substrate in each syringes to determine the methane production. The result shows higher in gas production from area closure 42.78% which indicates higher digestibility of forage implies that high quality of forage resulted lower methane production 9.61%, whereas lower in gas production from free grazing 37.56% which indicates lower digestibility of forage implies that low quality of forage resulted lower methane production 15.4% determined.

5. RESULT AND RECOMMENDATION

5.1. RESULT

Based on these study the following conclusion were made;

The overall farming system of the sululta district were characterized by mixed livestock-crop production system and the systems are highly integrated. The respondents result show that, the major feed type and source trend in last 20 years in the study area were feed from free grazing decreased by 94.3%, feed from area closure decreased by 50.6%, feed from crop residue decreased by 86.6%, feed from crop after math decreased by 80.7% and feed from concentrate increased by 50.6%. Furthermore, farmers in the study area had associated the decline in livestock production with land degradation due to overgrazing and depletion of pasture resources induced by heavy flooding and moisture stress linked to the failure of rain.

Based on the result of analysis of 30 rainfall and temperature data of the study area were changed over time. The trend annual rainfall shows decreasing trend with 1.251 mm/year with high annual variability of rainfall with coefficient variation CV 33.37% whereas normality standard precipitation index show the district have been receiving normal rainfall. However, both positive and negative anomaly have significant impact on crop production and livestock production in the study area.

The result of 30 years (1987-2016) temperature of the study area indicated that annual average Temperature decreased by 0.1497 °C over the last 30 years in the study area. The current finding of temperature data less than (NMSA 2007).In Ethiopia the temperature has been increasing about 0.37°C every ten years

In response to feed shortage the farmers practiced different type of adaptation strategies for both livestock production in the study area. Such adaptation practice were, shift from big to small ruminants 24.5%, use seasonal feed utilization plan 22.5%, income source diversification 21.7%, reducing the number of livestock 19.8% and purchasing forage and concentrates 11.5% were the major adaptation strategies practiced by farmers in the study district.

Livestock feed is the first important and the highest contribution among the above-mentioned feed resource was natural pasture followed by crop residue. The various feed resources are available and used in different seasons of the year. Since grass from area closure is collected and conserved very well, used almost throughout the year.

Feed Requirement On the average, an animal requires daily feed equivalent to 2.5 percent of its body weight, which is 2.28 tones per tropical livestock unit /TLU/ per annum (Oromia land use plan document, 2016). The total dry matter required for 29,819 Tropical Livestock Unit /TLU/ is 67,987 ton but the amount of dry matter existing now is 31,986.55 ton, which is 47.05 percent of the total feed required annually.

The total maintenance DM of feed requirement of the animals per year was 67987 tons while the actual DM of feed production was 31986.55 tons. The total DM of feed produced per year fulfilled the maintenance requirement of the animals only for 5.67 months of the year or shows -36,000.45 ton per year

The chemical composition and organic matter digestibility indicated that the mean OM, CP, ME, GP and OMD contents were higher at grasses of area closure than grasses from free grazing and these indicate that high-quality forage and low methane emission. On the other hand, the mean DM, Ash, NDF, ADF and ADL contents were higher at free grazing grass and these indicate low-quality forage and resulted in higher methane production.

The high-quality forage plants have lower fiber content and higher digestibility, resulting in increased daily dry matter intake, increased weight gain and consequently lower methane emission. E.g. the methane production potential of free grazing was higher than that of area closure because of overgrazing. The degraded land produces poor quality forage with high DM content.

Enteric CH_4 comprises 17% and 3.3% of global CH_4 and GHG emissions, respectively, and is largely derived from ruminant livestock (Knapp, 2014). The high CH_4 emission rate obtained from free grazing grass 15.3% and from area closure 9.61%. This was related to forage characterized as inferior mainly because of its higher fiber content and lower digestibility and consequently produce high CH_4 emissions.

5.2. Recommendation

Based on the finding of the study the following points are recommended:

- ✓ To alleviate feed shortage of the study area using different options such as climate-smart technology: development of improved forages with the use of irrigation and rain fed, Control overstocking /Destocking/ to bring the number of livestock down to the carrying capacity of the grazing area.
- ✓ In order to adapt the feed and water shortage, the farmer must reduce the number of animals and keep more tolerant animals and relatively productive.

- ✓ Mobilization of rural farmers to participate in grass land area closure to realize triple win approach to increase the role of livestock in livelihoods economic source.

Introduce grazing land management systems e.g.

- ✓ Zero grazing - system that prevents livestock from grazing freely in open pasture (livestock is confined in a stall and fed with cut and carried fodder-forage plant or others) and minimum the level of methane production.
- ✓ Controlled grazing- system to regulate environmental destruction, the amount of time and increasing cut and carry system feeding habit.
- ✓ It needs an immediate action to implement climate-smart Livestock development strategies which enable livestock to adopt climate change.
- ✓ The Government should give attention effective land use policy to control land degradation due to overgrazing and give a value equal to community-based water shade strategy.

It is important to study future effects of livestock on the environment based on different technological adaptation options: potential of area closure in carbon sequestration and enhancing grass land degradation.

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8. APPENDICES

8.1. Appendix 1: Questionnaires' for Household level.

Dear Respondent

This is to request you kindly take few minutes to reflect and answer the following sets of questions. This questionnaire is prepared with the aim of collecting data pertaining the impact of climate change on livestock production trends and farmers' adaptation strategies in crop-livestock system, in case of sululta district.

CONFIDENTIALITY: The information given shall exclusively be used for a major input for the master thesis research being conducted in pursuit of purely academic purpose.

Thank you for your cooperation!

Background Information

District name _______Kebele name ___________Village's name __________HH code: ___________

(Pre-filled) Are you the HH's head? 0=Yes 1=No Sex of the HH head: _______ (0=Male, 1=Female) Date of interview______Enumerator's name _____

Part 1

DETAILS OF HOUSEHOLD CHARACTERISTICS

	Household's Description	Codes	Response	
1	Age of the respondent (in years)			
2	Marital status	(0=Married, 1=Single, 2=Widowed , 3=Divorced)		
3	Level of Education of the HH head	(0= None, 1=Can read and write, 2. Primary school, 3=Secondary, 5= High school, 6=Above high school)		
4	Other Trainings	(0= None, 1= Short term, 2=FRC training)		
5	Other skills	(0=no other skills, 1=handicraft, 2=weaving, 3=carpentry 4=others(specify________)		
6	What family members of different age category within the household look like?		No. of persons	
			M	F
	How many children aged less than 10 years			
	How many children aged between 10 and 18 years			
	How many adults aged between 18 and 65 years			
	How many persons aged above 65 years			
	Total			

Part 2

Farm characteristics, income sources and livestock holding

i) **Farm size and its allocation**

1. How long have you lived in this village?______(years)
2. Do you have a land?   1= Yes   2=N0
3. If yes for Q4how much hectares of land do you have?(Total farm size)
4. Hectare/----- Timad/---
5. Which type of agricultural activities do you practice? 0= Cropping only, 1=Raising Livestock only, 2= Cropping and Livestock   3= None
6. How long you have been farming? (Years) ________________

ii) What grazing type you have? 1= private free grazing, 2=private area closure, 3=Both free grazing and area closure

iii) Livestock holding and livestock trends

1. Do you have livestock? 1=Yes   2=No

2. If yes, what do you have? (Herd size and its (composition trends)

Type	Number	Breed type	Trend in animal raising in the last 20 years				No change
			Increased	What is the reason for the Increase	Decreased	What is the reason for the decrease	
			0=Yes 1= No	List the reasons	0=Yes 1= No	List the reasons	
Cattle							
Sheep							
Horse							
Donkey							
Mule							
Other specify							

3 Trends of number of animal reared by household within last 10 years?

No	Type of animals	No of animals owned before 10 years(2008)	No of animals owned in 2017
1	Cattle		
2	Sheep		
3	Horse		
4	Donkey		
	Mule		

Part-3

I. Adaptation strategies of the farmers' farmers in the study area

1. What adjustments have you made in your farming to the impacts of climate change stated above? Please list all the possible response identified at FGDs level below

Which type of adaptation strategies you have mostly practicing for your livestock production in response to climate change in your locality.	What are the reasons for not doing the listed response (0=lack of money, 2= lack of information, 3= shortage of labour, 4= Other , specify

2. Do you have access to get credits from institutions during climate related hazards?

0=Yes 1=No

3. Do you get early warning information before the occurrence of climate related shock?

0=Yes 1= NO

4. If yes from where do you get information before the occurrence of hazards A. from local government institution B. from social media C. from NGO D. other (specify)

8.2. Appendix 2, Guiding questions for Focus Group Discussion (FGD)

Kebele:____________ Focus group size: _________________

1. Dou you think is there any change in temperature and rainfall in your locality? If yes, what are the local indicator of climate change in your locality?

2. How do you think about the cause of climate change in your locality? Please explain it?

3. Do you think that climate change affects livestock productivity in your locality? If yes, how it affects it?

4. Is there any change on livestock holding size, its composition and feeding system in your locality as compared to the last 2 decades? If yes what is the reason?

9. Part II Appendices

Appendix. Conversion factor used to estimate Tropical Livestock units (TLU)

Source: ILCA, 1990- livestock research manual, TLU 250kg 1wt, ILCA working paper, Volume 1, ILCA, AA, Ethiopia PP 309

Livestock	Conversion

	factors
Cattle	0.70
Sheep	0.10
Goat	0.10
Horse	0.80
Mules	0.70
Donkey	0.50
Chicken	0.01

Livestock population of the study area (2006-2015)

Year	Cattle	Sheep	Horse	Donkeys	Mule
2006	112345	180236	1719	25791	172
2007	111453	174786	1161	17421	116
2008	110987	178345	1598	23971	160
2009	109876	175345	1193	17889	119
2010	111897	182256	1885	28281	189
2011	112234	179789	1607	24107	161
2012	108456	181787	1862	27923	186
2013	101987	177898	1481	22208	148
2014	109876	177234	1419	21291	142
2015	111987	176543	1407	21111	141