CURRENT STATUS OF IMPROVED FORAGE PRODUCTION DESSIMINATION, ADOPTION ,AND NUTRITIVE VALUE IN DAMOT GALE DISTRICT, WOLAITA ZONE, SOUTHERN ETHIOPIA

M.Sc. THESIS

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CURRENT STATUS OF IMPROVED FORAGE PRODUCTION, DESSIMINATION , ADOPTION AND NUTRITIVE VALUE BY FARMERS IN DAMOT GALE DISTRICT, WOLAITA ZONE, SOUTHERN ETHIOPIA.

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APPROVAL SHEET-I

This is to certify that the thesis entitled **''Current Status of Improved forage Production, Adoption, Dissemination, and Nutritive Values in Damot gale district, Wolaita Zone, Southern Ethiopia** 'Submitted in partial fulfillment of the requirements for the degree of Master's with specialization in Animal production, to the Graduate Program of the School of Animal and Range Sciences, Hawassa University College of Agriculture, has been carried out by Tucho Tumato**,** under our supervision. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the school.

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APPROVAL SHEET- II

We, the undersigned, members of the Board of Examiners of the final open defense by **Tucho Tumato** have read and evaluated his thesis entitled **'' Current Status of Improved forage Production, Dissemination, Adoption, and Nutritive Values in Damot gale district, Wolaita Zone, Southern Ethiopia** and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science.

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DEDICATION

I dedicate this thesis manuscript to my wife Tesfanesh Barnbas, my son Anjonio Tucho my father Tumato Taba and my mother Lotae Brihanae for their endless love and moral support for their commitment in the success of my life during the study at Hawassa University.

STATEMENT OF THE AUTHOR

I declare that the thesis hereby submitted for the M.Sc degree at the Hawassa University College of Agriculture is my own work and has not been previously submitted at any other university or institution for any degree or diploma. I concede copyright of the thesis in favor of the Hawassa University, College of Agriculture.

Name: Tucho Tumato

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Place: Hawassa University, Hawassa

Date of Submission__________________

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LIST OF ABBREVIATIONS (ACRONOMY)

ADF	Acid-Detergent Fiber
ADL	Acid -Detergent Lignin
AEZ	Agro Ecological Zone
ANOVA	Analysis of Variance
BoARD	Bureau of Agricultural rural development
BoLFRD	Bureau of Livestock and Fishery Resources Development
CSA	Central Statistical Agency
CP	Crude Protein
EARO	Ethiopian Agricultural Research Organization
ESGPIP	Ethiopian Sheep and Goat Productivity Improvement Program
FAO	Food Agriculture Organization
FLDP	Fourth Livestock Development Project
FRG	Farmer Research Group
GDP	Gross Domestic Product
HH	House Hold
HSU	Herbage Seed Unit
ICTA	International Center for Tropical Agriculture
ILCA	International Livestock Center for Africa
IPCC	Inter-governmental Panel Climate Change
IPMS	Improving Productivity and Market Success
M ASL	Meter above Sea Level
MOARD	Minster of Agricultural Rural Development
NDF	Neutral Detergent Fiber
DM	Dry matter
SAS	Statistical Analysis System
SNNPR	Southern Nations Nationalities and Peoples Regional state
SPSS	Statistical Package for Social Sciences
TLU	Tropical Livestock Unit
UNECA	United Nations Economic Commission for Africa
WBISPP	Woody Biomass Inventory and Strategic Planning Project

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‘‘Current Status of Improved Forage Production, Adoption, Dissemination, and Nutritive Value in Damot gale district, Wolaita zone, Southern Ethiopia’’

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Abstract

This study was conducted to assess the improved forage crop production adoption dissemination and farmer's practices in high land and low lands of Damot gale District, Wolaita zone of Southern Nation Nationalities Peoples Regional State of Ethiopia. The study involved both field observation and household survey with a sample of 133 improved forage producing households; of which 69 were selected from the highlands and 64 from the lowland Agro-ecologies by using simple random sampling technique. The discussants were administered with semi-structured questionnaire on land and livestock holding, purpose of livestock production and improve forages adoption over years. Samples of improved forages were taken for analysis of chemical composition by following standard laboratory procedures. Descriptive statistics using SPSS version 20 was used to analyze the sample data and Chi-square and T- test were used to compare important parameters between the two agro-ecologies. The survey result indicated that, on average the family size of the households was 8 for high land and 7 for lowland. Average land size in the high land was 0.81±0.09ha and that of the low land was 1±0.09ha. The Overall cattle holding in the highland was 3.05± while the low land was 2.74±0.4. Purposes of cattle keeping were for milk sale, milk and meat for home consumption, financial security and income sources. The major improved forages available in the study area desho grass elephant grass Guatemala grass Rhoades pigeon pea and Sesbania were available. The majority of the interviewed households practice crop land and produce cultivated improved forages such as elephant grass, desho grass and Guatemala grass. Among improved forages, the highest CP content (34.02%) CP was obtained for Sesbania whereas the lowest CP (11.46%) was obtained from Elephant grass and also Sesbania had the highest ($P<0.05$) IVDMD Farmers produce improved forages which have better nutritive values such desho grass, pigeon pea, oat, Rhodes grass, Sesbania, elephant grass, and Desmodium. Lack of sufficient land along with poor forage seed supply and high seasonal fluctuation of rain fall are among factors influencing forage seed production. Although it is to a very little, farmers started adopting different coping mechanisms such as purchasing improved forages, use of crop residues, conservation of feed available during wet season and area enclosures. Smallholder farmers would produce improved forages following recommended forage development strategies at back yard, inter cropping food or fodder crops stock exclusion areas and alley cropping in both wet and dry seasons and agro-ecologies to mitigate climate change risks and improve livestock productivity which in turn contributes for household food security.

Keyword: *Agro-ecology, adoption, dissemination, improved forage, nutritive value, production*.

1. INTRODUCTION

1.1 Background and Justification

Livestock play an important role in the livelihoods of most small-scale farmers, as sources of food in the form of meat and milk, services (transport and draught power), cash income, manure (for soil fertility management and fuel) and serve as store of wealth and hedge against inflation. Despite enormous contribution of livestock to the livelihood of farmers, scarcity of feeds in both quantity and quality is a major and commonly reported problem for the development of viable livestock industries in the developing world (Sere *et al*., 2008).

In Ethiopia, the livestock sub-sector has significant contributions to the national income (Alemayehu, 2012) and the livelihoods of the small holder farmers. However, livestock productivity is very low attributable to different factors of which poor nutrition is the major one. A large proportion of livestock feed resources in Ethiopia are natural pastures, crop residues and aftermath grazing (Adugna, 2008; Getnet, 2012).These feed resources cannot support higher animal productivity due to their nutritional limitations. Different strategies can be employed to correct the nutritional limitations of these feed resources. One of such strategies that has been receiving recognition and considered to be the best option is production and use of improved forage species for animal feeding. Currently, with the rapid increase in human population and increasing demand of food, grazing lands are steadily shrinking being converted to arable lands (Muriuki, 2003).

The commonly available livestock feed resources include natural pastures, crop residues, improved forage and agro industrial products (Adugna *et al.*, 2012) .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).Despite high livestock population and existing favorable environmental conditions, the current livestock output of the country is little. This is associated with a number of complex and inter-related factors such as inadequate feed and nutrition, widespread diseases, poor genetic potential of local breeds, market problem, poor marketing, and infrastructure *(*Negassa *et al.*,2011).

Introduction, evaluation and utilization of improved multipurpose forage crops and trees such as Sesbania spp, Leucaena spp, Calliandra spp. and Chamaecytisus palmensis through integration with food crops in the mixed crop-livestock system in Ethiopia started since1970s to supplement roughage feed resources with browse species of better CP contents. (EARO, 2002; Alemayehu, 2006).

The experiences in improved forage seed production is one of the barriers threatening the adoption and wider scale production of improved forages. Factors such as inadequate improved production technology, lack of attention public and private institutions for forage seed production, lack of attractive price and poor market linkage and the low perception of end users resulted in difficulty of forage seed the production. Despite, so far a variety of approaches have been applied to establish and enhance improved forage seed production in Ethiopia.

Use of improved forages would reduce pressure on natural pasture, improve soil fertility and erosion of marginal lands, and improve carbon sequestration to mitigate against climate change effects. support system substantially and enhance natural assets and system reliance (ILRI, 2009) .In addition to these, promotion of integrated forage crops development has multiple functions in feeding livestock, conserving soil and soil water conservation, improve the productive capacity of arable lands, Provide fuel and timber value (Lal,2010;Rosegrant.*eta*l.2008)

The formal forage seed system in Ethiopia is underdeveloped due to lack of technical and business expertise in seed production, processing and marketing .Lack of a market-driven forage seed industry is also a key limiting factor to more and better quality seed being produced and marketed (USAID,2011).

According to Berhanu *et al*.,(2009) the importance of natural pasture is gradually declining because of the expansion of crop production into grazing lands, redistribution of common lands to the landless and land degradation. There is little or no base line information about the livestock feed resource availability, type of forage species and general nutritional qualities.(GRS, 2003)

In Damot galae district, respondents use improved forage crops in addition to natural pasture, crop residues, kitchen leftovers and leftovers of` roots and tuber crops. However, there is no adequate information on cultivated improved forage production adoption and dissemination practices and the feed balance of livestock feed in the district (BoARD, 2018). Therefore, it is important to assess the current status of improved forage production, dissemination, adoption and constraints and opportunities of associated with improved forage production and utilization

1.2. Statement of the Problem

In the central highlands of Ethiopia cereal crop production is increasing and the resulting high crop residues are used as potential feed source for livestock due to cultivation of grazing lands for crop production and cattle largely depend on crop residues that are of poor nutritive value that needs supplementation by high yielding improved forages and pasture crops, treatment of crop residues and utilization of tree legumes as animal feed is minimal.

The cultivation of improved forages and pasture crops is not well practiced in smallholder faming system. The quantity and quality of producing improved forage crop could be considered as the most important issue since animals cannot produce to their potential without adequate nutrition Therefore, grass, legumes and browses in damot gale and other nearby areas similar agro ecology.

1.3. Significance of the Research

Better understanding of current status of improved forage production and utilization is important to produce forage crops both in quantity and quality; this finally helps to improve livestock production and productivity to fill the fast growing demand for livestock products such as, meat, milk, and milk by products.

1.4. Objectives

1.4.1. General objective

- To assess current status of improved forage production practices, adoption and dissemination among smallholder farmers of Damot Gale district, southern Ethiopia.

1.4.2 Specific objective

- To assess improved forage crop production, dissemination, adoption and practices.
- To determine the nutritive value and *invitro* digestibility of the major improved forage crop in the study area.

2. LITERATURE REVIEW

2.2. Livestock and forage production in Ethiopia.

Ethiopia has diverse climate and consequently wide range of naturally occurring forage species. In the past four decades considerable effort has been made to evaluate the adaptability of different forage and pasture species under varying agro-ecological zones of the country. As a result, quite large numbers of useful species have been selected for the different zones and the selected species were found to be higher yielding and nutritional value and also longer growing period when compared to native pasture (Lulseged, 1985).

To keep the farming system healthy and sustainable, legumes could contribute a significant role and legumes use as components of multiple cropping and in crop rotation (Pearson *et al*., 1995). In many parts of the country, soil is nitrogen deficient and often limits the productivity of the crop. Among the plant nutrients, nitrogen plays a very important role in crop productivity and its deficiency is one of the major yield limiting factors for cereal production. Annual legumes are utilized in the form of green forage, forage dry matter, forage meal, grain, straw, silage, hay (Mihailovc *et al*., 2007).

These species represent excellent sources of green manure in the modern trends such as sustainable agriculture and organic farming. Getnet *et al.*, (2003) reported that non-conventional forage production system is highly important and appropriate in areas where land shortage is a problem and the agricultural production system is subsistence. Integrating forage legumes with cereals generally results in higher fodder protein yield than cereal alone. Despite farmers' recognition of the potential contribution of forage legumes to crop-livestock farming systems in the Ethiopian highlands, their integration is relatively low.

Feed resources are a major component of economic animal production in various animal enterprises. Feed availability and efficiency of use in specific agro-ecological zones and in smallholder production systems indicate to a very large extent the performance of both ruminants and non-ruminants.

Green fodder (grazing) is the major feed source (about 56 percent) followed by crop residues (3 percent) of Ethiopia. Crop residues can contribute up to 30% of the total feeds. Hay and by-products are also used as animal feeds which comprising about 12 and 3 percent of the total feeds, respectively (CSA, 2017). Moreover, very small amount of improved feed (like alfalfa, only about 1 percent) is being used as animal feed and other types of feed account about 12 percent in the country. (CSA, 2017)

2.2. Improved forage crop production strategies in Ethiopia

2. 2.1 Backyard forage production

Backyard forage production is based on small plots and hedge of productive forage and browse planted within house compounds and around their boundaries. This is the most important initial strategy since it is developed in the farmer's household, and is very convenient for intensive feeding of dairy animals or fattening of meat animals. The higher fertility levels typically found in and around house compounds also help with the successful establishment of backyard forage. This strategy introduces farmers to the concept of supplementing crop by-products and poor quality roughages with high quality forage in a location, which facilitates close attention to management (Alemayehu *et al.*, 2016). Backyard forage provides significant quantities of both forage and fuel wood where they can be conveniently used. Other benefits perceived by farmers include shelter, increased privacy, wood products construction and implements and bee products.

2.2.2 Contour forage strips

Forage strips are broad based mixtures of herbaceous and tree legumes, and grasses planted on contour bunds or in narrow strips along the contour without any physical structures. This is a multipurpose strategy providing forage, shelter, soil stabilization, and fuel wood. Forage strips planted along the contour contribute to soil conservation by directing ploughing along the contour and by reducing run-off down the slope. This increases infiltration and reduces soil erosion, and they produce a high yielding, high quality pasture, the legumes improve soil fertility, and allow a high stocking rate and high levels of animal production, especially where a thick sward of grass or herbaceous legumes is included in the forage strip planting (Abadi, 2017).

2.2.3 Forage Crop Production

Many of the temperate and tropical pasture and forage crops that have been tested and grown in Ethiopia have no problem of flowering and setting seed. This provides a good opportunity for the country to establish local seed production in the existing farming system. This is based on growing annual or perennial forage crops in prepared fields. It can then be used for finely controlled grazing by livestock or cut and carry. It is an expensive, high input system and thus is only suitable for high value animals such as dairy animals. It requires good, fertile soils, a longer growing season, good management and intensive enterprises. It produces higher quality forage that enables higher stocking rates (Abadi, 2017).

2.2.4 under sowing and Inter planting

Under sowing and inter planting is the establishment of forage species in an annual crop or perennial plantation. This strategy provides the most convenient approach to rapidly increasing on-farm forage supplies over a large number of farmers and should have a major impact in the short to medium term. The use of legumes in this system will contribute to the improved fertility and structure of cropping soils. Farmers seeing on-farm trials of under sowing and inter planting accept the strategy readily and understand the benefits and techniques very quickly. This is normally the second strategy to promote after backyard forage has been adopted by farmers. Under sowing and intercropping are probably the most important of the forage development strategies.

Tree crops and some vegetables can also be under sown or inter planted with leguminous forages. The establishment of annual or perennial legumes under tree crops is a reliable strategy, which is well accepted by farmers. It is particularly appropriate to the more intensive horticultural and forestry systems where the under sown legume is intensively managed with cut and carried systems for livestock feed. The strategy primarily involves lower altitude systems where fruit, coffee, coconuts, enset or chats are grown (Alemayehu, 2002)

2.2.5 Over sowing common grazing areas

This is the simplest and lowest cost form of forage development. It involves seeds of improved forage species or varieties being broad cast on common grazing lands, natural pastures and degraded areas. Forage yields are not large but some species establish well and these may spread and colonize grazing areas and increase overall species composition. They can spread very rapidly. Such species need to be able to establish easily on poor seedbeds, be tolerant of heavy grazing and be capable of setting seed and spreading even under heavy grazing. There needs to be some form of grazing management to be agreed and enforced to stop the overgrazing which caused the initial degradation. Over sowing have a number of advantages; expense is very low cost, requires little labor and little or no management, involves in improving forage production, soil fertility and forage quality (Abadi, 2017).

2.2.6 Stock exclusion areas

Stock exclusion areas are an important means of protecting degraded areas, key watersheds, and common land. They also provide an opportunity to develop forage banks for use during droughts or periods of seasonal forage shortage. Stock exclusion areas are particularly important for the conservation of highlands but are only accepted by farmers where they see sufficient benefits to organize grazing management groups or pastoral associations to control stock exclusion areas and voluntarily keep stock out. The introduction of browse species, productive legumes and improved grasses can rapidly increase the productivity of exclusion areas. The strategy is suitable for aerial seeding techniques which enable very large areas of land to be sown to forage quickly (Abadi, 2017).

2.3. Major type of improved forages.

2.3.1 Grasses

Tropical grasses were of lower quality than their temperate counter parts and introduction of adapted legumes into tropical grazing systems would simultaneously address the problem of low N status of leached tropical soils and low dietary protein intake by grazing ruminants. There is an emerging and significant role for legumes as a protein supplement to reduce reliance on expensive concentrates (Franzel and Wambugu, 2005) which often account for a high proportion of direct costs.

2.3.1.1 *Desho grass*

Desho grass is an indigenous grass of Ethiopia belonging to the Poaceae family of monocot angiosperm plants. It grows in its native geographic location, naturally spreading across of the Ethiopian highlands (Smith, G. 2010). Widely available in this location, it is ideal for livestock feed and can be sustainably cultivated on small plots of land. Due to its rapid growth rate, desho provides regular harvests, even reaching monthly cuts during the rainy reason. Once a year, just before the dry season, sufficient grass is harvested and stored as hay to feed the livestock until the rains return (Danano, 2007).

Very little has been done in collection and conservation of indigenous forage species which have invaluable importance in the livelihood of the farmers. Hence, introduction of high yielding and nutritious indigenous forage species like desho grass is the foremost issue to minimize feed shortage both in quality and quantity especially during dry season. The production of desho grass is widely practiced in the region due to its importance for both livestock feed and in soil and water conservation structures (EPPO, 2014).

As it has been mentioned above even though, desho grass has multi- functions the optimum planting space and fertilizer rate for optimum yield has not been identified both in regional and national level. Therefore the objective of this study is to identify effect of planting space and fertilizer rate on biomass yield, number of tillers and height at harvesting.

Desho grass plays multipurpose roles in southern Ethiopia such as soil conservation, animal feed and cash source. Research work indicated that desho grass is low in protein, hence it was recommended to supplement with protein source feed (Asmare *et al*., 2016).

2.3.1.2 Elephant Grass

It is a tall and deep-rooted perennial bunch grass well known for its high yielding capability and mainly used in cut-and-carry systems (FAO, 2015). Napier grass is propagated vegetatively by using stem cuttings, root splits or shoot tips (Tessema,2008) which usually vary across agro-ecologies (Getnet and Gezahagn, 2012). Napier grass *(Pennisetum purpureum*) is recommended as basal forage for intensive cattle production as its high biomass fresh dry matter yield 40 t/ha compared to other grasses (ILRI,2001). Napier grass is tall growing perennial grass, which is indigenous to tropical and subtropical climates. Bako Agricultural Research Center, *Pennesitum purpureum* (ILRI 1681) was found to be promising in terms of biomass this material was used for the preparation of the silage meant for the present study.

Amongst the improved forage crops promoted in Ethiopia, Napier grass could play an important role in providing a significant amount of biomass yield of 20 to 30 t DM/ha/year with good agronomic and management practices (Farrell *et al.*, 2002).

2.3.1.3 Guatemala Grass

Guatemala grass *(Tripsacum andersonii* J. R. Gray or *Tripsacum laxum* Nash) is a robust, strongly rhizomatous, tufted and leafy perennial grass that can form large bunches. The stems can be up to 3.5-4.5 m high and up to 1-5 cm in diameter. They develop at a very late stage and Guatemala grass remains leafy for a long time. The roots are shallow and the plant does not grow well during a long dry season. Guatemala grass is used for hedges or for contour stripping of cassava crops planted on steep slopes. Guatemala grass is a good soil binder and organic matter builder (FAO, 2012).

Guatemala grass is more effective at controlling soil erosion when combined with trees such as *Sesbania, Grevillea or Desmodium* (FAO, 2012; Bationo *et al*., 2011).Guatemala grass is cultivated primarily for fodder in cut-and-carry systems. It can also be used to make silage. Guatemala grass provides several environmental benefits, against soil erosion and the development of pests and diseases in neighboring crops (Cook *et al.*, 2005).Guatemala grass is usually propagated from stem cuttings or rooted culms at the beginning of the rainy season.

2.3.1.4 Rhodes Grass

Rhodes grass (*Chloris gayana* Kunth) is an important tropical grass widespread in tropical and subtropical countries. It is useful forage for pasture and hay, drought-resistant and very productive, of high quality when young Rhodes grass is primarily useful forage of moderate to high quality. It is grazed, cut for hay or used as deferred feed but it is not suitable for silage. It can form pure stands or is sown with other grasses or legumes. Many cultivars have been developed in order to suit different cultivation conditions or end-uses, such as early, late and very late flowering cultivars. *Chloris gayana* is useful as a cover crop and soil improver, as it improves fertility and soil structure and helps to decrease nematode numbers Cook *et al*., (2005).

Rhodes grass can be high quality forage for ruminants when grazed or harvested at an early stage of maturity. However, its nutritive value strongly decreases with maturity, especially after the first cut. Hay harvested at a later stage of maturity has a low protein content and a high fiber content, particularly in the stems, and it should be supplemented when fed to ruminants with nutritional requirements higher than those necessary for maintenance Rhodes grass is a spring and summer-growing grass found in open woodlands and grasslands, in road margins, disturbed sites and river banks. It is cultivated in sown pastures in irrigated terraces**,** (Quattrocchi, 2006; Cook *et al*., 2005).

2.3.1.5 Oats

Oats (*Avena sativa L.)* is one of the most important well-adapted fodder crops grown in the highlands of Ethiopia mainly under rain fed conditions. It is produced by some peri - urban dairy cattle producers and by smallholder farmers who own cross breed dairy cows. It is early maturing, palatable, succulent and energy rich crop. (Lulseged *et al* (1981) reported that its grain also makes part of the staple diet of human beings in some parts of central highlands of the Ethiopia.

Temperate and cool sub-tropical conditions are congenial for its growth. A well distributed rainfall of 400 mm and temperature range of 16-32 ^{0}C during the five months of its growing seasons is sufficient to meet its requirements as a fodder crop (Bhatti *et al* (1992).

2.3.2 Legumes

The leguminous forages are important as sources of nitrogen, fermentable organic matter and minerals in crop residues and poor quality natural based diets. The grass can be harvested at frequent intervals for cut-and-carry green feeding (Adugna, 2008) Legumes in the mixed crop-livestock system could help alleviate the fodder shortage. Among other species tagasaste and Sesbania are performing well in terms of adaptation and fodder production. An alley cropping experiment of tagasaste in barely crop at Holetta, Ethiopia showed that, allaying of tagasaste did not reduce grain and straw yield of barely in fact a higher amount of green fodder was produced which could be used either for livestock feed or as a mulching for the next crop (HARC, 1998).

According to Ayarza *et al*; (2007) most improved forage, in particular legumes, is multipurpose plants. Use of improved forages would reduce the pressure on natural pastures, improve soil fertility and reduce erosion on marginal lands. Tree legumes are extremely important elements in improved forage production programs because of their productivity and multi-purpose uses.

They have deep rooting systems which help them increase their productivity during the dry season, and they provide other products such as fuel wood, construction timber, and pollen and nectar for bees.

2.3.2.1 Cowpea

Cow pea, is the least cultivated and sparsely distributed grain legume in Ethiopia. It mainly grow s in Gamo Gofa zone, and Konso and Derashe special districts of the SNNP Regional State. Besi des, it grows in limited areas in Gambella Region, and in some pocket areas in Amhara and Oro mia Regional States. V. unguiculata subsp. unguiculata and V. unguiculata subsp. cylindrica are t he cultivated sub species found as farmers' varieties in the eastern parts of the country (IBCR, 20 01). Cow pea has its wild species in the northern, south-western and southern parts of 40 the cou ntry. It grows in adverse growing conditions with little annual rainfall distribution (Ali et al. 200 3). It can grow up to 2000 m.a.s.l. (Westphal 1974), and performs well with only 400 mm of rain fall per year (EIAR 2010). Unlike major pulses, little research attention has been given to this cro p mainly due to its restricted geographical and economic importance. Hence, the state of diversit y of the crop is not well known.

This precious tropical and subtropical legume is especially important for the semi-arid regions of the tropics for forage, green pods and grains (Adeyanju *et al*., 2007; Ali *et al*., 2004). Although cowpea can be grown under dry condition, irrigation highly promotes its vegetative growth and results late maturity of seeds (Peksen, 2007).Cowpea produced highest forage yields in sandy loam soils with proper irrigation regime .Cowpea hay is a nutritious balanced fodder for animals and has a great function in feeding animals during the dry season in West Africa .Cowpea can also intercropped with maize) and sorghum for a higher yield and quality compare to sole cropping (Ahmad*et al*, 2007)

2.3.2.2 Lablab

It grows best where average daily temperatures are between 64 to 86°F; but it can grow at 37°F for short periods Cook *et al*., (2005) and can tolerate light frosts .The leaf has crude protein of 21 to 38% and the seed contains 20 to 28% crude protein .The seeds contain large amounts of various vitamins and minerals. The leaves make excellent hay for cattle and goats, but the stem is difficult to dry, and must be mechanically conditioned through crushing Silage made. (FAO, 2012). In green manure applications, the crop should be terminated before flowering to return maximum amounts of N to the soil.

2.3.2.3 Vetch

Vetch is herbaceous legume that can grows in area with an altitude ranging from 1500 3000 meter with versatile soil type with minimum moisture as low as 400mm (ESGPIP,

2008). Vetch varieties are very good source of protein especially *Vicia dasycarpa* species with higher CP content (25-26%) than other varieties (Gezahegn *et al*., 2014). Recommended seed rate may range from 20-30 kg per hectare depending on different Factors including seed quality and soil condition.

Vetch is a vigorous climbing annual legume with a wide range of adaptation and high level of farmer acceptability. It grows well between 1500 and 3000 m altitude and is suited to a wide range of rainfall (above 400 mm/annum). It grows on a wide range of soils but requires good drainage. It is ideally suited for under sowing, mixed pasture and backyard forage plots and can be established easily even on rough surfaces. Seeds need inoculation before sowing. Sowing rates are 20 kg/ha for pure stands, 12 kg/ha for under sowing, and 5-12 kg/ha as a pioneer component of mixed pasture. When sown at 12-20 kg/ha with oats, vetch makes excellent hay. It is more suited for under sowing and seed yields range between 400 and 1000 kg/ha Mekonnen *et al* ;(2013).

2.3.2.4 Dismodium uncinatum (Silverleaf)

Silver leaf is a perennial, sprawling forage legume suited to under sowing, intercropping and improving stock exclusion areas. This species is less important than the related *Desmodium intortum* (Greenleaf). It grows below 2200 m altitude, requires more than 900 mm annual rainfall, and is tolerant of cool weather and light frost. Silver leaf can grow on relatively fertile, well drained soils. It requires careful grazing management for high productivity and is most productive with cut and carry systems based on under sowing and stock exclusion area strategies. Continuous moderate cutting or grazing is preferable to occasional heavy grazing. While sowing it requires a moderate to fine seedbed with sowing rates of 1 to 2.5 kg/ha. Accordingly, it is not suited for over sowing. Seed production is more promising when grown on trellises, tall cereal crops or browse trees with harvests of up to 400 kg/ha. Mekonnen *et al* ;(2013).

2.3.2.5 Medic ago sativa (alfalfa)

Alfalfa is a long-lived perennial producing large quantity of high quality forage under good management. Grows over a wide range of altitudes and is tolerant of a wide range of temperatures. It develops a deep taproot which enables the plant to withstand drought once established. It produces good forage yields with more than 600 mm of rainfall and is ideally suited to irrigation. It is suited to a wide range of well-drained soils but best production is on neutral to slightly alkaline soils. Inoculated seeds should be sown into a well prepared seedbed with seeding rates of 8-10 kg/ha for pure stands and 5-6 kg/ha in mixture. Young seedlings require early weed control for best results and so row planting is preferable. Seed should be sown to no more than 1 cm depth on heavy soils and no more than 2 cm depth on light soils. It can produce high forage biomass when cut with a rotational system at intervals of 30 to 45 days during the growing season. As a rough guide, it is ready to harvest when 10 percent of the forage crop is flowering. Alfalfa should be cut about 3 cm above the crown to avoid damage to the growing points and weeds should be controlled after each harvest. It has high feed value and can be used as supplement for crop residues and natural hay in a mixture of 30 percent alfalfa and 70 percent other roughages. Mekonnen *et al* ;(2013).

2.3.3 Browses

Livestock feed resources in Ethiopia are mainly natural grazing and browse, crop residues, improved pasture, forage crops and agro industrial by-products and the natural pasture. natural pasture comprises the largest feed resource, but estimates of the contribution of this feed resource vary greatly. According to (Alemayehu M 1998a) estimated that 80–85% of all feed comes from natural pasture while some estimates indicate the natural pasture provides 88–90%. In Ethiopia, there are 179 browse species from 51 genera, which is not exhaustive, of which 51 species from 31 genera are recorded as promising browse species. Currently 185 accessions from 41 species and 18 genera are systematically collected and conserved by ILRI (IBCRE, 2001)

2.3.3.1 Cajanus Cajan (Pigeon pea)

Pigeon pea is a grain legume mainly cultivated as a garden crop in Konso special district (EIAR 2010),Gamo Gofa and Wolaita zones (Ali *et al.* 2003) and Benishangul Gumuz Region (Awas 20 07). It is rarely found in other parts of the country, and it can be grown at the altitude range of 10 00 - 2400 m.a.s.l. (Hedberg and Edwards 1989). Pigeon pea is cultivated as intercrop with sorghu m and cotton. It is drought resistant, and grows with rainfall as low as 600 mm per year when oth er crops fail to yield satisfactorily (EIAR, 2010). Pigeon pea is cultivated for its edible seeds, and is mainly consumed at the local scale. Little study has been conducted on this crop and the state of diversity of the crop is not well known.

It is widely used for its dry seeds used as a pulse, or the green seeds used as a vegetable. The leaves are also sometimes used as a food for humans. When grown as forage, pigeon peas can be cut at 50 centimeters or more from the ground. The cut foliage is used fresh, dried as hay, or occasionally used as ensilage. Most varieties are photosensitive and thus grow vegetatively during most of the year and then flower as days shorten. Thus pigeon pea is good forage for the dry season when forage is scarce. However it can be produced year round (some races are perennial). Use of the plants for forage can be combined with use as a vegetable or grain. Pigeon peas are tolerant of many soils and are easy to grow. They do not need to be inoculated. Plants are established about 1 meter apart. They will produce well in semi-arid regions but are also tolerant of tropical rains. Nutritional value is high and this forage will result in good animal weight gains (Franklan, 1993).

2.3.3.2 Sesbania

Sesbania can survive for up to 7 years and will grow in environments not suited for either Leucaena or tree Lucerne. It is a highly palatable and primarily used for animal feed and it can also be used for shelter, fencing, and nitrogen fixation for companion crops. It adapts well in areas below 2300 m altitude, it is very frost sensitive, and do not tolerate drought well. It requires more than 600 mm rainfall for survival. In grows on a wide range of soils including very poor acid sandy soil and waterlogged soil, but responds well to improved fertility. Cutting intervals of about 6 weeks result in good productivity. Sesbani*a* produces less forage biomass than Leucaena but what it does produce is of very high quality. It should be grown with other browse species to reduce the impact of insect attack, which can be severe in monoculture. Sesbania highly suited to contour forage banks, as live fence in backyards, and alley farming. It is best established by direct sowing. Cutting or browsing should not begin until the trees are more than 1 m in height. It can yield 1 kg seed/tree Mekonnen (*et al*., (2013).

2.3.3.3 Tree Lucerne

Feeding small quantities of supplemental protein to animals grazing warm season perennial grasses has shown to increase forage intake. Although cool-season grasses usually contain more crude protein and are more digestible than warm season grasses, supplementation with energy or protein can increase dry matter intake. Instead of purchasing a protein supplement, producers may opt to use home grown forages, such as alfalfa (Lucerne) to provide supplemental protein to grazing livestock Philips *et al*., (2002).

2.4 Selection of Species and Varieties of Improved Forages

Selection of species and varieties is a basic, but highly important point that decisions regarding the forage species and varieties that were be planted and grown were have an enormous impact on productivity and profit potential. If a forage crop is not well adapted to a given soil and site, planting is likely to result in poor performance or even stand failure. Thus, it makes sense for a producer to refer to national agriculture research system soils maps, study literature describing the adaptation of various forage crops, and to have discussions with knowledgeable persons such as extension agents, industry representatives, and neighbors to learn from their training and experience Ball *et al*., (2008). Periods of inadequate crop residues and natural pasture supply. Even in the presence of abundant crop residues, which are often free fed to ruminants, forage crops especially legumes are needed to improve the utilization of crop residues (Tolera, 2008).The leguminous forages are important as sources of nitrogen, fermentable organic matter and minerals in crop residues and poor quality natural based diets. The grass can be harvested at frequent intervals for cut-and-carry green feeding (Tolera, 2008). Due to unprecedented population increase, land scarcity and crop-dominated farming, there has been limited introduction of improved pasture and forages to smallholder farming communities and the adoption of this technology by smallholder mixed farmers has been generally slow (Mekoya *et al*., 2008).

2.5. Improved Forage Crop Adoption

The conditions for successful introduction of forage technologies could socio-economic factors, policy options and feeding system. The demand for forage and the opportunities for diffusion of forage technology may be poor if livestock production is for subsistence and if livestock productivity and response to improved technology are low. In addition, potential for adoption may be high where livestock productivity is high, where livestock respond to improved feed technology and where profitability is high due to market-oriented production systems, such as dairying in the mixed farming system intensity of adoption increase with the extent of market participation, household resource base, and contact with extension workers and secure land tenure (Alemayehu, 2004).

According to Gebremedhin *et al, (*2003) household resource gift especially land utilization (modern soil fertility management practices and complementary with crops) and labor, market integration and crop intensification were important factors encouraging adoption of improved forage in Ethiopia. General adoption of forage-based technologies has, however, been variable. Whereas many large and medium-scale farmers have established pastures with improved grasses, access for small farmers has been limited due to high costs of seed and other inputs like labor. Adoption of legumes has been low. Although here seed cost does not need to be a constraint, incentive mechanisms for massive adoption are still inadequate or absent. Most of these technologies contribute to sustainable intensification of mixed crop-livestock systems and have proven their on-farm applicability. Recently, new perspectives have been added with a focus on value chain development (including improving farmers' access to markets, and increasing product quality) and putting emphasis on the contribution of improved forages to mitigation of climate change Reinvander *et al.,* (2016).

In order to support seed production farmers, private investors, government, NGOs and other partners need to play their share of responsibility in producing and supplying forage seeds (Alemayehu and Getnet, 2012). Farmers save or exchange their seeds with other farmers and/or use transitional systems like community-based seed production that exist between the formal and informal seed system. Breeders are producing early generation seed i.e. breeder, pre-basic and basic seed and providing them to different stakeholders to sustain the production. However, the demand of seed is tremendously increasing from time to time and unable to satisfy the requirement in the country.

On the contrary, the adoption of improved forage technologies in a sustainable manner at the household level is expected to assume a pivotal role in increasing animal production. Shrinking of grazing land has caused livestock feed problem in quality and quantity throughout the year and seasonality. In most part of the high land areas of the region, population pressure has led to cultivation of marginal land and steep slopes (Bezuayehu *et al*., 2002). This calls for the utilization of improved forages.

2.5.1. Forage management and adoption to the Ethiopian ecology

Annual forage crops require simple management practices for seed production and show higher productivity compared to perennial ones. Seed processing techniques such as threshing, drying and cleaning for most perennial species are difficult and require special skills and knowledge. Seed productivity of most perennial forage grasses and legumes is in a range of 1-4 quintiles per hectare. With the careful selection of well-adapted species of forage crops, Ethiopia could potentially establish forage seed production to supply domestic as well as international markets. Forage species can improve soil fertility, and mitigate the effects of soil erosion resulting in positive environmental effects. (Tekalign, 2014**)**

According to the FAO, over the past two decades several forages have been tested in different ecological zones. Considerable efforts have been made to test the adaptability of different species of pasture and forage crops under varying agro-ecological conditions. As a result, a number of useful forages have been selected for different zones. Improved pasture and forages have been grown and used in government ranches, state farms, farmer demonstration plots and dairy and fattening enterprises. Forage crops are most commonly grown as supplementary animal feed to improve the milk production of dairy cows. Common forage species include Oats, Vetch, Fodder beet, Elephant grass, Siratro, Desmodium, Rhodes grass, Lucerne, Phalaris, Trifolium, Sesbania, Leucaena and Tree Lucerne. Due to land scarcity and crop dominated farming there has been limited introduction of improved pasture and forages. During the FLDP, different strategies and species for pasture and forage development were selected (Alemayehu, 2002)strategies and forages have been promoted widely in crop and livestock systems, traditional grazing areas, around homesteads, within soil and water conservation structures and under plantation crops and forestry.

Feed quality and quantity, ecological degradation, overgrazing, border conflicts, drought and lack of seed and planting materials remain major challenges in developing Ethiopia's livestock sector. Natural grazing remains the major source of livestock feed, especially in the lowlands.

However, grazing lands do not fulfill animal's nutritional requirements leading to low productivity and quality. In the highlands, with the rapid increase of human population and high demand for food, pastures are steadily being converted to farmlands. Land that is not used for cultivation is often waterlogged, flooded and steep thus unsuitable for grazing. Environmental degradation due to deforestation and overgrazing have also substantially reduced soil fertility and further reduced arable and grazing land productivity.

Forages can be described as any vegetative part of a plant that is eaten by animals, but they are further defined as those crops grown mainly for the feeding of livestock. Inside the mixed farming systems, involving forage production within the cropping cycles can increase the farm's sustainability Reintjes, *et al* (1992.) Subdivided into groups, forages; include grasses, legumes, multipurpose fodder trees, and other browse species

2.5.2 Adoption of Forage Legumes in Mixed Farming Systems

Biological resources are fundamental to human well-being: in agriculture, livestock, and export earning, economic output and for their ecological services and functions (Alemayehu, 2001). The complex topography coupled with environmental heterogeneity offers suitable environments for a wide range of life forms. However, the threat of genetic erosion of herbaceous legumes is serious due to the fact that they are palatable and easily affected by overgrazing Getnet *et al*., (2003) the species and varieties of forage legumes are many in number and adapted to wide environmental conditions compared to food legumes. They have also different characteristics in terms of growth habit (erect, creeping, and climbing), life cycle (annual and perennial), climatic adaptation (tropical and temperate). These characteristics of legumes determine the utilization, production and the various management practices. Breeding of forage legumes has received little attention in the world, where the selection is usually made at species level based on high biomass yield, good nutritional quality, and high animal intake. Only few species, accessions and varieties are evaluated by mass selection but, advanced forms of breeding such as pure line selection and crossing are virtually not practiced Getnet *et al*. (2003).

2.5.3 Adoption of Forage grass in Mixed Farming System.

Forage species are generally adapted to specific climatic regions and, at the Centre of their adaptive zone, may regularly survive extremes of temperature and moisture as well as stress of lax management. Both genotypic and phenotypic plasticity influence adaptation (Nelson, 2000); the former depends upon survival of genotypes making up the population and the latter results from interaction between the genotype and the environment. Alfalfa (*Medicago sativa L.*) is an example of a forage species with high .genotypic and phenotypic plasticity enabling its adaptation to many eco regions (Baron and Bélanger, 2007).

2.6. Improved Forage crop Dissemination

The dissemination of improved forage crops is extremely low due to various factors including problem of seed supply. The shortage of seed supply places a serious constraint on various national efforts to tap the potential of improved forage crops for increasing livestock productivity (Abate, 1998; Alemayehu, 2004; and Solomon, 2008).

Planting materials of different forage crops have been being requested by various stakeholders including higher institutions, research centers, private sectors, bureau of agriculture and rural development and non-governmental organizations (NGOs'), but the center could not satisfy the demand. The current need for forage seed is expected to continue as the demand for feed increases to support the growing market demand for livestock and livestock products. The highly fluctuating demand for seed of improved forage is indicative of the fact that the demand is coming from GOs and NGOs, whose activities definitely rise and fall according to budget allocations (Solomon and Getnet, 2012). However, true demand for forage seed will come when adoption and sustained use of improved forage technology among livestock producers is realized.

When seeds of poor viability are distributed, the consequence is low germination and poor establishment. This affects the adoption rate of forage and pasture plants. Forage seed producers are not well organized to collect, store and test forage seeds. Individual farmers produce almost all forage seeds on a contractual basis and cooperative supported farmers and disseminated using informal seed dissemination pathways (Alemayehu & Alan, 1998) described the contractual seed system with service cooperatives, producer cooperatives and individual farmers. However, once such projects end, the contractual system ceases and forage seed production stops.

Distribution of seed must be planned in advance of the next cropping season. This is best achieved with an annual forage plan, which is developed by farmers and extension agents. This "bottom-up" participatory element is essential for successful extension and management of forage programs. The annual forage plan for the coming season will ideally have contributed to determining how much forage seed was contracted to be grown in the previous season. The coordination required for successful forage program planning requires time and skill and is best done on a regional or national level.

The production of forage and browse to overcome dry season livestock feed shortages is dependent on the availability of reliable supplies of quality seed at the time of planting. Forage development programs need to include local seed production to ensure their long-term sustainability and economic viability. Because of the wide range of agro-ecological zones and farming systems in Ethiopia, many species are required, but local production of seed for the key species can be initiated very early in the forage program. The principal objective of a local seed program should be to meet the forage and browse seed needs of a forage development program. (Alemayehu, 2002.)

This coordination requires an accurate knowledge of existing seed supplies so that any shortfalls can either be imported or taken into account by modifying the forage program for the coming season. Once regional forage program targets have been established, seed mixes and quantities are prepared for each administrative region. This may involve moving seed from one region to another to ensure that each region has sufficient seed to meet farmer demand or forage program targets. The production and maintenance of adequate quantities of adapted and promising pure forage seed is fundamental to a progressive national forage development program (Gezahagn *et al*., 2012). The formal forage seed production and supply system is not well developed as compared with seed systems of food crops in Ethiopia (Mesfin *et al*., 2012).

Generally, forage seed production and dissemination activities have received little attention and the majority of forage crops have not been widely adopted by farmers. Despite the many desirable characteristics of selected forages, they have not been disseminated to farmers because of critical seed shortage.

Forage seeds (KG) and Vegetative Parts (Numbers) distributed in 2015to 2018 from Areka Agricultural Research Center.

Forage Species	Years in G.C				Distributed Districts
	2015	2016	2017	2018	
Sesbania Sesbania	6	15	30	35	Damot Galae
Lupinus albus	40	50	10	15	Damot Galae
Desmodium intortum	2	4	5	7	Damot Galae
Chloris gayana	20	26	6	8	Damot Galae
Lablab purpureus	20	46	25	15	Damot Galae
Avena sativa (CI-8237)	30	20	20	15	Damot Galae
Vicia dasycarpa	12	18	15	15	Damot Galae
Vigna unguiculata (Cow pea – IT86D-716)	8	5	10	5	Damot Galae
Pennisetum purpureus (ILRI-14694) *	7500	8000	10000	15000	Damot Galae
Pennisetum Pedicellatum‘Desho’ grass*	100,000	45,000	120000	15000	Damot Galae
*Tripsacum andersonii*Guatemala grass	50000	75000	75000	10000	Damot Galae

Source: Wolaita zone, Damot Gale BoLFRD2018. - *root splits in thousands

2.7 Constraints of improved forage crop production

Land shortage is one of the major constraints to adoption in the Ethiopian farming system. This is a problem because farmers do not want to take land away from food production for other uses. Use of one of the intercropping techniques would not affect the cereal crops. Land tenure is a constraint to farmers wanting to adopt long-term technologies for soil improvement and tree development due to uncertainty of tenure. Labor shortages also play a role in whether farmers adopt forages or not. The times when labor is required for forages an often already occupied by other fieldwork. Hence, labor constraints may continue to be a factor influencing adoption.

During the latter part of the dry season livestock feed is normally in short supply and also of poor quality. Because of growing pressure on land resources from increasing populations and greater cropping amount, forage crops can only be produced in sufficient quantities if livestock and cropping systems are integrated. As a result, quite a number of useful forages have been selected for different zones, although the adoption rate is extremely low. The most constraints in forage production are low quality of forages, lack of improved forage feeding strategies, lack of integrated knowledge on forage production and conservation, market fluctuation, land degradation and decline in soil fertility (Yaynshet, 2010).

2.7.1) Feed Quality and Quantity

Natural grazing is the major source of livestock feed and in the lowlands livestock production is almost totally dependent on it. However, grazing lands do not fulfill the nutritional requirements of animals particularly in the dry season, due to poor management and their inherent low productivity and poor quality. In the highlands with the rapid increase of human population and high demand for food, pastures are steadily being converted to farmlands. Marginal lands unsuitable for cultivation such as waterlogged, flooded soils and steep lands are left for grazing and their productivity is also very low.(Tolera, and Abebe, 2007)

2.7.2 Ecological Deterioration

Gradual encroachment of cultivation into grazing lands is common in both highlands and mid-altitude areas. So many meadows in the flood plains have been converted into croplands.

Due to vegetation clearance many steep areas have become vulnerable to wind and water erosion. Important browse that was dry season forage has been wiped out to supply urban fuel and construction wood. Natural grazing land is deteriorating rapidly due to lack of attention and its carrying capacity declining due to high stocking rates.(Alemayehu, M., 1998a)

2.7.3 Land tenure change of ownership

In Ethiopia grazing land ownership is thought to be communal, where ethnic groups used to manage grazing lands. However, the federal or regional state can allow private investment in pastoral areas. Besides the loss of grazing land, investment may prevent free movement of pastoralists that crates border conflicts and initiate urbanization. If the nomadic pastoralists' sustainable way of life changes to sedentary farming the tragedy of the commons will become real-unless some adjustment is made (CSA, 1996)

2.7.4 Lack of seed and planting materials

The absence of quantity and quality seed and seedling production limits the vast expansion of improved pasture and forage development (especially around the dairy farming and fattening areas).

2.7.5 Soil fertility

The annual food and livestock feed deficit of the country is attributed directly to soil erosion and nutrient export. About half of the highlands are vulnerable to water erosion and the remainder has been cultivated without conservation measures for thousands of years.

2.8. Opportunities of forage crop production

Ethiopia has an immense ecological diversity and a huge wealth of biological resources. , great variations in indigenous fodder, feed and forage resources. The complex topography coupled with environmental heterogeneity offers suitable environments for a wide range of life forms, like variety of pasture species of herbaceous legumes, browse pasture species of herbaceous legumes, browse(Alemayehu, M., 2006.) Proper management and utilization of these resources is important to improve livestock production and productivity.

2.8.1 Biodiversity Conservation

Nowadays, due bush encroachments and cultivation of previously not suitable areas for crop production, diversity loss is becoming common. Conservation and use of indigenous feed resources germ plasm has made a significant contribution to the economic development of the country through the national pasture and forage research program The International Livestock Research Institute ILRI (ILCA) has done much to fill the gap by collecting grasses and legumes from different parts of Ethiopia and by acquiring access to world collections of forage grass germ plasma (ILCA,1991).

Currently over 371 accessions of grasses from 77 species and 37 genera, 2076 accession of legumes from 140 species and 35 genera and 185 accession of browse from 41 species 18 genera are collected and conserved (IBCR/E, 2001). This gives a great room for the development of various forage varieties adaptable to different agro-ecological zones of the country.

2.8.2 Pasture and Forage Seed Production

Many of the temperate and tropical pasture and forage crops that have been tested and grown in Ethiopia have no problem of flowering and setting seed. This forces the country to establish local seed production in the existing farming system. Seed production systems adopted in the country are farmer contract seed production system, seed production on ranches, seed production on specialized plots and opportunistic seed production (Alemayehu M., 1985). Of the seeds produced: Vetch, Lablab, Cowpea, Siratro, Stylos, Desmodium, Oats, Rhodes, Panicum, Tree-Lucerne, Leucaena and Sesbania are dominant. Large local seed production is under way using farmers' contract (Alemayehu, M., 2002)

2.8.3 Better Grazing Land Resource Management

At every point of resource management, community knowledge and participation, from the beginning to the end through evaluation and monitoring is vital. Ethiopia's farming people have traditional laws which govern the community, adopted for thousands of years. The presence of traditional community rules provides an opportunity in the management of the grazing and other land resources and the current government policies encourage people participation and community participation from project conception through planning and implementation to monitoring and evaluation undertaken the program (Alemayehu M., 2006.)

2.8.4 Improving Poor Quality Roughages

Livestock in tropical environments will have to eat feeds that contain a lot of fiber during most parts of the year. The bulky and fibrous nature of coarse feeds results in poor nutrient supply and reduced intake. Such feeds have to remain in the rumen/stomach for extended periods of time before they are sufficiently digested to move out of the rumen/stomach and allow more feed consumption. It is common for animals to lose weight and conditions produce less and even have difficulty breeding when fed on these low quality roughages. One approach to improving the feeding value of poor quality roughages is through treatment of roughages, either physically or chemically, is aimed at rendering the structural constituents more accessible to microbial digestive enzymes in the rumen (Alemu Y., 2009)

2.9. Chemical Composition and Digestibility of Improved Species

2.9.1. Chemical composition of improved forages

The chemical composition of improved forages like pigeon pea, Sesbania and Desmodium in Bako and Nekemte urban and Peri-urban areas studied by Driba (2014) the DM ranged between 90.7% to 94.2%. The ash content ranged between5.1% to 6.3%. The range concentrations of NDF content were from 46.8% to 60.3%. The ADF content ranges from 32.9% to 41.2%. The crude protein (CP) content varied from 22.9% to 24.2%. Another study indicated that desho grass, Sesbania and elephant grass the values of ash were ranging from 3.42 % to 5.25% in the rural area. The concentration of the fiber content NDF ranges from 44.11% to 66.19%, ADF from 24.04% to 30.83% .While the CP content of the improved forages were ranging from 11.6% to 16.14% reported by Nigatu, (2016) in Wolaita zone Sodo town.

For Rhodes grass as the nutritive value declines after flowering, it is important to maintain the plant in a leafy condition by regular defoliation. Crude protein content vary with age of material and level of available nitrogen and may range from 17% on a dry matter (DM) basis in very young leaf, to 3% in old leaves. Other sources report that crude protein content of Rhodes grass range from 4 - 13 % of dry matter. Crude protein content decrease as the grass matures and becomes steamy. To avoid over-maturity regular cutting or grazing should be practiced and over-mature pasture should be slashed or burned (Yenesew *et al*., 2015).

2.9.2. Factors affecting chemical composition of improved forages

2.9.2.1. Species and genotype

Legumes generally have a higher quality than grasses. Legumes have higher CP concentrations and a higher intake by livestock due to a higher percentage of rapidly digestible leaves.

However, the total digestible nitrogen concentrations of legumes and cool-season grasses are similar because legumes typically have more poorly digested lignin than grasses. However, there is much variation in forage quality within and among grass genera (Adesogan *et al*., 2015).

2.9.2.2. Stage of maturity

Maturity is the most important factor affecting forage quality. Forage-regrowth stage is determined by the number of days between harvests for hay and by the rest period in rotational grazing. Forage quality begins to decline during the regrowth period due to the accumulation of stems and deposition of poorly digested lignin in both leaves and stems. Therefore, forage quality generally declines with increasing length of the interval between harvests of stored forages or with longer rest periods in rotational grazing. Maturity of legumes and cool-season grasses can be assessed by determining the reproductive stage of growth. For warm-season grasses, however, weeks of regrowth are a better indicator of maturity because flowering may begin shortly after regrowth begins (Adesogan *et al*., 2015).

Maturity stage at harvest is the most important factor determining forage quality of a given species. Forage quality declines with advancing maturity. For example, cool season grasses often have dry matter (DM) digestibility's above 80% during the first 2 to 3 weeks after growth initiation in spring.

2.9.2.3. Season of the year

Seasonal effects on forage quality have been noted in grazing forage regrowth intervals were kept constant. Gains of grazing cattle have been less during the summer than in spring and fall, and this problem is called the "summer slump." The summer slump was dramatic with Bahia grass, but not apparent with elephant grass, even though similar cattle grazed adjacent paddocks of the two grasses. Summer regrowth may have lower quality because high temperature increases lignin deposition, and high rainfall increases growth rates and maturation of the forage (Adesogan *et al*., 2015).

2.9.3. Digestibility of improved forages

The *invitro* dry matter digestibility (IVDMD)) of improved forages ranged from 65.5% to 69.3% during the dry season in Bako and Nekemte urban and peri-urban areas studied by (Driba, 2014). The invitro dry matter digestibility that studied by Nigatu (2016) in the rural area were ranging from 62.4% to 70.69% during the dry season. The in vitro dry matter digestibility varies from 40-80% (Cook *et al*., 2005). Other sources report that digestibility of Rhodes grass range from 40-60% of dry matter, respectively. Young growth is very palatable, but after the plants have seeded they are less attractive and digestibility decrease as the grass matures and becomes steamy. To avoid over-maturity regular cutting or grazing should be practiced and over-mature pasture should be slashed or burned (Yenesew *et al*., 2015).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

Damot Gale is located in Wolaita zone south Nations, Nationalities, and Peoples' Region (SNNPR) of Ethiopia within the coordinate of 6° 53′ 0" and 7° 6′ 30" N and 37° 46′ 0" and 37° 58′ 40" E and an altitude range of 1482 – 2964 m.a.s.l. in East Rift valley at a distance of 370 km to the south of Addis Ababa and at about 140 km to the West of Hawassa, the capital city of (SNNPR) . consists of 27 rural and 1 urban Kebeles. Has an area of 410.1 km^2 with 151,079 (CSA, 2017) human populations. Annual rainfall in the area ranges from 700 mm to 1400 mm with minimum and maximum temperature of 12°c and 24°c respectively.

has three agro ecologies namely high land (26%), mid land (40.7%) and lowland (33.3%).Damot Gale is bordered on the southwest by Sodo Zuria, on the northwest by Boloso Sore and Damot Pulasa. the north by the Hadiya Zone, in the east by Diguna Fango, and in the south east by Damot Weyde.

The agricultural production and land use system dominantly mixed crop-livestock farming system.

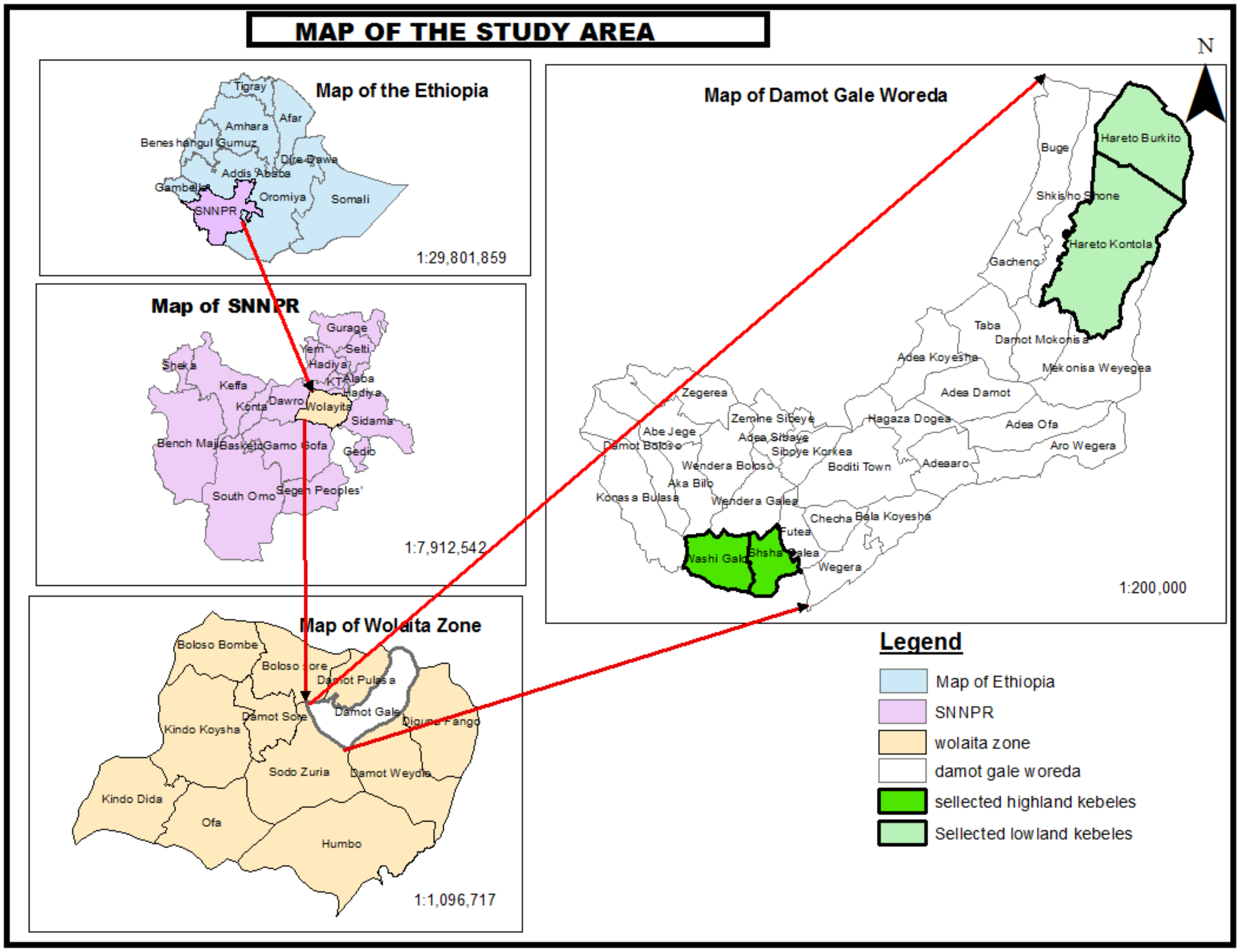

Figure 1: Map of the study area

3.2. Farming system

3.2.1 Crop Production

Crop production is an important component of the farming system and in the study area is mainly based on rain-fed crop production and livestock rearing. The area receives bimodal rainfall pattern with two rainy and cropping seasons that occurs between April and October. Maximum rainfall is received from June to August. The crops grown by the farmers are used both for household consumption and as sources of cash income. Coffee, fruits, spices such as garlic, onion are mostly grown for sale to generate cash income for the family whereas the other crops root tubers, potato ,sweet potato taro, enset, maize, barley, teff, wheat, chick pea, bean and haricot bean) are grown largely to satisfy the food consumption needs of the families.

The major feed resources for livestock in the area are natural pasture, crop residues (wheat straw, barley straw, maize Stover and *teff* straw) and some improved forages desho, elephant, Guatemala, Rhoades, oat, pigeon pea, Sesbania, cowpea, lablab Desmodium and vetch. The main crops produced in the *belg* season are maize (*Zea mays*), sorghum (*sorghumvulgare*) and chick pea. Similarly, in *summer* the main crops are teff *(Eragrostis teff)*, barley, wheat, pea and bean. The main crops in both season were haricot bean (*Phaseolus vulgaris*), potato, sweet potato, enset (*Ensete ventricosum*), vegetables, fruits, sugar cane, coffee (*Coffee arabica*) and chat (*Catha edulis)* are also important cash crops in the district (BoARD, 2018).

3. 2.2 Livestock Production

Livestock production is an important source of income and means of livelihood in the study area. Livestock are kept for various purposes including production of replacement stock, source of food for the family (mainly milk production and milk byproducts), draught power, transport, income generation (sale of products and live animals), soil compaction for planting small cereal crops and manure production for soil fertility management. They are the drivers of crop production mainly as sources of draught power and provision of manure for soil fertility restoration. According to BoLFR (2018), the district is estimated to have 96,346 heads of cattle, 19,982 sheep, 18,418 goats, 4,628 donkeys, 567 horses, 1,290 mules, 62,891 of chicken and 3,773 bee colonies.

3. 3 Land Use Pattern

The total land area of Damot Gale district is 22, 482.391ha. of these 14,321.877ha is suitable for agriculture. Land use data of the district shows 39.57% arable land, 10.13% grazing land, 24% forest, 18.8% potentially cultivated and 7.5% include others like rivers, inaccessible lands and gorges. The majority of the district population is dependent on agriculture.

3.5. The study method

The study comprised of survey work and laboratory analysis, The survey part included on socio-economic characteristics of the respondents, livestock feed resource, cultivated improved forage production, adoption, dissemination, and farmer's practices. The laboratory analysis focused on determination of the chemical composition and *in vitro* digestibility of improved forages used in the study area.

3.5.1. Sampling techniques and sample size for the survey study

The study kebeles were purposely selected based on their improved forage production potential and agro ecological representation of highland and lowland. The study was conducted on selected highland and lowland areas of the study district. Four kebeles were selected from the District. Two kebeles were selected from high land and the rest two kebeles represent the lowland of the study kebeles. A total sample size of 133 households data were collected from the four kebeles of the district. From the Lists of forage growing farmers in each of the selected kebeles which obtained from District livestock and fishery offices the households (respondents) were selected randomly. To determine the sample size of the study area, the formula adopted by Yamane (1967) was used. The formulas of sample size determination were both purposive and random sampling technique was used to select, owing livestock.

The formula given as, $n=\frac{N}{1+N(e)2}$

Where n= is the sample size

N= total population size

e= the acceptable sample error (7%) (0.07), $n=380/1+307(0.07)^2=133$

Out of the total population from the study area, 133 households that produce/cultivated improved forage and utilization were selected proportional sampling accordingly. From the highland agro ecological zone 69 respondents were selected. Woshe gale kebele 38 and Shasha galae 31. Likewise, 64 respondents were selected from the lowland agro ecological zone Harto burkito 34 and Harto kontola 30 were the improved forage producer farmers selected randomly from the study Kebeles based on the population of the kebeles.

Table: The name of improved forage producer sample kebeles from the study districts

Name of kebeles	Agroecolgy	No of improved forage producer farmers	No of improved forage producer sampled farmers
Woshe gale	Highland	108	38
Shasha galae	Highland	89	31
Harto burkito	Lowland	96	34
Harto kontola	Lowland	87	30
Total		380	133

3.6. Methods of Data Collection and Sources of Data

To collect data, structured questionnaires were developed and pre-tested for consistency and applicability of the objectives of the study. Both qualitative and quantitative data were collected from primary and secondary sources. Primary data were collected through household survey and personal on field observation (from highland and low land improved forage producer households) and key informant interviews that had better knowledge and skill on improved forage production and utilization. Secondary data were collected from district office of agriculture livestock types and population number, economic contribution, data on climate, agro-ecology, effect of improved forage production on livestock productivity and other related information were collected from Bureau of Livestock’s and Fishery Resources. Related information was also gathered from research reports, books, internet sources, government publications and journals.

3.6.1. Questionnaire survey

The questionnaire was used to collect primary data from selected respondents. The questionnaires were edited for its validity, consistency and clarity based on a pre-test result. The following data were collected through the questionnaire socio- economic characteristics of household's livestock species, purpose of keeping livestock, feed resources, livestock production constraint, were addressed in the questionnaire (Appendix IV). The survey was conducted by the researcher and well trained enumerators (development agents) of the respective kebeles.

3.6.2. Key informant interview

Key informant interview was conducted to gather relevant information from those who were knowledgeable and have better experience in the subject. They were youngsters, women, village leaders, socially respected individuals, DAs, expected elders and model farmers.

3.7. Evaluation on Nutritive Value of Major Improved Forages.

3.7.1. Chemical composition of improved forages

Improved forage crop types were collected from individual sampled farmers to determine Chemical composition and invtro-digestiblity. Improved Forage produced abundantly and used as feed in the study area were collected and sampled for study. Grasses, legumes and browses were collected from those farmers who have already planted forages like Elephant grass Desho grass, Guatemala grass Sesbania, Oats, Desmodium, Rhodes grass, Pigeon pea ,lablab, Cowpea and uses it as livestock feed.

Based on the survey results representative samples of feed resources that were commonly used by high land and low land farmer which are available in production seasons were collected randomly from both locations in one season (April to May) in the same stage of growth.

In the beginning the feed samples from sampling field sites were taken from quadrants placed and demarked across four corners and one center to put the quadrant throwing the specified size 1m by 1m of quadrant into the proposed area, was completely cut at ground level by sickle (manually) and Mix those samples well that were collected from different sites in order to make homogenous and half the sample into two equal parts to take representative sample.

Legumes and browses the sample systematically sampling procedures into 2 sub samples were taken from the upper, middle strata for each browse species. (leaf, steam,) were taken 6-8 improved forage species per plot, from individually randomly selected farmers The harvested samples were mixed thoroughly and 1/3 of it taken then, air dried. Wet feed materials were allowed to lose moisture under shade after measuring initial weight before transportation. Finally 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) using ANKOM Fiber Analyzer 220 (ANKOM Technology 05/03, Macedon, NY USA) and F57, ANKOM filter bags).

3.7.2. In vitro dry matter digestibility

The in-vitro digestibility of improved forages was estimated using a Daisy ^{II} Incubator based on the modified two stages *in vitro* Tilley and Terry procedure (1963) as modified by Van Soest and Robertson (1985). The dried and ground (1mm) sample of improved forages was placed in filter bags (F57) made from polyester/ polyethylene extruded filaments (50 x 55mm exterior size). The rumen fluid was taken before the morning feed (before feeding the diet supplement). Not more than 15 minutes before the trial starts, one liter rumen fluid was collected by using a rumen stomach tube in equal proportions from two donor sheep under the same feeding regime offered natural grass hay at Hawassa University. The sample was filtered through two layers of cheese cloth into a warm flask (kept in a bucket of water at 38°C) and flushed with carbon dioxide (Osuji *et al*., 1993).

According to Ankom technology procedures, 0.50 g of sample per bag was weighed. The bags (2 jars x 2 replications) were then incubated in an incubation jar in buffered ruminal fluid for 48hr. After incubation, the jars were drained and the bags rinsed thoroughly with cold tap water. The bags with residues were boiled for 75minutes in neutral detergent solution (in an Ankom$^{200/220}$ apparatus). After the solution was removed, 2 liters of hot (90°C-100°C) H_2O and 4.0 ml of α-amylase were used in the first and second rinses of bags. The bags were then oven dried and weighed immediately after the samples were allowed to cool at room temperature.

3.8. Statistical Analysis

Socio-economic data were analyzed using descriptive statistics such as mean, and percentages. The data was analyzed using Statistical Package for Social Science (SPSS, 2007, version 20). Other Qualitative data was analyzed using non parametric test chi-square, t- test. Indexes were calculated to provide ranking differences between the two agro ecologies as the follows:

Index = Σ (Rn × C1 + Rn-1 × C2 ... + R1 × Cn)/Σ (Rn × C1 + Rn-1× C2 + ... + R1 × Cn)

Rn = the last rank (example if the last rank is 5$^{\text{th}}$, then Rn = 5, Rn-1 = 4, R1 = 1).

C1 = the number of respondents ranked first

Cn = the number of respondents in the last rank, for all as (Endashaw *et al.,* 2012).The effect of agro-ecology and feed resources on the chemical composition of feeds was analyzed using the General Linear Model procedure of the statistical analysis system (SAS, 2002).When F-tests declared statistical differences means were separated using Tukey's test at $p<0.05$. The model used was:

$$Yijk = \mu + Ai + Bj + (AB)\ ij + Eijk$$

Where, Yijk = the chemical content obtained from sample feed/ or other dependent variables

μ= overall mean

Ai= agro-ecology effect (highland and lowland)

Bj= forage species resource effect

(AB) ij=the interaction effect of j^{th}feed and i^{th} agro-ecology

Eijk= random error.

4. RESULTS

4.1. Socio Economic Characteristics of the Households

Socio economic characteristics of the households of the study area were indicated in Table1. Household size is directly related to the supply and demand of basic human needs, such as food, shelter, health and educational facilities, which in turn directly or indirectly influence the production and adoption of improved forages.

4.1.1 Household demographic characteristics

4.1.2 Sex and age of the respondents

The majority of the respondents in the study area were male headed (Table 1). The proportions of male headed households are greater in the highland than lowland. However, statistically there was no significance difference $p>0.05$ between the two. Aerecological zone

The average age of the respondents ranged from 31-45 years across agro ecological zones (Table1).The mean value (Mean±SE) of age of respondents in the highland was lower than lowland. How ever there was no significant difference between highland and lowland AEZs.

Table 1: Sex and Age of the respondents in the study area

Variables	Agro –ecology						Pvalue
	Highland(N=69)		Low land(N=64)		Overall(N=133)		
Sex of household	N	(%)	N	(%)	N	(%)	
Male	52	73.90	47	75	99	74.45	0.049
Female	17	25.0	17	26.57	32	25.54	
Age of household	N	(%)	N	(%)	N (%)	(%)	
20-30	9	13.04	9	14.06	18	13.55	0.49
31-45	30	43.48	32	50	62	46.72	
46-60	24	34.78	18	28.1	42	31.44	
>61	6	8.70	5	7.80	11	8.25	
Average mean of age(Mean ±SE)	48.41±1.28		48.81±1.19		48.61±1.24		

N=Number of respondents, SE=Standard error

Family size and educational level of the respondents

The mean value (Mean±SE) of family size per household in the highland was greater ($P<0.05$) than in the lowland. This is due to high population density in the highland Aerecological zone than low land. Illiteracy level of the households was higher in lowland than in the highland. The primary level of the respondents in the lowland was lower than highland Aerecological zone (Table 2). This could be due to less access to learning institutions in the lowland than highland.

Table 2: Family size and educational level of the respondents in the study area

Variables	Agro –ecology	P value

	Highland(N=69)		Low land(N=64)		Overall(N=133)		
Family size in number	N	%	N	%	N	%	
1-5	5	7.24	4	6.25	9	6.74	0.02
6-8	35	50.72	19	29.68	54	40.20	0.05
9-10	27	39.13	39	60.93	66	50.03	0.01
11-14	2	2.89	2	3.12	4	3.07	0.05
Family size(Mean ±SE)	8.05±0.29		6.95±0.26		7.50±0.27		0.01
Educational status	N	%	N	%	N	%	
Illiteracy	11	15.94	24	37.50	35	26.72	0.04
Literacy	13	18.84	16	25	29	21.92	0.07
Primary	11	15.94	10	17.18	22	16.56	0.01
Junior	12	17.39	6	9.37	18	13.38	0.02
Secondary	12	17.39	5	6.25	16	11.82	0.06
Preparatory	5	7.24	1	1.56	6	4.40	0.05
Diploma and above	5	7.24	2	3.12	7	5.18	0.07

N=Number of respondents, significance P<0.05 SE=Standard error

4.1.3. Land holding and land use patterns

Land is one of the most important resources required for successful implementation of any agricultural farming activities. About 65.6%-78.2% of the households own land size of 0.6-1in the highland and lowland respectively. On the other hand, some households in the highland15.9% and lowland 17.1%owned 0.6 -1.0ha; relatively.

Fewer households (2.89%) in highland and (9.37%) in the lowland has own b/n 1.1-2 ha (Table 3). The overall results showed that most of the households (71.9%) possess land below 0.5ha. Only about 5.35% of the households have total land in the range of greater than 2.1ha and there was significance difference $P< 0.05$ in land holding between the two agro-ecologies. This might be due to the increasing population pressure in the study area which has created serious shortage of crop and forage as well as grazing land.

Table 3: Land holding of the Respondents in the study area

Land holding interval in ha	Agro-ecology						
	Highland(N=69)		Lowland(N=64)		Overall(N=133)		P value
	N	%	N	%	N	%	
0.0-0.5	11	.15.94	11	17.18	22	16.56	0.06
0.6-1	54	65.62	42	78.26	96	71.94	0.01
1.1-2	2	2.89	6	9.37	8	6.13	0.02
>2.1	2	2.89	5	7.81	7	5.35	0.04

N=Number of respondents, %=Percent, Significant difference $p<0.05$.

4.1.4. Land utilization per households in the study area

The overall mean crop land, forage land, grazing /Pastureland, and fallow land holding per households in the study area are presented in Table 4. The mean land holding per HH in highland was lower as compared to lowland production systems.

Table 4: Mean ±**SE** of land use Pattern (in ha) in the study area

Land utilization	High land(N=69)	Low land (N =64)	Overall(N=133)
	Mean ± SE	Mean ±SE	Mean ±SE
Crop land	0.37±0.04 [b]	0.43±0.04 [a]	0.37±0.24
Grazing/Pasture land	0.31±0.02	0.37±0.02	0.34±0.01
Forage crop land	0.07±0.01[b]	0.11±0.01[a]	0.09±0.01
Fallow land	0.06±0.02	0.09±0.02	0.07±0.01
Overall land holding	0.81±0.09 [b]	1.00±0.09 [a]	0.87±0.27

[a,b.]means with different superscript letters in the same raw are significantly different at (P<0.05)

N=Number of respondents, SE=Standard error

4.1.5. Livestock holding and herd composition

As in most mixed crop livestock systems, in all the study areas livestock are important components of the farming system. Cattle, sheep, goats, equines and chicken are livestock species dominantly found in the area. These animal species provide multiple benefits to the farming community as a source of food, income, power and manure. There is high interaction between the two components of the system as animals offer power for land preparation, ploughing and fertilization and the cropping system offers feed to animals in the form of crop residues and aftermath.

As indicated in Table 5, the total livestock holding per household in the study area was found to be higher in the lowland areas (6.64±2.00 TLU) than in the highland areas (4.35±0.58TLU). This may be due to the presence of the relatively larger forage land and private grazing land which is suitable for livestock production. Cattle are the dominant species (2.03 ± 0.28) in the study area and were followed by goats (1.36 ± 0.77), sheep (0.93 ± 0.1), equines (1.12±0.13) and poultry (0.04±0.005) in that order. There were significant differences $p<0.05$ between the two AEZs in livestock holding except for chickens. The average goats holding in the highland was no herd composition than that of low land and most of them are of indigenous types.

Table 5: Means livestock holding (TLU) in the study area

Livestock species	Highland (N=69)	Lowland(N=64)	Overall (N=133)
	Mean ± SE	Mean ± SE	Mean ±SE
Local cows	1.88 ±0.12	1.84±0.12	1.86±0.12
Heifer	0.30 ±0.05 [a]	0.21±0.05 [b]	0.26±0.05
Calves	0.18±0.02	0.18±0.02	0.18±0.02
Oxen	0.29±0.09 [b]	0.35±0.09 [a]	0.32±0.09
Young bulls	0.16±0.04 [a]	0.10±0.04 [b]	0.13±0.04
Cross bred cows	0.24±0.08 [a]	0.06±0.08 [b]	0.15±0.08
Overall Cattles	3.05±0.40 [a]	2.74±0.40 [b]	2.89±0.40
Sheep	1.55±0.06 [a]	0.31±0.06 [b]	0.93±0.10
Goats	0.12±0.03 [b]	2.73±0.00 [a]	1.36±0.77
Small Ruminants	1.55±0.06	3.04±0.06	2.29±0.87
Donkeys	0.06±0.04 [b]	0.15±0.04 [a]	0.51±0.06
Horses	0.07±0.03 [a]	0.00±0.03 [b]	0.50±0.03
Mules	0.07±0.02 [a]	0.00±0.02 [b]	0.10±0.03
Overall equines	0.20±0.09 [a]	0.15±0.09 [b]	1.55±0.17
Chicken	0.05±0.05	0.04±0.05	0.04±0.05
Overall livestock	4.85±0.60 [b]	5.97±0.60 [a]	6.77±1.49

[a.b.] means with different superscript letters in the same raw are significantly P<0.05 different; TLU=Total livestock Unit=Number; SE= standard error.

4.2 Purpose of keeping Livestock

4.2.1. Purpose of keeping cattle and chicken in the study area

The survey indicated that the respondents have kept cattle for different purposes. These were for draft power, cash income, skin production, meat production, milk production, milk products (butter, ergo, local cheese (*ayib*) and butter milk (*arera*)), manure, credit, insurance, gifts and saving purpose. In both agro-ecologies the purpose of cattle rearing were the same but the index values were different. In highland agro-ecology the respondents ranked the importance of cattle production for milk production, meat products and cash income from first to third respectively, similarly; in the same way as in lowland the importance was ranked as milk, milk products and cash income first, second and third respectively with but different index values (Table 6).

Poultry production is one of the important agricultural subsectors for rural and urban communities as sources of immediate cash income, egg and meat consumption. In both agro-ecologies the purpose of chicken rearing were the same but the index values were different. The result indicated that the respondents keep their chicken production for different purposes. In highland agro-ecology the importance of chicken were ranked as egg consumption first, cash income second and meat consumption third. Correspondingly, in the same way as in low land the importance was ranked as egg, cash income and meat first, second and third respectively, but with different index values (Table 6).

Table 6: The purpose of keeping cattle and chicken in the study area

Purpose of Cattle	Highland(N=69)		Lowland(N=64)		Purpose of chicken	high land(N=69)		Low land(N=64)	
	Index	Rank	Index	Rank		Index	Rank	Index	Rank
Cash income	0.47	1st	0.45	1st	Egg	0.49	1st	0.50	1st
Draft power	0.30	2nd	0.31	2nd	Cash income	0.29	2nd	0.29	2nd
Meat	0.23	3rd	0.24	3rd	Meat	0.22	3rd	0.21	3rd

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

4.2.2. Purpose of keeping sheep and goats in the study area

As shown in Table 7, the respondents have kept their sheep production for different purposes. These were cash income, meat, manure, wool/fiber and saving. In both agro-ecologies the purposes of sheep rearing were similar but the index values are different. In highland agro-ecology the respondents ranked the importance of sheep production for cash income, meat and saving, from first to third, respectively: similarly in low land the importance was ranked as cash income, meat and saving as first, second and third respectively but with different index values.

The survey indicated that the respondents have kept their goats for different purposes. These were cash (sale income), meat, manure and saving. In both agro-ecologies the purpose of goats rearing were the same but the index values are different. In high land agro-ecology the respondents ranked the importance of goat production for sale income, meat and saving, from first to third, respectively: similarly in low land the importance was ranked as sale income, meat and saving as first, second and third, respectively but with different index values (Table7).

Table 7. Purpose of Keeping Sheep and Goats and their importance in the study area.

Purpose of Sheep	Highland(N=69)		Low land(N=64)		Purpose of Goats	Highland(N=69)		Lowland(N=64)	
	Index	Rank	Index	Rank		Index	Rank	Index	Rank
Sale for income	0.43	1st	0.43	1st	Sale for income	0.42	1st	0.39	1st
Meat	0.36	2nd	0.33	2nd	Meat	0.37	2nd	0.36	2nd
Saving	0.21	3rd	0.24	3rd	Milk	0.21	3rd	0.25	3rd

4.3. The Major Farming Activities in the study area

From the focus group discussion, the major farming activities in the study area were crop and livestock production. The dominant crops were maize, bean haricot bean, barely, wheat teff, root tuber crops and there were tradition of intercropping maize with haricot bean & faba bean. The major crops planted in the main rainy season were maize, sorghum, haricot bean cassava and, taro. In the short rainy season teff, barley, wheat, bean and haricot bean were well cultivated. The livestock production was the second activity in the study area. The livestock production system was more of partial grazing type. During the cropping season cattle, small ruminants and equines were kept in the back yards in a fenced /tethered compound.

4.4. Livestock Feed Resources

The major livestock feed resources in dry and wet periods are presented in Table 8. Overall, the most important feed resources to livestock in the study areas were found to be crop residues, natural pasture, hay, stubble grazing (crop aftermath), browse trees, green grasses, hay and improved forages.

4.4.1. Dry and wet season feeds

The study areas receive bimodal rainfall with the main rainy season from mid-June to early September. There could be also splash rain in the Belg (February to April), which is less in amount. During the dry period of the year the major livestock feed resources in the study both areas were ranked as natural pasture, crop residue and improved forages in order of importance in the high land and in the low land (Table 8). It was also showed that in the wet period of the year major livestock feed resources were ranked as natural pasture, crop residue and improved forages respectively in both agro ecologies. In the wet season because of the need to keep livestock out of the croplands, tethered grazing or cut and carry system of feeding are practiced. Likewise, the utilization of improved forage plants as animal feed was poor in both agro-ecologies. Relatively better feed is available during the wet season (July to September). During this period animals gain body weight and body condition duetothe improved feed supply. But later on the long dry period proceed the body weight of the animals reduce gradually.

Table 8: The major feed resources during the dry and wet season in the study area

Feed type in the dry season	high land(N=69)		Low land(N=64)		Feed type in the wet season	high land(N=69)		Lowland(N=64)	
	Index	Rank	Index	Rank		Index	Rank	Index	Rank
Crop residue	0.40	1st	0.38	1st	crop residue	0.39	1st	0.40	1st
Natural pasture	0.33	2nd	0.37	2nd	Natural pasture	0.32	2nd	0.34	2nd
Improved forages	0.27	3rd	0.25	3rd	Improved forages	0.29	3rd	0.26	3rd

4.5. Livestock Production Constraints

In the study area the livestock production constraints were water shortage, poor genetic makeup, poor management, feed shortage, shortage of cash, poor infrastructure, disease and parasites, predator, poor extension services, lack of improved technologies and market fluctuation for livestock and livestock products. The major livestock constraints in the highland were as well as in the lowland ranked as feed shortage, water shortage, and poor genetic makeup of the local animal from first to third order.

Table 9: Livestock Production Constraints in the study area

Constraints	High land(N=69)		Low land(N=64)	
	Index	Rank	Index	Rank
Poor genetic makeup	0.39	1st	0.19	3rd
Feed shortage	0.32	2nd	0.36	2nd
Water shortage	0.29	3rd	0.45.	1st

4.6. Grazing Land Utilization

The grazing feed supply in the study area is ever reducing due to increment of human population for the purpose of crop cultivation and settlement. As indicated in Table 10, there was higher utilization of communal grazing land as source of animal feed in the lowland than in the highland. However, statistically there was no significance difference of grazing utilization between the two agro-ecologies at ($p>0.05$) (Table 10).

Table 10: Grazing land utilization in the study area

Types of grazing land	High land (N=69)		Lowland(N=64)		Overall (N=133)		Pvalue
	N	%	N	%	N	%	
Private grazing	18	24.08	14	20.3	32	22.19	0.42
Communal grazing	40	58.72	42	68.2	41	63.46	0.21
Road side grazing	11	17.2	8	11.5	19	14.35	0.41

%=Percent, N=Number of respondents, significance difference $p<0.05$

4.7. Coping Mechanism of Feed Shortage

In the study area, seasonal variations in feed quantity and quality was the main restriction to animal production and cause fluctuation in productivity throughout the year, particularly in the dry seasons during which feed was scarce and poor in nutritive value. Among the many factors that contributed to the low production and productivity of livestock in highland and lowland was feed shortage.

In high land agro-ecology when there was feed scarcity, the measures taken by respondents to alleviate feed shortage were use of crop residues, preserve any feed during time of abundance, area enclosures, sale of livestock and purchase of forage, being ranked as first, second, third, fourth and fifth solution, respectively. In low land areas the measures taken to alleviate feed shortage as use of crop residues, preserve any feed during high abundance, area enclosures, purchase forage and sale of livestock first, second, third, fourth and fifth respectively (Table 11).

Table 11: Coping Mechanism for shortage of feed in the study area

Intervention mechanism	highland(N=69)		Lowland(N=64)		Overall(N=133)		Pvalue
	N	%	N	%	N	%	
Purchase forage	6	5.70	10	14.48	14	10.09	0.02
Use of crop residues	31	49.56	35	57.78	63	53.67	0.01
Preserve any feed during time of abundance	12	21.74	13	18.84	28	20.29	0.05
Area enclosures	11	13.01	4	5.78	13	9.39	0.03
Sale of Livestock	9	10.00	2	3.12	9	6.56	0.1

%=Percent, N= Number of respondents, Significance $p< 0.05$

4.8. Improved Forage Production

Improved forages production in the study area includes elephant grass (*Pennisetum purpureum*), desho grass (*Pennisetum pedicellatum*), Guatemala grass (*Tripsacum andersonii*), Rhodase grass(*Chloris gayana*) ,pigeon pea (*Cajanus cajan*). While the most preferable improved forage crops production by the respondents (Figure 2) both in the high land and lowland are ranked as elephant grass, desho grass and Guatemala grass were ranked. (Table 12)

Table 12: Cultivated Improved Forages grass production ranked by the respondents in the study area

Cultivated forage grass species	High land(N=69)		Low land(N=64)	
	Index	Rank	Index	Rank
Elephant grass(*Pennisetum purpureum*)	0.40	1st	0.41	1st
Desho grass (*Pennisetum pedicellatum*)	0.38	2nd	0.30	2nd
Guatemala grass(*Tripsacum andersonii)*	0.22	3rd	0.29	3rd

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

Elephant grass Desho grass Guatemala grass

Figure 2: Stands of elephant grass, desho grass and Guatemala grass in the study area.

4.9. Forage Development Strategies

The overall survey result showed that the most widely used forage development strategies are back yard/homestead followed by alley cropping and forage pilots/land, livestock exclusion area, inter cropping and over sowing. Moreover, between the two Agro ecological zones in selection of suitable forage development strategies in the study areas. With regard to forage land development, highland areas were slightly lower than lowland agro-ecology (Table 13).

Table 13: strategies of forage establishment in the study area

Forage establishment method	Agro-ecology						
	Highland(N=69)		lowland(N=64)		Overall(N=133)		Pvalue
	N	%	N	%	N	%	
Back yard/homestead	23	33.30	10	16.60	33	24.90	0.47
Alley cropping and live fence	16	23.20	11	19.7	27	21.50	0.45
Forage land	22	31.90	8	11.35	30	21.60	0.32
inter cropping	3	4.30	2	3.80	5	4..05	0.72
Livestock exclusion areas	3	4.30	30	43.60	33	24.00	0.66
Over sowing	2	2.80	3	4.80	5	3.80	0.55

%=Percent, N= number of respondents, Not Significant difference p>0.05

4.10. Establishment Methods of Improved Forages

The overall survey result showed that the most widely used forage establishment method was cutting, followed by broad casting ,row seeding, seedling and. However, there were statistically no significance different at p<0.05 among the methods of establishment techniques in both agro ecologies (Table 14).

Table 14: Methods of Planting Improved Forages in the study area

Activities	High land(N=69)		Low land(N=64)		Overall(N=133)		Pvalue
	N	%	N	%	N	%	
Row seeding	19	27.50	10	17.30	29	22.40	0.58
Broad casting	6	8.50	28	44.20	34	26.50	0.57
Seedling	14	20.30	6	8.50	20	14.40	0.59
Cutting	30	43.50	20	30.30	50	36.90	0.05

%=Percent, N=Number of respondents, Not significance difference $p<0.05$

4.11. Purpose of Improved Forage Production

Improved forage cultivations have been carried out under the smallholder farmers for various purposes, Such as cash income, human food (pigeon pea).Based on the current study, forage plants were for the purpose of animal feed, hedge fence; soil and water conservation, honey bee flora and wind break (Table 15). The animals were supplemented with green forages during the long dry seasons. The overall averages mean on both two agro ecology was only 0.09% of the total land allocated for improved forage crop production. In view of the economic situation, it is unlikely that farmers will set aside land for pasture production. However, forages could be grown as hedges around field edges and on soil bund, particularly on the sloping land, intercropped with cereals and alley cropping is also a possibility.

Table 15: Purpose of Producing Improved Forages in the study area

Purpose improved forages	highland(N=69)		Lowland(N=64)		Overall(N=133)		P value
	N	%	N	%	N	%	
Livestock feed	57	82.90	55	86.41	112	84.65	0.04
Soil and water conservation	3	4.30	0	0	3	2.15	0.02
Honey bee flora	7	10.00	5	7.81	12	8.90	0.01
Wind break	0	0	4	5.78	4	2.89	0.03
Hedge fence	2	2.80	0	0	2	1.40	0.05

%=Percent, N= Number of respondents, Significance difference p<0.05

4.12. Availability of Feed Resources during Different Months of the Year

Seasonal feed availability and feeding calendar is shown in Table 16, 96.7% of the respondents said that feed is in short supply during December to May while 100% of the respondents said that very critical during the month of April to May. During this period all preserved crop residues were exhausted and grazing grasses also become extremely poor. The farmers strategies used to cope with the feed shortage in the months were supplementing livestock with any available dry crop residues and tree leaves.

The availability of feed resources varied in seasons with respect to quality, quantity and type of feeds (Table 16). Based on the reports of respondents, the availability of improved forages was dominant found from September to December with limited amount starting from May to August. The principal feed resources available to livestock both in the wet and dry seasons include crop residues (cereal and pulse crops), stubble grazing, natural pasture (both private and communal grazing lands), weeds/green grass and improved fodder crops mainly elephant grass, desho grass and Guatemala grass through cut and carry system.

Table 16: seasonal availability of improved forage and others used as major feed sources in the study area

Types forages	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Au
Elephant grass	X	X	X	X	-	-	-	-	*	*	*	*
Desho grass	X	X	X	X	-	-	-	-	-	*	*	*
Guatemala grass	X	X	X	X	-	-	-	-	-	*	*	*
Sesbania	X	X	X	X	-	-	-	-	-	-	*	*
Desmodium	X	X	X	X	-	-	-	-	-	-	*	*
Pigeon pea	X	X	X	X	-	-	-	-	-	-	*	*
Rhodes	X	X	X	X	-	-	-	-	-	-	X	X
Oat	X	X	X	X	-	-	-	-	-	-	X	X
Natural pasture	X	X	X	X	*	*	-	-	-	X	X	X
Maize strover	*	X	X	X	*	*	-	-	-	-	-	-
Teff straw	-	-	X	X	X	X	X	*	-	-	-	-
Enset leaves	X	X	*	*	*	*	*	*	-	-	-	-
Wheat straw	-	-	X	X	X	X	X	-	-	-	-	-
Barely straw	-	-	X	X	X	X	X	-	-	-	-	-
Green grass	X	X	*	*	-	-	-	-	*	*	X	X
After math	-	X	X	X	X	X	*	*	-	-	-	-

X= the improved forages and others mentioned were available in the specified month/months, -UN =unavailable,*=limited availably

4.13. Challenges of Improved Forage Development and Utilization

The main challenges for cultivation of improved forages in the study area are shown in Table17. In the highland as well as in the lowland agro-ecology the main challenges were lack of land, lack of forage seed and poor adaptation of improved forages which ranked first ,second, third, respectively.

Table 17: Main challenges of improved forage growing and utilization ranked by the respondent

Challenges	High land (N=69)		Low land (N=64)	
	Index	Rank	Index	Rank
Lack of land	50.20	1st	40.60	1st
Lack of forage seed	26.70	2nd	26.50	2nd
Poor adaptation of improved forages	14.20	3rd	20.40	3rd
Seasonal rain fall fluctuation	8.90	4rth	12.50	4rth

%=Percent, N= number of respondents, t-test, Not significance difference at ($p<0.05$)

4.14. Forage Seed Harvesting and Fodder Production

The result of this study showed that majority of the respondents cut the forage directly and feed their cattle without any post-harvest processing.. The most common harvested improved forage seeds were for Sesbania, pigeon pea, Rhodes, lablab cowpea and, Oat. (Figure4).

Table 18: Forage seed harvesting and fodder production in the study area

Harvest forage seed	highland N=(69)		Lowland N=(64)		Overall N=(133)		P value
	N	%	N	%	N	%	
Yes	30	43.50	59	92.2	89	67.80	0.059
No	39	56.50	5	7.80	44	32.10	
Total	69	100	64	100	133	100	

%=Percent, N= number of respondents, t-test, Not significance difference at ($p<0.05$)

Pigeon pea Cowpea Lablab

Rhodes Oat Sesbania

Figure 3. Some of the harvested improved forage seeds in the study area

4.15. Opportunities of Improved Forage Production and Development

According to the respondents report indicated in table 20, there are different opportunities for improved forage production and development, such as active extension services, training on forage production, management and utilization of forage crops. Among the other opportunities most of the respondents were selected extension services followed by Training and input supply as higher opportunity in highland agro-ecology. In lowland agro ecology the respondents were selected as higher input supply followed by extension services in the study area respectively.

Table 19: Opportunities for improved forage production and development

Activity	Agro-ecology						Pvalue
	high land(N=69)		Low land(N=64)		Overall(N=133)		
	N	%	N	%	N	%	
Training	33	47.80	20	31.20	53	39.5	0.32
Extension service	16	23.20	10	17.30	26	20.2	0.21
Inputs supply	13	18.01	28	37.70	41	27.8	0.35
Demonstration site	7	10	6	8.60	13	9.30	0.65

N=Number of respondents, NS= not significance at ($p<0.05$)

According to the responses of the households indicated that in (Table 20) the most adopted improved forage crops include desho grass, Guatemala grass, elephant grass Rhodes grass cow pea, lablab, vetch and oat. The dissemination and adoption of the improved forage crop practices have a critical role to maximize the productivity of cultivated forage adoption practices.

Table 20: Adoption of major improved forage crops in the study area

Major improved forage crop	Agro-ecology						
	High land(N=69)		Low land(N=64)		Overall(N=133)		Pvalue
	N	%	N	%	N	%	
Desho	19	27.5	12	20.3	31	25.8	0.57
Guatemala	15	21.7	10	17.2	25	19.5	
Elephant	13	18.8	19	31.3	32	26.0	0.58
Cowpea	0	0.00	16	25.0	16	12.5	0.65
Lablab	4	5.7	7	10.9	11	8.35	0.02
Vetch	7	10.5	0	0.00	7	5.25	0.03
Rhoades	3	4.30	0	0.00	3	2.15	0.05
Oat	8	11.59	0	0.00	8	5.8	

%=Percent, N= number of respondents, t-test, Not significance difference at ($p<0.05$)

The results show that in table 21 the dissemination of different forage crops vary across years and the highest demand was recorded for desho followed by Guatemala and elephant grass, the lowest request for seedlings belonging to oat pigeon pea and Sesbania. The current need for forage seed, cuttings/root splits is expected to continue as the demand for feed increases to support the growing market demand for livestock and livestock products. The highly fluctuating demand for seed of improved forage is indicative of the fact that the demand is coming from GOs and NGOs. However, true demand for forage seed will come when disseminated and sustained use of improved forage technology among livestock producers is realized.

Generally, improved forage seed activities have received little attention and the majority of forage crops have not been widely disseminated by farmers. Despite the many desirable characteristics of selected forages, they have not been disseminated to farmers because of critical seed shortage.

Table 21 Dissemination of major improved forage crop in the study area.

Major improved forage crop	Agro-ecology						
	Highland(N=69)		Lowland(N=64)		Overall(N=133)		Pvalue
	N	%	N	%	N	%	
Desho	23	33.30	20	31.30	43	32.30	0.36
Guatemala	16	23.20	16	23.20	32	46.40	0.56
Elephant	12	17.40	22	29.10	34	46.50	0.58
Oat	10	14.50	5	7.80	15	11.1	0.65
pigeon pea	5	7.20	3	4.30	8	5.75	0.08
Sesbania	3	4.30	3	4.30	6	4.30	0.06

N=Number of respondents, non-significance at ($p<0.05$)

Table22 shows the list of the organizations disseminating improved forage crops as reported by respondents planting materials of different forage crops are supplied requested by various stakeholders including higher institutions, research centers, private sectors, bureau of agriculture and rural development and non-governmental organizations (NGOs').

Amount of seeds and seedlings/root splits of different forage crops were distributed by the Extension service (Gov).

In order to support seed production farmers, private investors, government, NGOs and other partners need to play their share of responsibility in producing and supplying forage seeds (Alemayehu and Getnet, 2012).

Table 22: List of organizations disseminated improved forage crop the study area

	Agro ecology						
Name of organization	Highland(N=69)		Low land(N=64)		Overall (N=133)		P value
	N	%	N	%	N	%	
Extension service(Govt)	39	56.5	31	57.5	70	57	0.01
Ngos	18	26.1	22	29.1	40	27.6	0.35
Research center	12	17.4	11	13.4	23	15.4	0.59
Total	69	100	64	100	133	100	

%=Percent, N= number of respondents, Not significance difference at (p<0.05

4.16. The Effects of forage species and Agroecolgy on the Chemical Composition of improved forage

The effect of Improved forages Species, agro-ecology and chemical composition of major forage in the study district is shown in Table23.All the chemical Compositions analyzed varied significantly difference (P<0.05) among different forage species and Agroecolgy had shown except for Ash and ADL.

The ash content was the lowest for oat and the highest for cowpea. The ADL content was the highest for desho and the lowest for Sesbania. The results revealed that, Sesbania had higher CP and cowpea had lower DM & digestibility than Guatemala and Rhodes grasses .Desho grass had relative higher DM than Other grasses. There was none significance in chemical composition between the Ash and ADL content on different forage Species. There was a difference with regard to other chemical compositions. In the case of variables of the nutritive value of forage in the in-between rows, there was an interaction between Agroecolgy and forage species for dry matter and CP Contents.

The interaction of chemical composition on improved forages significantly difference ($P<0.05$) except DM and ADL. All the chemical composition across agro ecology were NDF, CP, IVDM Significantly difference ($P<0.05$) except DM, Ash, ADF and ADL. All the forage species of chemical compositions significantly difference ($P<0.05$) except ADL. The chemical composition of the improved forage samples and their descriptive statistics (over all mean, standard error (SE) and coefficient of variation (CV %)) were presented in (Table 23). The overall mean DM content of the samples was 95.39%. With values ranging from 94.98% for cowpea to 96.24% for Desmodium Variation in DM concentration among the forage species was not wide.

Where the ADF, NDF, CP and in vitro digestibility showed positive relationships significance difference ($P<0.05$) with the dry matter content, the rest Ash and ADL chemical contents showed negative relationship. On the other hand, the Sesbania forage species positively relate with high CP content and better digestibility. In addition, the result showed that the grass species (with high NDF and ADF) were the least digestible. NDF, ADF, CP content and IVDMD were higher nutritive value by both higher zones the rest ones lower on lower altitudinal zone. While. The DM content of Elephant grass (96.09%) was the highest in the grasses. Among the grass species, the ash content in (11.63%) was the highest. the highest and the lowest was in the Crude protein (CP) content varied from 33.28% to11.46%.

The comparison between the leguminous and the non-leguminous types of forage species were higher nutritive value in leguminous than non-leguminous. Based on chemical composition invitro dry matter digestibility; grass forage species have higher DM and ash content than legume species. Legume forage species have higher CP content and IVDMD than grass forage species. Grass forage species have higher NDF and ADF content than legume forage species (Table23). This is due to soil type, species composition, stage of growth and harvesting date.

Table 23: Effect on chemical composition of Forage Species and interaction by Agro ecology

Agroecolgy	Forage Species	Chemical composition (except DM, all values are represented on DM basis) in percent (%)						
		DM	Ash	NDF	ADF	ADL	CP	IVDMD
		Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SD	Mean±SD
Highland								
	Desho	96.00±0.21[a]	7.64±1.21	60.28±6.89[ab]	38.83±3.93[ab]	5.18±0.99	18.33±2.46[bc]	51.81±3.17 [c]
	Elephant	96.09±0.11[a]	11.63±1.00	72.35±5.72[a]	39.69±3.26 [a]	3.72±0.82	11.46±2.04 [c]	54.91±2.63 [ab]
	Guatemala	95.06±0.220[a]	9.18±1.21	64.12±6.89[abc]	32.02±3.93[bc]	4.13±0.99	23.80±2.46[ab]	52.92±3.17 [a]
	Pigeon pea	95.00±0.33[a]	5.96±1.80	51.40±10.20[abc]	29.35±5.82[abc]	4.15±1.47	21.68±3.64[a]	60.46±4.69[bc]
	Sesbania	95.00±0.21 [a]	7.79±1.21	42.48±6.89 [c]	23.84±3.90[c]	2.49±0.99	19.53±2.46 [ab]	65.25±3.17 [a]
	oat	95.85±0.32[a]	7.84±1.80	27.25±10.20[bc]	12.03±5.82[c]	1.77±1.47	34.02±3.64 [a]	86.63±4.69 [a]
Lowland	Desho	95.31±0.21[b]	9.15±1.21	33.37±6.89[abc]	12.53±3.93[abc]	4.45±0.99	33.28±2.46[abc]	80.80±3.17[bc]
	Elephant	95.24±0.3[b]	8.30±1.80	33.03±10.20[abc]	20.74±5.82[abc]	1.99±1.47	28.43±3.64[ab]	81.79±4.69 [c]
	Guatemala	94.98±0.32[b]	13.62±1.80	22.82±10.20[abc]	21.97±5.82[abc]	2.48±1.47	26.02±3.64[abc]	80.50±4.69[ab]
	Pigeon pea	94.9±0.29[b]	6±0.13	31.8±0.13[b]	37.2±2.87[ef]	25.9±4.45	4±1.46[bc]	63±2.2[c]
	Rhodes	95.00±0.21[a]	7.79±1.21	42.48±6.89 [c]	23.84±3.90[c]	2.49±0.99	19.53±2.46 [ab]	65.25±3.17 [a]
	Cowpea	94.98±0.32 [a]	13.62±1.80	22.82±10.20[abc]	21.97±5.82[abc]	2.48±1.47	26.02±3.64[abc]	80.50±4.69[ab]
Agroecolgy		***	NS	***	***	NS	***	***
Forage Species		***	NS	***	***	NS	***	***
Interaction		***	NS	***	***	NS	***	***

[abc.....]means with different superscript letters in the same column are significantly different; ***=P<0.05 NS=Non significant CP= crude protein; NDF= neutral detergent fiber; ADF=acid detergent fiber; ADL=acid detergent lignin; IVDMD=in vitro dry matter digestibility; SE=standard error; DM= dry matter; %= percentage.

5. DISCUSSIONS

5.1. Household Characteristics

5.1.1. Age, sex and family size of respondents

The average age of the respondents in the study area was 48.6 years higher than the mean age of 42.8 years reported by Admasu (2008), Eba (2012) for Fogera district, Alaba district and the highlands of the Blue Nile Basin ,in the study respectively. The higher male respondents compared with female in urban and rural areas is in line with that of Assefa *et al*. (2013) and Azage (2006) who reported that, the majority (85% and 67%) of the respondents were male household heads in AdamiTullu Jiddo Kombolicha District respectively.

The mean family size per household in the study area 7.5heads was less than the mean 7.88 heads reported by Admasu (2008) for Alaba district and 8.5 heads by Wondatir (2010). The recorded family size in the present study area appeared to be larger than the national average of (5.1) reported by CSA (2013). Moreover, the relatively large proportion of the family members within the productive age category than any other category indicates the potential labor available for farming activities. On the other hand, large family size may imply stronger competition for land resources in both high land and low land agro-ecologies.

5.1.2. Educational status of respondents

The proportion of illiteracy in highland16%and lowland 37% were lower the values reported by admasu (2008) and bogale (2013) for alaba and Damot gale districts.

Education plays a vital role in once national economic development. Education was an important factor for agricultural development via the transfer of improved technologies and practices. Many researchers confirmed the importance of education in the adoption of improved agricultural technologies (Mulugeta, 2005). The low level of education of the households can have an influence on the transfer of agricultural technologies and their participation in development.

5.2. Land Holding and Land Use Pattern of the Households

Land was the major limiting factor of agricultural activities. The average land holding per household in the present study area (0.83ha) was lower than 0.92ha for Boresa water shed in Meskan District (Abera *et al.,* 2014) and 1.27ha in highland and 1.77ha in lowland area of Dale district (Assefa,2006). Similarly, the value recorded in the present study was lower than the national average of 1.77ha (CSA, 2017). The differences could be due to high population of the study area which leads to strong competition for land resources.

The land use pattern in the lowland and highland agro-ecological zones are different with that reported by Abera *et al*., (2014) who indicated that out of the total land holding, 82.7% was allocated for annual crop production, 17.3% for perennial crop production, while only 1.27% and 9% of the area were covered by forest and grazing land, respectively in Boresa water shed of Meskan district. The land allocated for crop production and private grazing in the highland was smaller as compared to lowland and this could be due to the availability of small size of land per household in the highland. The mean private grazing land in the study area (0.34ha) was greater than 0.18ha reported for Dale district (Assefa, 2006) 0.31ha for Fogera, Diga and Jeldu district (Abebe, 2012) and lower than 1.65ha for Adami Tullu Jiddo Kombolcha district (Assefa *et al*., 2013). The current result agrees with reports from the highland areas of

Ethiopia (Tolera *et al*., 2012) who showed that most of the pasture lands left for grazing are either water logged bottom lands; land interrupted by gullies and rocks, or degraded steep slopes.

5.3. Livestock Holding and Herd Composition

In both Agro-ecological zones of the study area, livestock were the second ranked income source and closely linked to the social and cultural lives of the community. The average cattle holding per household in the current study is in accordance with earlier studies Asrat *et al*., 2013, and Yigrem *et al*., 2008 in Delbo (3.9TLU) watershed of Wolaita, and in Boditti (3.6TLU), respectively. The average cattle holding per household in the current study was much lower than the average cattle holding per households reported by Belay *et al*. (2015) for Guduru districts in western Ethiopia and that reported (7.7TLU) by Asaminew and Eyassu (2009) from Bahirdar Zuria of north Ethiopia. The cattle herd size variation per households in different parts of the country and different areas might be due to the difference in household land holding, variation in human population density and existence of grazing land. The higher number of sheep in highland as compared to lowland Aerecological zone could be related to better adaptation to the tethering on small land area. Livestock species composition varies across the study agro-ecologies but cattle were consistently the major livestock species and this observation agrees with findings of Abera *et al*., (2014).The higher number of mulesin high land as compared to low land might be related to better adaptation to the environment and suitability of these animals for people to overcome transport problems. Horses were more kept in highland agro-ecology. Horses and donkeys are generally used as pack animals in the study area.

5.4. Purpose of Keeping Livestock

The purpose of keeping cattle as ranked in the study area was similar with that of Wondatir (2010) who reported cattle were mainly held to satisfy milk production, milk products and drought power in the highlands of the Blue Nile Basin. When during grain food shortage for home consumption, small ruminants were the first animals to be sold to purchase essential requirements for family needs (to purchases agricultural inputs and food shortages as well as household income generation). In both agro-ecologies the purpose of keeping small ruminants were similar with the findings of Abera *et al.*, (2014) who reported almost all farmers in the study area appreciate the importance of small ruminants indicating that keeping them was similar to saving cash in a bank in Meskan District, Gurage zone, SNNPR. The main purpose of keeping chicken was for immediate sources of cash income from production of eggs and meat as well as for family consumption.

5.5. Livestock Feed Resources

In Ethiopia, feed resources support different livestock production systems that were part of the mixed subsistence farming. The role of pasture as a major livestock feed resource was diminishing from time to time due to high degree of chronic degradation and shrinking of grazing land in size. Similarly, the use of native hay was limited in coverage and it was better in terms of its feeding value than crop residues if timely cut and proper handling and storage measures were applied(UNECA, 2005).Each and every feed source has its own unique constraints for utilization and improvement. Such uniqueness of each type of feed increases the available opportunities for improvement and development. Feed problem was one of the major factors that holds back the development and expansion of livestock production. Among the feed resources, crop residues followed by natural pasture contributed the largest source of feed to livestock in both highland and lowland agro-ecologies, which agrees well with the reports from the other highland areas of Ethiopia (Alemayehu, 2004 and Tolera *et al*., 2012). The major crops grown by farmers in the study area were wheat, maize, barley, teff, field pea, and haricot bean. In the study areas, farmers traditionally conserve the straws of crops mostly wheat and teff in a stack for later use, usually after harvesting crop residues together with the grain and after threshing the grain. The largest proportion of almost all types of crop residues was used for livestock feeding rather than any other uses due to the serious shortage of livestock feed in the area, but the residues were fed without any treatment. The feeding of livestock with crop residues in the morning and evening was a common practice in the area particularly in the late dry and early wet seasons due to reduced amount of herbage yield from pasture. In developing countries like Ethiopia, crop residues were major feed resources for livestock, but were low in quality to maintain optimal livestock performance (Bogale *et al.*, 2008).

In the current study, sampled households reported that natural pasture was the second major feed resource in the area, which disagrees with previous study by Tadesse *et al*. (2014). Grazing was the most important ruminant feeding system in most parts of smallholder crop-livestock production systems in Ethiopia (Solomon, 2004).

5.6. Livestock Production Constraints

In the present study in both agro-ecologies feed shortage, water shortage, poor management and poor genetic makeup of the local livestock were the major constraints for livestock production systems. Among the different factors that constraints livestock productivity in Ethiopia feed shortage and disease were considered to be the major ones. In support to the results of the present study, Adugna (2008) reported that feed shortage in terms of quantity and quality is the main cause for the poor performance of the livestock sector in Ethiopia. The present study showed that, livestock production constraints in the study area was similar with Tadesse and Tesfaye (2008), Wondatir (2010), and Assefa *et al, (*2013) and they reported the major livestock production constraints were livestock feed shortage followed by, water shortage, shortage of artificial insemination, shortage of veterinary services, shortage of extension services, shortage of market and poor genetic potential of the animals. Based on pair wise ranking, major problems were ranked by the respondents in the lowland and highland agro-ecologies in order of their importance. The major problems identified in the two groups were the same although there are some differences on the importance of the problems. The livestock production constraints as reported in the present study were similar with the observations of Desta *et al*. (2000) who indicated that the inadequate feed and nutrition, poor health, low productivity of local breeding stock were the main livestock production constraints in Ethiopia.

5.7. Grazing Land Utilization

The feed supply contribution from the grazing areas was ever reducing due to increment of human population for the purpose of crop cultivation and settlement. Farmers have devised mechanism to cope up with limited grazing lands. They produce alternative feed resources like improved forages, buy concentrate feeds or agro-industrial by products, improve productivity of grazing areas, rehabilitate and restore degraded areas, use feeds from protected areas, feed preservation, reduce animal number and replace local animal breeds with exotic breeds. Most of the small holder farmers use crop residues and hay instead of cut and carry system and free grazing during dry season in the study area. This offers the natural pastures to recover and set seeds for regeneration and better carrying capacity. Feed preservations are practiced by the farmers to store feed at plenty time and use it when feed shortage faced cut and carry system of feeding is practiced especially on the meadow by dividing the field in to individual who own livestock and kept regularly to escape from free grazing of the natural pasture. This observation concurs with the finding of WBISPP (2003) and Yaynshet (2010).

5.8. Improved Forage Production and Utilization

Cultivated forages and pastures in the study area were important green fodders in the form of cut and carry system as a supplement to crop residues during the dry season. Likewise, Wondatir (2010) reported that only 13% of farmers practiced improved forage production in central highlands of Ethiopia. Lack of awareness about the importance of the improved forage species, lack of forage seeds and shortage of land were the main reasons for not practicing improved forage production (Wondatir, 2010 and Tadesse *et al.,* 2014). Alemayehu (2005) noted forage adaptability and production trials were made across the different agro -ecologies in the country for the past two decades and certain favorable forages were selected. In terms of quality also many scholars underline that crude protein content of local feed resources was not even sufficient for maintenance. Therefore, improved forage production practices both for enhanced productivity and higher feed quality are of paramount importance in mixed crop livestock systems. The most preferred forage species by surveyed households were elephant grass, desho grass, and Guatemala grass, in descending order of availability in both agro-ecological zones in the study area. In this study, based on multifunctional attribute the accepted cultivated forage species by farmers well agrees with that of Feleke *et al*. (2015) who stated that the main forage species widely distributed in the study area were elephant grass, desho grass, Rhodes grass, Sesbania and Leucaena with their descending order of availability in Shashogo district, Hadiya Zone.

5.9. Forage Development Strategies

The overall survey result showed that the most widely used forage development strategies was back yard/homestead followed by alley cropping and forage farm, livestock exclusion area, inter cropping and over sowing. Numerous strategies for forage development have been devised for Ethiopian conditions as well as study area and these were being promoted by the Bureau of Agriculture and Rural Development (BoARD) and other development partners. This observation concurs with the finding of Alemayehu (2002) and Robertson (1990).

5.10. Establishment Methods of Improved Forages

The overall survey result showed that the most widely used forage establishment method was cutting followed by broad casting, seedling and row seeding. In the finding of ESGPIP, (2008) and Patrick (2004) the few plants that resulted from dormant seeding generally were less competitive with weeds for growth resources than the more numerous plants that were established in the spring. Dormant seeding seems to be a risky practice for establishing forage legume stands. The most desirable time to seed non-irrigated area is immediately before the season of the most reliable rainfall, and when temperature was favorable. Perennial species at the onset of the longest wet season when the soil has received sufficient moisture to support germination and establishment are sown (ESGPIP, 2008). The establishment of forage nursery sites such as shashagale and harto kontola nursery sites in the district was to assist farmers in establishment of improved forages or pasture crops through provision of planting materials and training. However, the contribution is very low from point of dissemination of the technology to farmers. The dissemination and utilization of this feeds as such practices have a critical role to maximize the productivity of cultivated forage utilization practice. Around the cultivated forage and pasture development nursery sites farmers were better forage producers compared to other farmers in the study area.

5.11. Purpose of Improved Forage Production

Based on the current study, forage plants were primarily grown for the purpose of animal feed. Especially protein and energy are important for better animal performance because milk and other products increases their nutrients flourish for neonate and human nutrition (Alemayehu, 2002) According to Michael (2008) improved crop adaptation enhances adaptation of grasslands to climate change. According to Getnet (2012), the integration of improved forage crops in agricultural systems has many advantages including soil conservation, weeds, pests and disease controls, besides to their primary as high quality animal feeds.

5.12. Challenges of Improved Forage Development and Utilization

In support to the results of the present study, Alemayehu (2012) reported that lack of forage seeds remains to be the major constraint to wider adoption of improved forages by farmers in Ethiopia. According to Mulualem and Molla (2013), if improved forages are being integrated and produced at household level in a sustainable way, animal productivity was increased. However, adoption and cultivation of improved forages at small holder farmer's level remains the main challenge in Ethiopia due to different factors. In the study area, the production of cultivated forages and pasture faces different constraints such as lack of land, lack of forage seed, and poor adaptation of improved forages and seasonal fluctuation of rain fall. Similar constraints were reported for cultivated forages and pasture production by Abera *et al*. (2014)

who stated that shortage of land, lack of awareness of farmers on benefits of cultivated forage crops and shortage of availability of forage seed and planting material in decreasing order of importance in Meskan district and in Shashogo district. Similarly, Wondatir (2010) and Tadesse *et al*. (2014) reported lack of awareness about the importance of cultivated forages, lack of forage seeds and shortage of land as the main reasons for not practicing cultivated forage production in the highlands of the blue Nile basin.

5.13. Improved Forage Technology Adoption.

The majority of smallholder farmers in Ethiopia are producing both crops and livestock. However, the productivity of the agricultural sector is very low due to low adoption and application of improved agricultural technologies. The main constraints hindering adoption of improved forages is land shortage In agreement with this result, Assefa *et al*. (2015) in Shashogo district of Hadiya zone, southern Ethiopia. The major forage species widely planted in the study area were desho grass, elephant grass, Guatemala grass, and Sesbania. From sampled households, 27.5% of respondents have planted mainly desho grass on highland and 20.3 on lowland, indicating that the use of desho grass is common in the study area. This indicates that this species of improved forage is suitable for this agro-ecology. This result is similar with the result of Feleke *et al.* (2015)

5.14. Chemical Composition of Improved Forage Species under Different Agro ecologies

Several factors contribute towards the nutritive value of forages which include forage species, plant part, stage of maturity and climatic variables. The wide variation in chemical composition between legume and grass species was as expected.

The ash content for forage feeds in the current study was lower than the value reported by Tesfaye (2008) and Wondatire *et al. (*2011) for forage feeds**.** However, ash in the current study was higher than the values reported by Solomon *et al*. (2008) and Fekede (2004). The CP content of feed samples taken from different sources had different values in highland and lowland agro-ecologies. Sesbania has the highest CP content 34.02% within the improved forages and between the forage species whereas elephant grass has the lowest CP content (11.46%) within and between the forage species and elephant grass has the highest NDF content within the forages, while Rhoades grass the lowest NDF content within and between forages This is due to species difference and soil where they were grown. The authors Tolera and Said (1994) who indicated proper utilization of the DM of feed obtained when CP content is higher than the critical value of 7% and all forages exhibited their higher CP level in their vegetative stage and then gradually the CP content decrease towards flowering stages (Gholamerza, 2013).

The CP value for forage feeds in the current study area was greater than the values reported by Wondatir (2010) and Terefe (2007). Generally all improved forages evaluated in the current study had higher CP contents than the minimum level of 7% CP required for optimum rumen microbial function (Van Soest, 1982). Feeds with CP content less than 7% inhibits voluntary intake and microbial activity, resulting in poor digestibility (Van Soset, 1994). The NDF content of feed samples in the current result was within the range of reported by Gemiyo *et al.*(2013) where the values of grass species varied between 32.2 to 78% in mixed farming system of southern Ethiopia. Intake potential of feeds is negatively related with NDF content (Buxton, 1996). The NDF content of most of sampled forage species were within the range of the critical level of 55-60%, which was reported to decrease voluntary feed intake and feed conversation efficiency due to longer rumination time (Shirley, 1986). The extreme cell wall concentration (NDF) of diets that would not hinder intake and animal production can be as high as 70 to 75% NDF for matured beef cows and as low as 15 to 20 NDF for finishing ruminants (Buxton, 1996). Similarly Tolera and Said (1994) reported that, the total cell wall concentration (NDF) exceeding 60% was reported to be associated with lower voluntary feed intake, longer rumination period and decrease efficiency of conversion of metabolic energy to net energy. Based on Singh and Oosting (1992), forage diets were categorized into average quality feed, if NDF content of less than 45% is high quality, 45-65% as medium quality and those with more than 65% as low quality forages. Kellems and Church (1998) categorized forage with less than 40% ADF as high quality and above 40% as low quality. In the current study most of the improved forages except elephant grass and desho grass in forage species had lower value of ADF content. This could be indicative of its better digestibility in these forage species. Lignin is a component, which attributes strength and resistance to plant tissue, thereby limiting the ability of the rumen microorganisms to digest the cell wall polysaccharides, cellulose and hemicelluloses, resists microbial enzyme attack and hence reduces digestibility (Reed *et al*., 1988).

5.15. Invitro Dry Matter Digestibility of Improved Forage Species under Different Agro-ecologies

The in vitro DM digestibility values greater than 65% indicates good nutritive value and values below this level result in reduced intake due to lowered digestibility (Meissner *et al*., 2000). Hence, in the current study in both agro-ecologies, the IVDMD values of Sesbania, Guatemala, cowpea, Rhodes, and pigeon pea were higher than (65%) this critical level, whereas the IVDMD values for desho grass, elephant grass, oat and Desmodium were less than the critical level. Xing (1995) reported that, as plant gets mature, nutrient digestibility generally decline, this is may be due to a decrease in the digestibility of cell wall components and the variation in chemical composition and digestibility of improved forages among cultivars. Generally the mean values of CP and IVDMD were higher in the highland compared to lowland agro ecology. This is due to the frequency of cutting, species composition, climatic conditions, soil fertility status and season of harvesting.

6. CONCLUSION AND RECOMMENDATIONS.

6.1 CONCLUSION

The current study showed that livestock activity plays a great role in livelihood of farmers. However, improved forage production shortage is one of leading constraint productivity of the study area. The available feed can also not meet the requirement of animals both in quality and quantity. Shortage of land and lack of awareness creation were the main constraints that hinder the adoption of improved forage in the study area.

Farmers in the study area have less access to grazing land for their animal. Because of less accessibility of grazing land farmers keep small number of animals and their number decreases from time to time. Low productivity of Ethiopian livestock is a result of several factors among which nutrition is the major limiting factor. Due to critical feed shortage problem, the importance of improved forage crops is being well realized by farmers and demand for improved forage seeds by different stakeholders is increasing in the country. Seed production of forage crops demands considerable experience and knowledge of the special requirements of each crop. Planting forages on their own land was the key factor that enabled smallholder farmers to improve livestock production. .It is known that grazing land which is communally owned is poor in quality due to its effect on the re-growth of the grasses. This leads to the insufficiency of feed available from such sources. In addition to grazing, utilization of crop residues mainly *teff*, maize, barley and wheat is common in the area.

it is concluded that the current study, obtained in the study area include improved forages like Desho grass, Elephant grass, Guatemala grass , Pigeon pea and Sesbania were common in the study area well adopted and disseminated. In which their availability varied depending on season and agro-ecological zones. Farmers gave particular emphasis to lactating cows, fattening beef cattle and calves in utilizing the improved forage.

6.2 RECOMMENDATIONS.

The following points were recommended for future research and development directions based on the findings of the present study;

- ✓ Developing improved forages and allocating lands for forage development.
- ✓ Increasing accessibility of forage seed and creating awareness Creation on importance.
- ✓ Giving training on livestock Production, and improved forage crop utilization of feeds
- ✓ Production of forage crops in integration with cereal crops and integration with natural resource management activities.
- ✓ Pre-scaling up of improved forage crop Production, Adoption and Dissemination system.
- ✓ Forage Seed production from improved forage crop need to be encouraged.
- ✓ Farmers should produce the high biomass and drought resistant grass such as elephant grass, desho grass and Guatemala grass.
- ✓ Extension service in the use and utilization of improved forage need to be encouraged.

7. RESEARCH LIMITATIONS

During my research study the following limitations were appeared, Data collection, timing of study and Financial Resource. There are different ways to collect data such as key informant interviews, questionnaire surveys and focus group discussions etc. among this focus group discussions was not completed. While the other research limitations is Due to Worldwide Pandemic (COVID 19) Corona virus the transport is double cost to move from place to place contacting with the advisors on face to face to discuss on detail. In addition to that the university library is closed for additional hard copy written M.sc thesis documents, books Budget constraint is always a problem sometimes it is needed to purchase the necessary equipment for a study like Sensitive balance, to hire people for data collection.

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LIST OF APPENDIX

Appendix I. Conversion factors of livestock number to Tropical Livestock Unit (TLU)

No	Livestock species	Conversion factor	
		Local breed	Cross breed
1	Local cow	0.8	1.8
2	Heifers	0.5	0.7
3	Oxen	1.1	1.9
4	Caves	0.2	0.4
5	Young bull	0.6	0.8
6	Sheep	0.1	----
7	Goat	0.1	----
8	Donkey	0.5	----
9	Horse	0.8	-----
10	Mule	0.7	-----
11	Chicken	0.01	----
12	Bee colony	-	-

Source: (Bekele, 1999; ILCA, 1991; Gryseels, 1988); TLU= Tropical Livestock Unit

Appendix II. Analysis of variance (ANOVA) for chemical composition of major improved forages in highland and lowland agro-ecology.

	DF	Sum Square	Mean Square	F value	Pr>F
DM					
Agro-ecology	1	0.09806	0.09806	0.69	0.4183
Forage	8	28592.5719	3574.0714	25157.1	<.0001
Agro-ecology *forage	4	2.0858	0.5214	3.67	0.0264
Ash					
Agro-ecology	1	4,1924	4.1924	6.170	0.0245
Forage	8	25612.5757	3201.5719	4709.40	<.0001
Agro-ecology *forage	4	86.3023	21.5755	31.74	<.0001
NDF					
Agro-ecology	1	88.7976	88.7976	4.38	0.0525
Forage	8	12418.7891	1552.3486	76.66	<.0001
Agro-ecology *forage	4	3102.54621	775.63655	38.30	<.0001
ADF					
Agro-ecology	1	327.3935	327.3935	11.71	0.0035
Forage	8	5052.0998	631.5124	22.59	<.0001
Agro-ecology *forage	4	1168.6801	292.1700	10.45	0.0011
ADL					
Agro-ecology	1	11.5284	11.5284	3.90	0.0659
Forage	8	2359.0543	294.8817	99.68	<.0001
Agro-ecology *forage	4	31.4671	7.8667	2.66	0.0711
CP					
Agro-ecology	1	21.8495	21.8495	10.14	0.0058
Forage	8	7372.5586	921.5698	427.82	<.0001
Agro-ecology *forage	4	588.0257	147.0064	68.24	<.0001
IVDMD					
Agro-ecology	1	4.93680	4.93680	0.23	0.6416
Forage	8	18696.2547	2337.0318	106.5	<.0001
Agro-ecology *forage	4	358.4144	89.6036	4.08	0.0181

Appendix III**.** The houses hold survey in the study area.

Appendix IV. On farm field observation in the study area

Desho grass Elephant grass Guatemala grass Desmodium

Oat grass Rhoades grass Pigeon pea Sesbania

Fig 4. Some of the improved forages used by the respondents in the study area.

APPENDIX IV. STRUCTURED QUESTIONNAIRE

Region: ________ Zone: _______ Wereda: _________ Kebele: _____ Mender: ______

Questionnaire no Interviewing date; ---------------------------

Enumerator's name: ________

A. Household General Information

1. Respondent name: --------------- HH code: ------------

2. Respondents sex (Tick) Male---------Female--------

3. Respondent position (Tick) Head --------- Spouse----------- Son---------Daughter -----------

4. Respondent age Male---------- Female--------

5. Respondent Family size in number-------------

6. Respondent Education level (Tick) Illiterate------Read only----- Primary ---- Junior -----
Secondary------------- Preparatory-------------

7. Land size in hectare: Crop farming --------- Forage farming --------Private forest -----------
Private grazing ---------- Fallow land

Farm Activity (√) Crop------------ Livestock ------------mixed-------other if any-----

B. Household livestock ownership

Livestock number (Enter No)				Cattle class (Enter No)				Cattle breed (Enter No)		
Cattle		Mules		Ox		Steer		Local	Cow	
									Bull	
Sheep		Camels		Milking cow		Male calf		Exotic	Cow	
									Bull	
									Bull	

C. Purpose of keeping livestock in your area (Rank 1-3) and tick (√) the others

Type of livestock	Meat	Milk	Milk products	Sale income	Work/ Draft	Manure/ compost	Breeding/ mating	Saving	Hides & skins	Egg	Gift	Insurance
Cattle												
Sheep												
Goat												
Chicken												

D. Livestock feed resources

Feed type	Dry season		Wet season		How much Duration		
	Tick(√)	Rank (1-3)	Tick (√)	Rank (1-3)	When month	Frequency	Quantity
Natural pastures							
Crop residues							
Crop aftermath							
Hay							
Browse plants							
Feed type	Dry season		Wet season		How much Duration		
	Tick(√)	Rank (1-3)	Tick (√)	Rank (1-3)	When month	Frequency	Quantity
Natural pastures							
Crop residues							
Crop aftermath							
Hay							
Browse plants							
Weeds and green grasses							
HH wastes*							
Attela							
Improved forages							

E. Livestock production constraints

Livestock production constraints and ranking to their importance/seriousness

S.N	Constraints	Tick (√)	Rank (1-3th)	Remark
1	Poor genetic make up			
2	Poor animal husbandry practices			
3	Feed shortage (quality and quantity)			
4	Shortage of capital/cash			
5	Poor infrastructure			
6	Disease and parasites			
7	Water			
8	Poor extension services			
9	Lack of improved technology/inputs			
10	Shortage of man power (labor)			
11	Market fluctuation for livestock and livestock products			

F. Grazing land usage

1. Do you use grazing land? A) Yes B) No (If no skip to No 6)

2. If yes, what type of grazing land is it? A) Private grazing land B) Communal grazing C) Fallow land D) Road side grazing__ E) Others

3. If it is Communal grazing, what type of grazing system do you use? A) Continuous grazing B) Deferred grazing C) Zero grazing (cut & carry system) D)Others (if any) __ E)All__

4. If it is communal grazing land, what is the status? A) Decreasing B) Increasing C) No Change

5. If it is private grazing land, what type? A) Open grassland B) Tree covered grassland C) Bush land grassland D) Grazing pasture and fodder trees/shrubs E) Swampy F) others (if any)

6. Is the grazing resource adequate to your animals? A) Yes B) No

7. If no, what measures do you take to alleviate this problem (shortage of grazing land)?

A) Purchase concentrates B) Purchase forage C) Use crop residues D) Preserve any feed during high abundance E. Area Enclosures F) Livestock take off programme G) others (if any)

G. Improved forage/cultivated forage

1. Do you have grown improved forage plants? A) Yes B) No (If no skip to No 22)

If yes, list the forage plants commonly grown and order of importance?

S.N	Scientific Name	Common Name	Area	Rank (1-3)	Remark
1					
2					
3					
4					
5					

3. By what mechanism of forage development strategy do you establish? A) Backyard/homestead B) Alley cropping and live fence C) Forage farm D) Under sowing (food crops and fruit and Vegetables) E) Livestock exclusion areas F) Forage strips (Conservation structures) G)Over sowing(Reseeding) H) Others or list the mixture of the listed above__

4. By what mechanism do you planted them? A) Row seeding/Seed bed B) Broad casting C) Seedling D) Cutting E) Others

5. For what purpose do you grow the improved forage? *(*Not read the alternatives but encourage telling the truth)A) Only Livestock feed B) Soil and water conservation C) Honey bee flora D) Wind break E) Carbon sequestration F) Shelter providing G) to fertile soil H) hedge fence I) Others__

6. Have you practiced feeding your livestock with the improved forage? A) Yes B) No (if No, skip to No 8)

7. If yes, at what stage of maturity do you utilize? A) Early maturity B) at maturity stage (flowering) C) late maturity (after seeding) D) Not known

8. How do you utilize the planted improved forage for feeding? A) Grazing *in situ* B) Cut and carry system C) Others (if any)

9. If cut and carry system, how do you feed to livestock? A) Feed alone B) Feed mix with roughages (straw/hay) C) Others (if any)

10. At what time of feeding do you offer the improved fodder? A) morning before grazing/Straw B) At mid-day after grazing/straw C) At evening after day feeding D) Before milking at any time E) After milking at any time F) Others Specify _____

11. is there priority of grazing on the livestock type? A) Yes __ B) No __

12. If yes, which livestock types allowed offer according importance/ (Rank)

Livestock type	Lactating cow	Dry cow	Pregnant cow	Draft oxen	Bull	Heifer	Calves	Small ruminants	Equines	Weak livestock	Others	Remark
Tick & Rank												

13. Do you perceive any advantage due to these forage feeding? A) Yes __ B) No __ C) answer

14. If yes, in what term?

Feed effect on	↑Milk yield(Lit)	↑ Growth/fattening(gm)	↑ Disease tolerance	↑ work/traction	↑ Reproductive performance	Remark
Tick						

15. What challenges do you face during improved forage feeding? A) unknowing of maturity stage (cutting height) __ B) Wilting problem __ C) Non-Mixing with other feeds __ D) Chopping Problem__ E) Bloating__ F) Others Specify __________

16. What you made if plenty of improved forage produced during a period? A) Feed adlib tom B) preserve_ C) Nothing__ D) Others Specify________

17. Where did you get the improved forage plants? A) Government (Extension service) __ B) NGO's __ C) Research Institutes__ D)Private (from available)__ E) Neighbor__ G) Others (specify) __

18. Do you get any material or technical support from concerned bodies including government in relation to forage production, management and utilization? A) Yes __ B) No__

19. If yes, specify the support? A) Training __ B) Advice__ C) Orientation__ D) Inputs (eg. Improved forage, planting tools, fertilizer etc.) __E) Exposure visit/Demonstration__ F) others specify____

20. Did these technical supports bring about change in your professional capacity? A) Very high __ B) High__ C) Medium__ D) less__ E) Very less__ F) No change __

21. Do you have fruit and vegetable irrigation access? A) Yes__ B) No___ (If no skip to No 23)

22. If yes, why you introduce the improved forages for your livestock feed around irrigation? A) lack of technical support__ B) water shortage__ C) Land shortage__ D) shortage of forage seed/source__ E) nutrient competition__ F) devoid of awareness__ G) Under story problem__ H) Not interested in it__ I) Others specify_____________________

23. Would you consider beneficial introduction or sowing of improved forage by any means? A) yes__ B) No__ (If no, skip to No 26)

24. If yes, so why? A) Expecting high forage yield and quality product for your livestock__ B) to control soil run off__ C) to boost up soil fertility__ D) Others Specify______________

25. If no, why? A) does not establish__ B) requires much care__ C)do not tolerate grazing__ D) Invade crop land__ E) Others specify_____________

26. Most challenges of improved forage growing and utilization?

S.N	Most challenges of improved forage production & utilization	Tick (√)	Rank (1-3)
1	Cost		
2	Poor adaptation		
3	Lack of forage seed		
4	Lack of land		
5	Disease		
6	Seasonal fluctuation		

H. Questions about forage Seed and Fodder production

1. Do you practice to harvest forage seeds? A) Yes ___ B) No ____

2. How often? A) Every month __ B) 2 times per year__ C) At the end of year __ C) Any time needed

3. What do you do with the forage seed? A) Sell to government _ B) Sale to NGOs__ C) Sale to private __ D) Sale at Market __ E) Give to neighbor or interested individuals F) other ___

4. If sale, how much cash do you collect per year or month from seed? ____________

5. Do you practice fodder selling? A) Yes ___ B) No _____

6. If yes, how often? A) Every day ____ B) Every month ____ C) Every year ____ D) Any time ____ E) Others __

7. In which season you use cultivated forage as a major feed source?

(Identify the month)

Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	June	July	August

When –feed shortage------------ Excess of food -----------Always------------

8. in which month the availability of improved are high, low and medium?

(Put high **XXX,** medium **XX,** low **X**)

Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	June	July	August

8. Which Animals given priority to be supplemented

Types of Animals	Dry season		Wet season	
	Tick (√)	Rank (1-3)	Tick (√)	Rank (1-3)
Drought oxen				
Lactating caw				
Bulls				
Heifer				
Small ruminants				
Calves				

I. Improved forage dissemination

1) What type of improved forage is disseminated? A) Grass B) Leguminous C) Browse

If the Answer is A What are they List-------------------------

If the Answer is B what are they List-----------------------

If the Answer is C what are they List-------------------------

2) Who are disseminated the improved forage?

A) NGO B) Non –Ngo (Governmental)

List the name of the organization-------------------

3) What amount of forage seed/Cuttings have got?

4) The disseminated month and year

5) What kind of training taking on forges Production?

6) For what purposes you produce improved forage A) for livestock feed utilization B) for selling

If u used for livestock feed utilization for what types of animals? -------------------------------If u used for selling for what organization

J. Forage and forage seed technology adoption in Farming community

1) Did you adopt improved forages in your farm? 1. Yes 2. No;

2) Which forge crop 1. Desho grass 2. Elephant grass 3. Oats 4.sesbniya 5. Others-----------------2) what are the adopted improved forage productions --------------

3). what are the non adopted improved forage productions ---------------?

4) What is the effect of improved forage on livestock performance-------------?

5) Did you produce seed from these improved forages? 1. Yes 2. No; if yes how much kg each-------------------------------

6) What did you do the seeds? 1. Store for coming years 2. Sell 3. Give as gift for other farmers--

7) Amount of land allocated to improved forages in square meter? 1. Desho-----------------elephant grass----oats----------------Sesbania---------------others----------------------

8) Where did you get these improved forages seeds and cuttings? 1. Other farmer 2. NGO 3. Agricultural extension 4. Research organization 5. Others---------------------------------------

9) Have you ever produced seeds from these improved forages? 1. Yes 2. No; if yes from which forage crop? 1. Desho--------2 elephant grass------3.oats--------------------4. Phalarisis 5. Sesbania 6. Others-----

10) If yes how much in kg or cuttings 1. Elephant grass----------2.oats---------3. Phalarisis------ 4. Others-----

11) Did you give cuttings or improved forage seeds as gift for surrounding farmer? 1. Yes 2. No; if yes, which forage crop-?

12) How did you acquire these cuttings and or seeds of improved forage? 1. As gift 2. Purchasing 2. Both 4. Others------

13) How do you feed this improved forage your livestock? 1. as supplementary 2. Basal diet 3. both 4. Others----------------

14) If u feed as supplementary feed, with witch feed categories usually? 1. Crop residue 2.weeds 3. Browses 4. Concentrates 6. Enset leaves 7. Enset leaves and psudostem 8. others---------------

15) Did you give these improved forages for all livestock at equal level? 1. Yes 2. No, if no, for which livestock category mostly? 1. Dairy cow 2. Beef cattle 3. Heifer and bull 4. Calves 5. Sheep and goats 6. Others----------------------------------

16) If you provide these improved forages for some livestock category, why? ----------------------- Have your take training of improved forage and forage seed production? 1 yes 2. no; if yes when---------------EC; by which organization? 1. Research center 2. NGO 3. Agricultural Offices 4 others---------------for how many days----------

17) Do you have your own/private grass land? 1. Yes 2. No; if yes area timad-------------------

18) Do you have private grass land for cutting and carrying system? 1. Yes 2. No, if yes for which livestock do you use cut carry system? 1. Calves 2. Fattening cattle and shot 3. Pregnant cow 4. Ploughing ox 6. 0thers-----------------------

19) When did you use cut carry system for livestock keeping? 1. Dry season 2. Wet season 3. Others---

20) How do you keep livestock? Tethering 2 cut and carry 2. Free grazing 4. Others------------

21) Do you have access to communal grazing land? 1. Yes 2. No if yes; when did you usually use this communal grazing land for gazing? 1. Dry season 2. Wet season 3. Both 4.others---

22) Distance in km between your residence & communal grazing land-------------km------minute-walk

23) Did you practice conservation of improved forages as seed for future on the ground? 1. Yes 2. No, if yes how much of the total u have-----------m^2; conserved as future seed------------$m^{2,}$ which forage grasses? 1. Desho grass 2. Elephant gasses 3. Phalarisis grasses 4. others-----

24) Who is responsible for collecting improved forages in your household? 1. Mother 2. Daughter 3. Son 4. Father 5. Others---------

25) Who is responsible for collecting improved forages seed in your household? 1. Mother 2. Daughter 3. Son 4. Father 5. others---

26) Who is responsible for tethering livestock in your household? 1. Mother 2. Daughter 3. Son 4. father

27) Who is responsible for watering in dry season in your household? 1. Mother 2. Daughter 3. Son 4. father

28) Who is responsible for watering in wet season in your household? 1. Mother 2. Daughter 3. Son 4. Father

29) Who is responsible for tanking out in your household? 1. Mother 2. Daughter 3. Son 4. Father

BIOGRAPHICAL SKETCH

Tucho Tumato was born in 1981 in Damot Woyde District, Wolaita Zone, Southern Nations Nationalities and Peoples Regional State of Ethiopia from his mother loatae brihane and from his Father Tumato Taba. He attended his education in Sura koyo elementary school, next Boditti junior schools and completed his senior secondary Education at boditti High School.

Upon successful completion of his high school studies, he joined Mizan teferi Agricultural Technical Vocational Educational Training College (ATVETC) and graduated with a diploma in Animal Science July31, 2005. Later he joined Ministry of agriculture and Worked as Animal production expert in Wolaita Zone humbo District. Consequently he joined Wolaita Sodo University and graduated with B.sc in Animal and Range Sciences in Dec8, 2010and then starting from April 11, 2011 he was employed by Southern Agricultural Research Institute (SARI) and worked Areka Agricultural Research Center. Until he joins Hawassa University College of Agriculture the Department of Animal and range Science to Specialized on Animal Production in the year July 18, 2016.He is married and is a father of one daughter.