Mekelle University

Green Feed Management and Utilization for Dairy Production in Irrigated Areas along Ahferom-Adwa-Laelay Maichew Milk sheds, Central Zone of Tigray

By:

Atsede Teklay Berhe

A Thesis Research Paper

Submitted in Partial Fulfillment of the Requirement for the Master of Science Degree in Livestock Production and Pastoral Development

Department of Animal, Rangeland and Wildlife Sciences

College of Dryland Agriculture and Natural Resources, Mekelle University

Major advisor: Tikabo Gebremariam (Asst. Prof)

Co-advisor: Mulubrhan Balehegn (PhD)

Co-advisor: Yayneshet Tesfay (PhD, associate professor)

January, 2017

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DECLARATION

I, **Atsede Teklay Berhe,** hereby present for consideration by the **Department of Animal, Rangeland and Wildlife Sciences** within the College of Dryland Agriculture and Natural Resources at Mekelle University, my thesis in partial fulfillment of the requirement for the degree of Masters in **Livestock Production and Pastoral Development** with thesis research entitled '**Green Feed Management and Utilization for Dairy Production in Irrigated Areas along Ahferom-Adwa-Laelay Maichew Milk sheds in, Central Zone of Tigray**.' I sincerely declare that this thesis is the product of my own efforts. No other person has published a similar study which I might have copied, and at no stage will this be published without my consent and that of the **Animal, Rangeland and Wildlife Sciences** department.

Name of the student_____ Signature & date_____

Approval

Name of the major adviser_____Signature & date_____

Name of the co-adviser_____Signature & date _____

Name of the co-adviser_____Signature & date _____

Name of external examiner_____Signature & date_____

Name of internal examiner _____Signature & date_____

Name of Postgraduate coordinator_____Signature & date _____

Name of Department head _____Signature & date _____

DEDICATION

This thesis manuscript is dedicated to all Ethiopians in general and to all my family in particular my sincerely father Ato Teklay Berhe, my mother Mitslal Fisseha, My husband Mr. Gebre Gebretsadik, and my daughter Mahlet Teklay and my brothers for their dedicated partnership in the success of my duty. I deeply wish that the lord gives them a eternal peace of mind.

BIOGRAPHICAL SKETCH

The author was born in 1988 in the Ahferom district, Central zone of the Tigray Regional State, Ethiopia. She attended her elementary school in Enticho. Elementary School, and junior and Preparatory education in Enticho High School and Preparatory School respectively, for 1994-2006.

The author joined her undergraduate program in Mekelle University, College of Dryland Agriculture and Natural Resources and graduated with a BSc. Degree in Animal Rangeland and Wildlife sciences in July, 2009.

After her graduation, she was recruited in Ahferom District Agricultural and Rural Development office in the profession of animal production and forage development from 2010-2012. From 2013 until now she has been working as vice head of the office of construction, road and transport. Then in July 2014, she joined the school of graduate studies at Mekelle University in the Department of Animal Rangeland and Wildlife Sciences to pursue her MSc. Study with Livestock Production and Pastoral Development with the research title '*Green Feed Management and Utilization for Dairy Production in Irrigated Areas along Ahferom-Adwa-Laelay Maichew Milk Sheds, Central Zone of Tigray northern Ethiopia*' at college of Dryland Agriculture and Natural Resources, Mekelle University.

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ABBREVIATIONS AND SYMBOLS

ARDOAW	Agriculture and Rural Development, Office of Ahferom district
ARDO	Adwa rural development office
CSA	Central Statistical Agency/Authority
ETB	Ethiopian Birr
FAO	Food and Agricultural Organization of the United nation
GOs	Governmental organizations
LIVES	Livestock and irrigation value chain for Ethiopian smallholders' project
LMWARDO	Laelay Maichew district agricultural rural development office
LSD	Least Significance Different
M.a.s.l	Meter above sea level
NGOs	Non-governmental organization
OLS	Ordinal least squares
Qt	Quintal
SPSS	Statistical Package for Social Science
VIF	Variable inflation factor

Table of Contents

LIST OF TABLES

Table Pages

LIST OF FIGURES

Green Feed Management and Utilization for Dairy Production in Irrigated Areas along Ahferom-Adwa-Laelay Maichew Milk sheds, in Central Zone of Tigray

By: Atsede Teklay (BSc)

Thesis supervisors: Tikabo Gebremariam (Asst. Prof.), Mulubrhan Balehegn (PhD) and Yayneshet Tesfay (PhD, associate professor)

ABSTRACT

This study was conducted in Ahferom–Adwa –Laelay Maichew milkshed areas, Central Zone of Tigray, with the aim to assess irrigated green feed, production, management and utilization for dairy production. Five Tabias were selected purposely based on their potential in green feed production and dairy farming using purposive sampling method. A total of 200 respondents using the random sample from the list of green feed user and non-user. These were stratified to (100 irrigated forage adopters and 100 non-adopters). Primary and secondary data collection methods were employed during the course of the study. The primary data were collected using household interviews, focus group discussions, direct field observations, informal discussions and some measurements to understand the biomass (DM yield) of the irrigated forages. Descriptive statistics and econometric analysis were done using probit model. The study found that the common green fodder was Sesbania sesban, alfalfa, elephant grass, leucaena, cowpea, lablab and local grass. Major feed resources were crop residues, hay, green feed and weeds, Attela, improved forages and browse trees. From these crop residues and hay contribute largest. Sesbania sesban, alfalfa, elephant grass, leucaena, cowpea, lablab and local grass are the major improved forage species grown under irrigation in the areas. The DM productivity of these common green feed were measured to be 1.79t/ha for *Alfalfa,* 4.2t/ha *elephant grass, 0.*061t/ha *Leucaena, and* 0.8t/ha *Sesbania. The management practices of green feeds differ according to the nature and type of plants. The tree legumes are planted by seedling and direct sowing, elephant grass by cutting stems and splitting roots, and herbaceous legumes by direct seed sowing. Out of the total green feed users, 69% practice land preparation, 68% watering practice, 69% fertilizer and close their land from grazing. The farmers feed the green fodder to animals alone (48%) majority grass species, herbaceous legumes in mix with roughage (17.5%) and both (25%). The probit model showed that sex, education level, land size, seed access, media access and distance extension service canters significantly determined green fodder adoption. Shortage of land, shortage of water, health problem (especially bloating), shortage of capital, poor knowledge and awareness, low forage production, shortage of labor, shortage of input, shortage of forage seed, free grazing and lack of credit access were identified as constraints for green fodder production. The forage producers get institutional support from both governmental and non-governmental organizations. Feeding green feed have good on the milk production, body condition and controlling health problems. Farmers have good perception on green feed and appreciated for their importance in improving feed supply, soil fertility, crop yield and animal diseases tolerance. There are more opportunities for green forage development related to the institution, research, policy, technology, extension and market demand. From the study, common irrigated green feed was identified, production, management and utilization practice of respondents were assessed, eleven determinant factor for green feed adoption was determined and the effect of green feed on dairy production, body condition and health conditions was discussed. from these findings, the study recommends that was scale up the size of common irrigated forages and increase the adoption rate of nonadopters by training, awareness creation and demonstration of the adopters work. Strengthen the utilization mode of forage, improving relation of forages production with market oriented commodities and strength forage development of government attention and NGOs to improve adoption.*

Key words: Green fodder, fodder management, fodder utilization, irrigation, milksheds.

CHAPTER ONE: INTRODUCTION

1.1. Backgrounds and justifications

Livestock is a major contributor to food and nutritional security, and serves as an important source of livelihood for nearly one billion poor people in developing countries (Frans Swanepoel, 2010). Keeping livestock is an important risk reduction strategy for vulnerable communities, an important provider of nutrients and traction for growing crops in smallholder systems. Livestock products like milk, meat and other products contribute 17 percent to kilocalorie consumption and 33 percent to protein consumption globally (Melkamu Bezabih Yitbarek, 2014).

Most of the dairy production in the country is mainly dependent on indigenous Zebu breeds. Total cattle population in Ethiopia with ~52 million cattle. Integration of cross breed cattle to the sector is imperative for dairy development in the country. The promotion of large private investment in dairy farm and smallholder's dairy production increases milk production. The government promotes integration of cross breed cattle in to the smallholder sector through artificial insemination service, veterinary service and credit (Tsegay, 2010).

Dairy production is one branch of livestock production with many uses. It is an important matter in Ethiopia's-livestock-based society where livestock and their products are important source of food and income, and dairy has not been fully exploited and promoted (Tangka *et al*., 1999). In Ethiopia, the increase in milk production was mainly due to the increase in herd size and due to improvement in productivity per animal resulting from technological intervention (Mamo and Dessie, 2007).

One of the major problems to low milk production in the country is associated with shortage of livestock feeds both in quantity and quality, especially during the dry season (Wondatir, 2010). During years of good rainy season, forage is not adequate to feed livestock in the highlands for reasons associated with controlled grazing land and poor management (Gashu *et al.*, 2014). A basic failing of the natural grasslands as a source of feed for livestock is their low production of dry matter, absence of proper utilization of natural grass lands ,keeping unproductive animals and the seasonality of plant growth, which is an image of the annual rainfall circulation pattern, further limits the accessibility of herbage for the grazing animal to four or five months of the wet season over most of the natural grasslands of the country (Galmessa *et al.*, 2013).

Thus, feeding management is significantly important for dairy production. Availability, quality and quantity of feed vary among dairy production systems. Cattle largely depend on rangeland grazing or crop residues that are of poor nutritive value. The feed is not uniformly supplied and the quality is poor. Seasonal fluctuation in the availability and quality of feed has been serious challenges in livestock production (Mengistu, 2005). The feed shortage mostly happens in dry season of the year (Ibrahim and Olaloku, 2000). In other words, under normal circumstances in lowlands when there is adequate feed for cow, milk tends to be sufficient for home consumption as well as for market (Nardos, 2010). Improving the improved forage supply is a base for introducing intensive indoor dairy management and feeding practice (Tesfay, 2014).

In an attempt to solve the animal feed shortage and poor management, forage development programs have been undertaken in Ethiopia in general and the Tigray region in particular. Likewise, farmers of Tigray have grown forage in their land holding. Various improved forage species have been introduced across time since the last 20 years. Regardless of the efforts, however, the forage progress goes and consumption practices were not respected and could not

achieve the probable change in animal feed supply. Feed is the most important input in livestock production and its satisfactory supply throughout the year is an essential prerequisite for any substantial and sustained expansion in livestock production (Menbere *et al*., 2008)

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The present green feed management and utilization for dairy production need to be addressed fully in order to design proper forage improvement programs with the dairy production in the region in general and the study areas in particular. Identifying the actual useable green feeds, assess current management practices, modes of utilization and determinants for adoption of irrigated forage in a given region is a prerequisite for planning appropriate forage developments and increasing dairy production and productivities that largely benefit producers. understanding the level of green feed gaps in the availability of different feed resources is also essential for implementing appropriate supplementation strategies. With this knowledge, this study was done to investigate and analyze the green feed management and utilization for dairy production systems in Ahferom-Adwa-Laelay Maichew district, central zone of Tigray.

1.2. Statements of the problem

Ethiopia has a large livestock population with low production where there is scarcity in quality and quantity of feed to sustain the demand of livestock. Additional irrigation practices are common in crop production with small forage cultivation. Irrigated feeds play a great role during dry season to increasing production and productivity and contributes to job creation. There is scarcity of studies on green feed management and utilization for dairy production in irrigated areas in Ahferom-Adwa-Laelaymaichew districts. The available irrigated fodder types, fodder management practices, irrigated green fodder utilization methods, determinant factor for the green feed adoption, the existing constraints in green fodder production, management and utilization and impact on dairy production had not yet studied. So, it has been

difficult to take solutions for development of green feed management and utilization for dairy production in the area. Hence, this study was designed to investigate green feed management and utilization of dairy production systems in selected irrigated areas along Ahferom-Adwa-Laelay Maichew milk sheds in the central zone of Tigray, Northern Ethiopia.

1.3. Objective of the study

1.3.1. General objective

- The general objective of this study was to investigate irrigated forage and local grass utilization and identify major constraints for dairy production systems in selected irrigated areas along Ahferom-Adwa-Laelay Maichew milk shed in the central zone of Tigray, northern Ethiopia.

1.3.2. Specific objectives

1. To identify and estimate common useable improved feeds and local grass for dairy cattle along Ahferom-Adwa-Laelay Maichew Milksheds.
2. To assess current production, management and utilization practices of green feeds along the Ahferom-Adwa-Laelay Maichew Milk Sheds.
3. To identify determinants of the adoption of irrigated green feeds in the study areas.
4. To identify the existing constraints in irrigated green feed production, management and utilization in the study areas.
5. To assess the impact of irrigated green feed development on milk yield, body condition and health condition

1.4. Research questions

1. What are the useable irrigated green feeds used for dairy cattle in the study area?
2. How much irrigated biomass production is available within household level?
3. What do the current management practices on irrigated green feeds in the study area look like?
4. What are the specific modes of utilization of irrigated green feeds for dairy cattle?
5. What are the main determinant factors for adoption of irrigated green feed plants?
6. Has the current green feed production brought any positive changes in production (E.g. Milk yield and improve production and body condition?

7. What are the key constraints in the irrigated green feed production, management and utilization practices?

1.5. Significance and scope of the study

These study district are characterized by huge natural resources such as irrigation areas and various feed resources. Different groups and individuals will be benefited from the result of the paper. The findings of the study will different governmental organizations and development partners in understanding the current green feed production and utilization and thereof to design their future programs and strategies with regard to green feed production and utilization in the study areas. It may also help for researchers as an input in their further research works.

CHAPTER 2: LITERUTURE REVIEWS

2.1. Feed resources in Ethiopia

The major sources of feed for cattle in Ethiopia including Tigray are hay, crop residues, grazing, crop aftermath and non-conventional feedstuffs (like 'Atela' and weeds) (Mengistu, 2003). In the finding of Yadessa (2015) pasture grazing, crop residues such as wheat and barley straw, hay, Atella and crop aftermath were mentioned as the major feed resources for livestock. Pastoral livestock production sole depends on extensive range grazing while the mixed crop-livestock production systems use both natural pastures and crop residues to sustain the animal requirements.

Feed resources commonly used for dairy include grazing land, hay and purchased succulent grass, cereal crop residues, maize Stover, improved forages, mixed/balanced homemade concentrate feeds, plant weeds, and non-conventional feeds like *attella* (brewery by-product from locally produced beer, and other alcoholic drinks), and leaves of other palatable agro-forest plant. Maize Stover is the most usually used roughage feed resource in all the production systems during wet and dry seasons (Sintayehu Yigrem and Gebremedhin, 2008). According to Tekalign (2014) the utilization of animal feed in Ethiopia covers natural pastures 57.49%, crop residue 29.61 %, improved forage 0.22%, hay 7.05%, by-products 0.91% and others 4.72%.

2.2. Forage development in Ethiopia

Forage development is one of the strategies to address feed scarcity and low livestock productivity in Ethiopia. Fodder production and management is predominantly traditional, with modern efforts in forage development being undertaken by the Office of Agriculture and Rural

Development (OoARD), and community and non-governmental organizations (NGOs) (Shiferaw *et al*., 2011). The dominant forage development strategies practiced in central and eastern zone districts are backyard development, alley cropping, intercropping and gully treatment and by small number of farmers a combination of three strategies (backyard development, alley cropping, and gully treatment) are used by most forage growers (Tesfay *et al*., 2016).

Many factors influence the level of success of forage development endeavors. Perhaps one of the major factors is the full participation of communities. The basis for the development forage, continuously need to adapt a process approach, which allows communities to contribute in all stages of the forage development cycle, i.e., from planning to implementation and evaluation (Ayele, 2003).

In the highlands; better ways are the low-cost methods such as backyard, under sowing and over sowing, which are more attractive to farmers. These strategies provide farmers with proper use of their land for cultivation of crop/pasture and forage/trees, where products can be used for food, feed and firewood respectively. Some perennial grasses can be planted vegetatively; *Festuca arundinacea, Phalaris arundinacea* and *Setaria sphacelata* are well adapted to waterlogged conditions and easily established by root splits (Mengistu, 2006). Integration of forage into farming system in Ethiopia heavy emphasis is put on the use of forage legumes in cropping systems (through under sowing, improvement of fallows and establishment of tree legumes hedges) to partly address the major problems of long-term sustainability of crop production (Mengistu, 2006).

The common strategies that are currently practical across different districts include intercropping of annual food crops with legumes, planting in eroded communal areas and irrigated fields, rain-fed arable farms, watersheds, and at the backyards (Tesfaye, 2010).

2.2.1. Common useable green feeds in irrigated areas

Irrigation has been experienced for many years. This is a good opportunity for off-season pasture and forage crops. The potential for irrigated forage is unexploited and still there is a great opportunity for producing seasonal and long term irrigated pasture and forages. In trails in the highlands of Ethiopia wheat and barley under sown with Lucerne, annual clovers, tall fescue, perennial rye grass, *Setaria* and *Phalaris*, the sowing of both cereals and forages was at the same time. All under sown forages established successfully except Lucerne and there was no significant reduction of cereal yield (Mengistu, 2006).

Even useful forages have been selected for different zones, but the adoption rate is very low in Tigray. Improved pasture and forages have been fully-grown and used in government ranches, state farms, farmers' demonstration plots and dairy and fattening areas. From grass species, the most regularly occurred are elephant grass (*Pennisetum purpureum*) and Rhodes (*Chloris Guyana*); from legumes the most frequent species are sesbania (*Sesbania sesban*), Leucaena (*Leucaena leucocephala*), and alfalfa (*Medicago sativa*) (Tesfay *et al*., 2016).

Even if diverse kinds of forage species are tried to introduce in Tigray, the adoption and practical uses of such feeds for meat animals is low. Thus, agricultural extension workers and producers should apply intensive efforts to make use of such green feeds for commercial meat production (Tesfaye, 2010).

Effective collection, preservation and proper utilization of crop residues and hay making might increase the quantity of available feed, and observing for other alternative options such as use of urea treatments, nutrient block, silage making and scale-up of improved forage species with participatory approach can improve the nutritional quality of available feed for dry season (Abera *et al*., 2014).

Even in the presence of plentiful crop residues, which are often freely fed to ruminants, forage crops, especially legumes are needed to improve the utilization of crop residues. Crop residues often provide energy while forage legumes provide proteins. Forages also provide benefits such as soil fertility through their nitrogen-fixing ability and are also useful in breaking insect, weed or disease cycles, which are likely to occur when they are not supplemented. In many situations, however, forages compete with other crops. In land scarce smallholders, forages may compete with other crops for land, while inland abundant pastoral systems, they may compete for the herders Labor (Birhan and Adugna, 2014).

Forage crops are commonly grown for feeding cattle with oats and vetch mixtures, fodder beet, elephant grass mixed with siratro and dismodium species, Rhodes/Lucerne mixture, phalaris/trifolium mixture, hedgerows of sesbania, leucaena and tree-Lucerne (Alemayehu, 2003). According to the Mekonnen Yirga and Ali Seid (2013) tree legumes are extremely important elements in improved forage production programs because of their productivity and multipurpose 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. Forage production and management practice in irrigated areas

2.3.1. Forage production and productivity

The productivity of forage depends upon many factors, including available moisture and nutrients and the presence of productive forage species. Loss of production may be due to weather, the decline in fertility and poor management. While it may not be possible to influence the weather, there are options to correct some of the other causes. The presence of productive forage species in pasture ecosystem is a significant factor in determining the productivity of the

forage field. Choice of species and combination need critical consideration. In grass-legume mixed pastures, dry matter yields quite often are higher per unit area than either sole grass or sole legume pasture. Production yields vary widely, depending on such factors as species of grasses and legumes, inherent soil fertility, fertilization (amount and time of application), percentage of legume, available soil moisture, intensity of defoliation, light intensity and temperature (Tanko, 2014).

Even many species was introduced to Tigray forage productivity is generally low, in central and eastern zone of Tigray on average about 430 kg/ha, and contribution to livestock feeding is less than 25% (Tesfay *et al*., 2016).

Production of livestock forage through irrigation has recently been identified as one of the potential intervention measures of dealing with the highly variable livestock feed supply. Ethiopia has a long history of traditional irrigation systems. Simple river diversion still is the dominant irrigation system in Ethiopia (Ayele, 2011).

Irrigation is a good opportunity to grow off-season pasture and forage crops. Medium- and large-scale schemes are of much more recent origin, mostly in the Rift Valley for cash crops. There is some irrigated forage in the Rift Valley growing lucerne/Rhodes mixture for commercial fattening and dairy farming. The potential for irrigated forage is untapped and still there is a great opportunity for producing seasonal and long-term irrigated pasture and forages (Mengistu, 2006).

This will entail growing, harvesting and storing of the forage in the form of hay, or preserving it as standing hay and utilizing it during the dry season when the open pastures have been completely utilized (Schatz, 2003).

Legume forage crops can improve the utilization of low quality roughages and they are being used more extensively throughout the world. In various production systems legumes are capable of enhancing both crop production through sustained soil fertility and livestock production through increased availability of high quality feed (Assefa and Ledin, 2001).

To deal with this challenge, range land scientists, pasture experts and animal production specialists has considered several options of 'bridging' the feed supply/demand gap. One of them is the large-scale cultivation of fodder through irrigation within the arid and semi-arid lands where water for irrigation is available from sources such as rivers, dams, or harvested rain water stored for use during the dry seasons. A number of studies have evaluated the performance of range grasses under irrigation and some species have shown great potential for higher yields under rain fed cultivation (Opiyo, 2011).

2.3.2. Green feed management of dairy production in Ethiopia

Feeding management is an important idea for dairy production. Availability, quality and quantity of feed vary among dairy production systems. Cattle largely depend on rangeland grazing or crop residues that are of poor nutritive value. The feed is not uniformly supplied and the quality is poor (Ibrahim and Olaloku, 2000). Seasonal fluctuation in the availability and quality of feed has been a common phenomenon, inflecting serious changes in livestock production (Mengstu, 2005). The feed scarcity mostly happens in the dry season of the year (Ibrahim and Olaloku, 2000). In contrast, under normal circumstances in the lowlands when there is sufficient feed for cow, milk tends to be adequate for home consumption as well as for market (Nardos, 2010). Even though there are different improved forage species cultivated in the different areas of Tigray but the utilization practice is not as expected. Cultivation of these species has good quality to increase the dairy production with proper management.

2.3.3. Season and stage of harvesting of green feed

The season can vary the production of forage. The problems of seasonal availability of roughage feeds can be minimized through conventional feed conservation practices like hay making, silage making and straw treatment so that sustainable supply of roughage feeds can be ensured throughout the year (Mapiye *et al.,* 2006b). The stage of green feed for direct consumption is on the green leaf 50 % flowering and before setting seed, whereas for the storage cutting, of the hay during the autumn season, especially in September month and from irrigation product especially for direct use on fresh or green feed for their cattle. Seasonal changes in the nutritive value of improved grasses have been quantified on hand-clipped forage and on esophageal extrusa. The most important feature is the decline in protein content as the wet season progresses (as the plant matures) (Mapiye *et al*., 2006b). The amount of forage vegetation available is mainly influenced by rainfall variability, while the productivity, then, depends how the available forage resources are used (Sonder *et al*., 2003).

2.3.4. Feed storage methods

Fodder conservation is an important tool for evening out peaks and troughs in feed supply in a grazing enterprise and the fodder conservation process commences with the cutting of the crop still latter use (Meconen, 2014). The timing of the cutting influences the potential quality or feed value of the hay or silage. Cutting forage at a phase in the growth cycle, where vegetative growth and plant sugars are at or near their peak. This ensures that important feed attributes such as protein, digestible energy, dry matter percentage and digestibility are at their highest potential at the beginning of the conservation process. Most grasses and limited legumes have made into hay of varying quality. However, all successful hay making relies on wilting the cut plant to a moisturizing or dry matter level where it is dry enough not to ferment and wet enough not to shatter when baled. This is usually at about 12-14% moisture content, but varies according to bale size and shape (Tesfay, 2014).

Farmers use different forms of conservation practices in Tigray. The most common practices for conservation of feed resources are hay making, traditionally conserved crop residues, and grazing in the form of standing hay. It is the oldest and still the most important conserved fodder in all altitude zones, despite its reliance on the presence of suitable weather at the time of harvest.

2.4. Green feed utilization for dairy production

2.4.1. Modes of utilization of green feeds for dairy cattle

Forages play varying role in different livestock production systems. In general, however, they are important as a mix to crop residues and natural pastures and may be used to fill the feed gaps during periods of inadequate crop residues and natural pasture supply by coming to feeding place as cut and carry system, give to the animals either by chopping and cutting. 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. Crop residues often provide energy while forage legumes provide proteins by mixing crop residue with improved forages and also improved forage production as livestock feed and natural conservation structures in Tigray .The purpose of mixing the different feed ingredients is to improve the quality and intake of the inferior quality feed resources such as crop residues (Feyissa *et al*., 2014).

Legume forages also provide benefits such as soil fertility through their nitrogen-fixing ability and are also useful in breaking insect, weed or disease cycles, which are likely to occur when they are not supplemented. In many situations, however, forages compete with other crops. In land scarce smallholder, forages may compete with other crops for land and in land abundant pastoral systems, they may compete for the herders labor (Birhan and Adugna, 2014).

In Tigray livestock feeding is based on grazing communal grazing lands, roadsides, area closures and crop residues (straw, maize and sorghum Stover). There is a culture of closing part of grazing lands during the rainy season, but the system of utilization of grasses grown in closures differs from place to place. In some areas, farmers have bylaws to administer and use closures at the end of the rainy season (Gebreyohannes and Hailemariam, 2011). The crop residue mixes with irrigated forage, upgrade the quality and palatability of feed. Whereas societies having the potential of irrigation opportunity cultivate improved and local grasses around the side of cultivated land, intercrop with vegetation or sow separately and use the fodder through cut and carry system to feed their animals (Birhan and Adugna, 2014). In Central and Eastern zone of Tigray Farmers used to improve crop residues include mixing with other feeds and helping a mixed feed to livestock (Tesfay *et al*., 2016).

2.4.2. Effect of improved forage for dairy production

Feeding is a fundamental aspect of dairy cattle production. In order to improve milk production levels, energy inputs such as concentrate feeds have to be considered essential for any dairy enterprise. Dairy cows compared to other farm animals produce large amount of milk, hence require sufficient quantity and quality feeds with all necessary nutrients, including energy, protein, minerals and vitamins. Various improved legume and grass forages like alfalfa and elephant grass are fed to dairy cows to satisfy their nutrient demand. In a good quality pasture, some dairy cattle weighing 400kg are able to eat 40-60 kg fresh grass per day, which is enough for a milk yield of about 7-8 kg. If the pasture is poor (dry season, overgrazed), additional feed is required even at lower milk production levels (MOA, 1999).

From the tree legumes *Leucaena* leaf meal is often fed to cows and the more *Leucaena* leaf meal provided, the higher the milk yield. A level of 2.6 kg of *Leucaena* leaf meal with 1.8 kg

of cottonseed husks gave similar milk yields as a manufactured1.8kg cotton seed cake (Chaussa, 2013b).

2.5. Theoretical Background of green feed Adoption

The adoption process of new technology is defined in several ways adoption process refers to changes that took place within the mind of an individual with respect to an innovation from the moment that he/she first becomes aware of the innovation to the final decision to continuously use it or not. The term adoption defines as it relates to the use or non-use of a particular innovation by individuals (Say farmers) at a point in time or during an extended period of time (Colman and Young, 1989).

The rate of adoption is defined as the percentage of farmers who have adopted a given technology and the intensity of adoption is defined as the level of adoption of a given technology. Intensity of adoption increases with the extent of market participation, household resource base, contact with extension workers and secure land tenure (Arega, 2009). The number of hectares planted with improved seed or the amount of input applied per hectare will be referred to as the intensity of adoption of the respective technologies (Gashu *et al*., 2014).

2.6. Determinants of the adoption of green feed utilization in irrigated areas of Ethiopia

The conditions for successful introduction of forage technologies could be socio-economic factors, policy options and feeding system. Potential for adoption may be advanced 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. According to Gebremedhin *et al*. (2003) household resource endowment,

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.

Some of the most common cultivated forages in Ethiopia are oats, vetch, elephant grass, alfalfa, cowpea, Rhodes grass, etc. The contribution of cultivated forages is very small. In spite of many years of work on forage research and extension activities, the adoption of improved forages by smallholder farmers is very low (Mekonnen Yirga and Ali Seid, 2013). The possible causes for the low adoption of improved forage by smallholder farmers could be many and may vary from place to place. It was mentioned that the possible reasons for the low adoption of improved forages by smallholder farmers include low level of awareness of smallholder farmers about the production and importance of cultivated forages; lack of adequate extension service in adoption of improved forage technologies; lack of suitable forage seeds and planting materials; competition of forage production for resources (land, labor, and possibly other inputs) with crop production; and relatively low price of animals, and animal products that does not encourage farmers to intensify their livestock production (Tsegay, 2010).

A number of empirical studies have been conducted by different people and institutions on the adoption and diffusion of agricultural innovations both outside and in Ethiopia. But, the studies are mainly conducted around major cereals and other crops and practices and due to this fact, the studies conducted in the area of green feed management and utilization are very limited. As a result of this, the review mainly included such studies conducted in different contexts. For ease of clarity the variables so far identified as having a relationship with adoption are categorized as personal and demographic variables, economic factors, socio-psychological related factors, and extension/communication factors (Petros, 2010).

2.6.1. Personal and demographic variables

Household's personal and demographic variables are among the most common household characteristics, which are mostly related with farmers' adoption behavior. From this category of variables, education, experience in farming and age are cause factor for adoption of green feed (Arega, 2009).

2.6.2. Dairy production and distance

It is important to note that dairy farming is not taken as a major economic stay of the farmers in the rural areas; rather it is mostly treated as opposite. Such a tendency is also observed in urban centers. The development or progress so far shown since its beginning is believed to be unsatisfactory in which demand proceeds supply due to high rate of population growth in most urban centers (Tsegay, 2010).

2.6.3. Land scarcity

Especially due to land scarcity and crop-dominated farming there has been limited spontaneous introduction of improved pasture and forages. During the Fourth Livestock Development Project, different strategies and species for pasture and forage development were selected (Mengistu, 2006). Low adoption of forage can affect for the production of animals. According to Wondatir and Mekasha (2014) the major constraint to such low productivity is a shortage of livestock feeds in terms of quantity and quality, especially during the dry season. Moreover, progressive decline of average farm sizes in response to rising human populations, encroachment of cropping land onto grazing areas and onto less fertile and more easily erodible lands, and expansion of degraded lands, which can no longer support either annual crops and pastures contributes to shortage of feed resources. Feed supply from natural pasture fluctuates following seasonal dynamics of rainfall (Alemayehu, 1998). Despite these problems, ruminants

will continue to depend primarily on forages from natural pastures and crop residues. According to Nardos (2010) the average landholding size of the smallholder dairy producers was reported to be 0.089 hectares (ha) in Mekelle, which is less than the result of Guteta and Abegaz (2015) the average farm size of the catchment of Arsamma Watershed, Southwestern Ethiopian Highlands was 0.98 ha .This has negative consequences on the household income and dairy production.

2.6.4. Access to credit

Access to credit is one of the ways in order to finance and expand any business like dairy business. Absence of access to credit and limited their production by having only few numbers of cross breed cows and shortage of improved as well as green feed. These credit need to have more cows if they get access credit to finance their dairy farm (Nardos, 2010).

The majority of the farmers could not afford to raise enough capital to purchase the required inputs (such as planting material, fence, machinery, implements, fertilizer, chemicals, etc.). And later meet the labor costs required to manage the forages (Jahnke *et al*., 1988). Capital availability was a major factor affecting adoption of improved forages in Kenya (Steinfeld H, 2006). Access to credit for purchasing inputs plays a crucial role in the development and adoption of new technologies and improved feed resources, especially in low-income households (Mapiye *et al*., 2006a).

2.6.5. Low yields and lack of persistence of legumes

Little yields and lack of persistence were stated as one of the factors limiting adoption of forage legumes in this study. This was mainly qualified to low rainfall, especially during the dry season. Low agronomic performance was described as a restriction for adoption of some browse species in the Chikwaka communal area in Zimbabwe (Hove *et al*., 2003). In Uganda, Kabirizi

J (2004) designated that forage legumes were not the best option for resolving dry season feeding because of the little yield and absence of persistence during the dry season. Persistence is a significant quality of forage legumes that regulates their use as permanent pastures (Frans Swanepoel, 2010).

2.6.6. Mass media exposure

The adoption process of agricultural technologies depends primarily on access to information and on the willingness and ability of farmers to use information channels available to them. Mass media exposure was also hypothesized to be one of the determining variables to affect the adoption of conservation technologies. A study showed that media exposure (exposure to radio, TV and printed media) has a positive effect on adoption of technologies (Petros, 2010).

Mass media and neighboring farmers also important in diffusion of agricultural innovations, and Particularly, interpersonal communication networks among farmers are important and reported in many studies to have positive influence on farmers' adoption decision. This have positive relationship of mass media with adoption of agricultural technologies (Gecho, 2005).

2.7. Impact of green feed on dairy animal Performance

Performance of dairy cattle can be measured by the production and reproduction parameters which are done by different researchers. Dairy cattle which do not access adequate feeds necessary to meet their nutritional requirements for maintenance, production, and reproduction, results in delayed age at first calving, long calving intervals and low milk yield. For a normal dairy cow, dry matter consumed within 24 hours should be 2.5-3% of its body weight. For a cow weighing 600kg require 15.4kg dry matter when grazing for 8 hours (Chaussa, 2013a).

2.7.1. Milk yield

Good quality roughage is the basis of a high milk production. Examples of good quality pasture grass and hay which has been harvested at an early stage of growth (before seed setting), various legumes, and elephant grass with dark green color and harvested at the length of 90 cm. Roughages of poor quality are maturing hay, cereal straw, maize stove and overgrown Napier grass (Chaussa, 2013a).

According to Weldemariam (2010) average daily milk productivity of crossbred cows increased by about 51% in 2009 compared to 2004 and that of local cows by 34.6%. This was mentioned to be due to the combined efforts exerted on fodder availability, improvements in animal health services and breeding technologies. Average milk production (L/cow/day) for crossbred dairy cows was 10.82 in 2009 compared to 7.17 in 2004 and for local dairy cows, the milk productivity was 2.06 L/cow/day in 2009 compared to 1.53 L/cow/day in 2004. The result coincides with the milk yields of crossbred cows ranges 9-21 L/day/cow while that of local cows' range is 1-5 L/day/cow in Atsbi-Wemberta district, eastern Tigray (Weldemariam, 2010). Management through different trainings, study tours to exemplary areas inside and outside the district was another reason for the milk production improvement.

2.8. Constraints of green feed production, management and utilization

More number of useful forages have been selected for different zones, although the adoption rate is extremely low. This is obviously reflected in many parts of Tigray where the agricultural extension system has tried to introduce and distribute various improved forage species and up now the success rate, measured in terms of better-quality animal production benefits, is under expectancy (Tesfaye, 2010). In other studies, the major constraints to forage and browse legumes were shortage of inputs (27.2 % of the households), low yield and lack of persistence

of legumes (24.0 %) and lack of fencing material (18.6 %). Other constraints mentioned were lack of capital (10.0 %), lack of knowledge (7.1 %), shortage of labor (5.7 %), shortage of land (4.3 %) (Mapiye *et al*., 2006a).

2.8.1. Shortage of quality feed

These constraints result in low milk production, longer parturition intervals, and lower animal weights. Shortage of feed and high cost of feed is a number one problem. Shortage of feed happened due to many reasons, mainly due to less provision of crop production and depends on rain fed agricultural system. Crop production availability is based on the season, during the dry season animal feed like hay and roughage are very scarce and with a high price (Nardos, 2010).

2.8.2. Lack of inputs

The main inputs limiting adoption were scarcity of planting material, inoculants, implements, fertilizers and chemicals. Farmers infrequently collect or use seeds from their own farms or from their neighbors, as they still imagine the forage/tree seedlings or seeds from projects, government and non-governmental organizations (Mapiye *et al*., 2006a). Provision of inputs and services related to livestock production is important in improving the productivity of the livestock sub-sector. The major inputs related to livestock are forage seeds, forage planting materials(Gebreyohannes and Hailemariam, 2011).

2.8.3. Land and forage seed

Land is an important asset for the resource poor farmers, helping to prepare improved feed by planting different types of grass like alfalfa, elephant grass which helpful for milk production increment and minimize cost of feed to be purchased. Even if dairy producers are interested to expand their dairy farm, the land size may not allow most of them to do so. As land size

increases more and more facilities become inevitable that take-up space other than the animal barn (Nardos, 2010).

2.8.4. Water shortage

Water shortage affect the forage growth and production. Proper utilization of water and conserving for dry season is good to sustain forage development .Under Infrequent irrigation had reduced biomass accumulation of sorghum forage ; the reduction of biomass was higher when low irrigation frequency (Aishah *et al*., 2011). Other studies indicate about drip irrigation decreasing water supply decreased fresh and dry yield of alfalfa however it increases Irrigation water use efficiency and consequentially water saving (Ismail and Almarshadi, 2011). Ruminates require water to maintain the water content of their body, and water availability affects voluntary feed intake; less water leads to inadequate intake of dry matter. For animals kept under pastoral production system, the frequency of watering is very important. During the dry season water is available only from wells and some lakes and streams (Ibrahim, 2002). This leads to overgrazing around watering points. Water intake increases as watering frequency is decreased and feed conversion efficiency becomes lower as watering interval increase (Ibrahim and Olaloku, 2000).

CHAPTER 3: MATERIALS AND METHODS

3.1. Descriptions of the study areas

3.1.1. Physical characteristics

This study was carried out in the central zone of Tigray along Ahferom-Adwa-Laelay Maichew milk sheds where irrigation-based forage production is practiced. These three districts are found in the milk shed belts of Tigray region for their suitable climatic conditions for improved dairy animals. Ahferom, Adwa and Laelay Maichew districts are amongst the 34 rural weredas of Tigray region, located in the central zone. These are located at 14^0 06' 30" to 14^0 38' 30", 14^0 08' 43" to 14^0 11 '47", 14^0 07' 00″ to 14^0 09' 20″ North latitude and from 38^0 56' 30" to 39^0 18' 00", 38^0 53' 55"to 38^0 57' 30", 38^0 38' 00″ to 38^0 49′ 09″ East longitude, respectively.

Ahferom district is bounded by Eritrea in the North, Adwa in the West, Ganta-Afeshum and Gulo-Mekeda in the East and Worei-Leke in the South. Adwa is surrounded by Merebleke District from North, Ahferom and Werileke Districts from East, Werileke and Laelay Maichew Districts from South, and West. Likewise, Lailay-Maichew district is bordered in the east by Geter-Adwa district and Werileke districts, north by Merebleke district, southern by Naidier-Adiet district and west by Tahitay-Maichew district.

The total area of Ahferom District is about 133,979 hectares, of which 23,434 (17. 5%), 21,458 (16%), 18,823 (14.04%), 7,389 (5.5%), 1,374 (1.02%) and 51,501 (38.44%) hectares are cultivated, forest covered, bare land, grassland, unused land due to Ethio-Eritrea conflict and miscellaneous, respectively. The total area coverage of Adwa district is 65,531ha with 22,049 ha forest plantations (33.6%), 24040 ha ex-closures (36.6%), 13714 ha farmlands (20.9%),

2283 ha grazing areas (3.5%), 1481.5 ha settlement (2.26%) and 1599.5 ha miscellaneous (2.44%). Whereas the total area coverage of Laelay Maichew District is 43237.38 ha; of which 15214 ha is arable (35.2%), 7253.1 ha is forestland (16.7%), 15601.1 ha is grazing (36.08%), 1389 ha is barren land (3.21%), and 3419.2 hectares (7.9%) others.

Ahferom district has a total human population of 206,993. Of the total population, 48% and 52% are males and females, respectively. The numbers of households living in the rural areas are 36,524 (23,923 male HHs and 12,601 female HHs). The livelihood of the population living in the district is directly or indirectly engaged in the agricultural activities (ARDOAW, 2014). Adwa has a total human population of 112,987; of which 56,307 are males and 56,680 females and the total households are 25,165 with 17,654 males (70%) and 7,571 females (30%). It has a population density of 163 persons per km^2 with 4.4 average numbers of persons per rural household. The total human population of Laelay Maichew district is 80,817; out of which 40,285 (49.8%) are males and 40,532 (50.2%) females. Laelay Maichew district holds about 17,986 households with 73% male HHs and the rest 27% female HHs. Economically active population of the District (15-64 years of age) is estimated at about 41,621 people; out of which, 20,747 are males and 20,874 females. The settlement pattern in the District is mainly dispersed (LMWARDO, 2011).

The main economic activities of these study areas are mixed crop-livestock farming, which been practiced by the small holder farmers (crop cultivation and livestock rearing). The dominant crops produced in the areas are cereals (Teff, wheat, '*Hanfets'* mixture of barley and wheat, finger millet, sorghum and maize), vegetables (onion, tomato, garlic, cabbage, carrot, and lettuce) and oil crops (linseed) and noug (Niger seed). Livestock population of the central zone is 732,701 with and 92,399 milking cow are local and cross which are from rural and urban farmers with different production system. With regards to the specific study districts,

Ahferom contains 310,382 cattle, 11,0389 goats and sheep, 3,649 equines and 255,794 poultry. Adwa includes 30,091 cattle, 85,258 goats, 46,573 sheep, 12,198 equines and 132,773 poultry. Little irrigation and forestry activities are the sources of livelihood next to crops and there are also some supportive activities like food/cash for work in governmental and non-governmental organizations and other off-farm activities(ARDO, 2011).

The livestock population of Laelay Maichew district has an estimated livestock population of 49,202 cattle, 33,823 sheep, 51,626 goats, 9,782 donkeys, 154 camels, 35 mules, 8,293 beehives and 73,005 chickens. The availability of feed and water are serious constraints to livestock production in the district. Communal grazing areas, private pastures and crop residues are the principal sources of feed (LMWARDO, 2011).

These districts receive an annual rainfall ranging from 700-1500 mm, 600 to 850 mm and 550-941.5 mm for Ahferom, Adwa and Laelay Maichew, respectively. And the annual mean temperature ranges 22 to 27^{o}C, 12^{o}C to 27^{o}C and 20-27^{o}C, respectively. The altitude ranges between 1,617 and 2990 m.a.s.l. Ahferom district comprises 33 Kebeles; of which 6 are urban Kebeles and 27 are rural kebeles. The agro-ecological zones of the district are Kola, Woina-dega and Dega. Of the 33 kebeles, 5, 19 and 9 kebeles belong to Kola, Woina-dega and Dega, respectively (ARDOAW, 2014).

The study was carried out in five tabias: Sero and Laelay- Megariatsemri from Ahferom, Mariam-Shewito and Betehans from Adwa and also Dura from Laelay-Maichew. These tabias have irrigated areas with Sero (580 ha), Laelay-Megariatsemri (690 ha), Mariam-Shewito (534.5 ha) and Betehans (766 ha) and Dura (580 ha) with little irrigated forage, respectively, also there are small town around and Enticho-Adwa-Axum towns to purchase their dairy products.

The map of the study districts was made by Ethiopian projection coordination system which was by Adindan-UTM-zone 37 North.

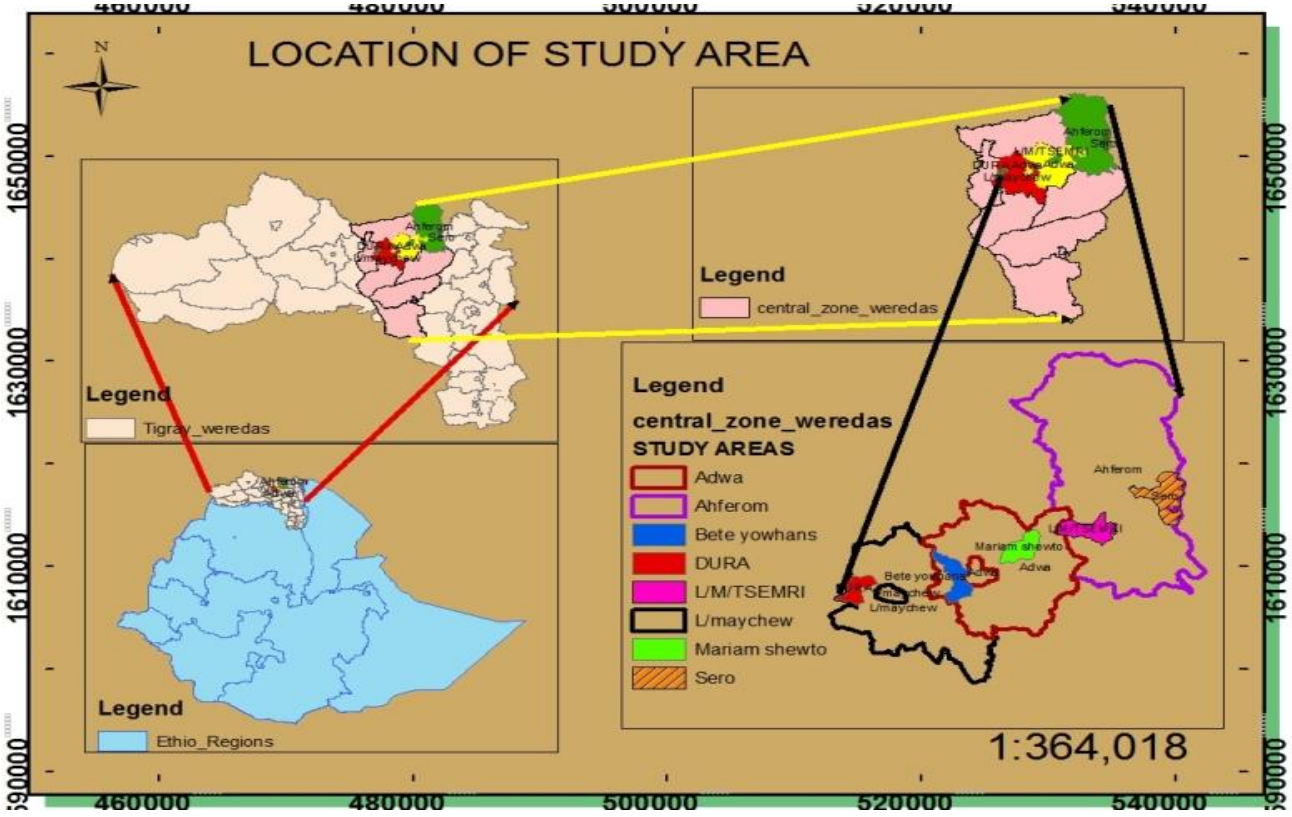

Figure 1.Location map of study districts and tabias

Source (own work, 2016)

3.2. Sample size and sampling methods

The study was carried out in five tabias of the three selected districts, namely Ahferom, Adwa and Laelay-Maichew, which are located in the central zone of Tigray region, northern Ethiopia. These three districts are found in the milk shed belts of the region for their suitable climatic conditions for improved dairy breeds. In addition, these three districts are working sites of the livestock and irrigation value chain for Ethiopian smallholder's LIVES-ILRI project which offered financial support to this research project. The four stage sampling techniques were applied in sample selection processes. In the first stage three districts were selected based on their potentiality in dairy production and irrigated forage cultivation purposively.in second stage five tabias (Table 1) were chosen purposively based on their potentiality in dairy production and irrigated forage cultivation. In third stage from the household of study *tabias*

3.5 % of the household were purposively selected proportional to size for the sample size. A total of 200 respondents were selected. Fourth stage the dairy producers were stratified in to irrigated feed adopters (100) and non-adopters (100) using random sampling methods from the list of districts. Of the total sampled dairy producer respondents about 13.5% were female households. The list of common green forage users and non-users for dairy production were taken from the district and tabias offices of agriculture and rural development.

Table 1. Sample size determination for Household survey

S/n	Tabia	Total HH	Sampling size		
			adopters HH	non- adopter HH	Total sample
1	Sero	1400	25	24	49
2	Laelay MegariaTsemri	1089	19	19	38
3	Mariam Shewito	1208	21	21	42
4	Betehans	1065	18	19	37
5	Dura	979	17	17	34
Total		5741	100	100	200

(Source: District Agricultural Office. 2016)

3.3. Data collection methods

Data sources

In this study, both primary and secondary data sources were employed to gather the required data. Primary data were collected through interviews, focus group discussions, field observation and personal observation during sample were taken. Secondary sources such as published and unpublished literatures were collected from different governmental and non-governmental offices. The source and methods used to obtain data for the research are outlined below.

3.3.1. Household interviews

The questionnaire was translated in to the local language (*Tigrigna*) and pretested in nearby tabias. After checking the pretested semi-structured questionnaire, it was continued for practical collection of the data from individual respondents. Available data were collected by interviewing respondent's perception in their own words, a very desirable strategy in qualitative data collection. Structured and semi-structured questionnaire was developed to collect data through the household interview. This allows the surveyor to present the meaningfulness of the experience from the respondent's perspective. The research interview made to understand the situation from the subject point of view, to unfold the meaning of people experience and uncover their lived world. A total of 200 dairy producer respondents were interviewed using the semi structured questionnaire. Quantitative and qualitative data were collected on:

- Household socioeconomic characteristics:
- sex, age, family size, education level, land size holding, livestock type, number of dairy cattle, experience in dairying, purpose of cattle rearing and other relevant information;
- Farmers' indigenous knowledge and management practices on green forage utilization;
- The green fodder harvesting and utilization techniques in relation to dairy production;
- Agronomic practices for each and every irrigated species;
- The propagation practices/methods of irrigated feed;
- The green fodder preservation and conservation methods;
- Irrigated forage production with the benefit of producer and consumer;
- The impact of green feed on animals productive and body condition like milk production, body condition, health condition;
- Challenges and prospects of dairying;
- The potential determinants for adoption of green forage; availability of green feed to utilize, merits of plant (increase animal productivity), the distance of home (from the FTC, districts),

education level, sex of household, access to training, access of seed, land holding, communication media and type of livestock production in the study area;

- Constraints related to irrigated feed production, management and utilization practices; and
- Perceptions of the dairy producers toward the introduced irrigated green fodders.

3.3.2. Focus Group discussions

Five focus group discussions (one from each tabias) were held to gather qualitative data and prioritize some important variables. The group discussion was composed of 10 people comprising of key informants, elders, women and youths. A list of questions was forwarded for discussion in which the researcher acted as facilitator. In addition to this, formal and informal discussions were held with districts experts, tabias administrators and development agents. The discussions enabled to gather qualitative data that also helped to validate the data collected through household surveys.

3.3.3. Estimation of green fodder production

First the major available forage species were identified and prioritized according to their importance and availability during the group discussions. Field measurements for biomass production were carried out on the common forage species that cultivated in the study areas. Herbaceous forages were measured using quadrant methods (1m x1m size) from representative samples. About 42 sample quadrants were taken to measure the biomass of alfalfa, elephant grass and composite local grass from pasture area within three level of production from high production level, medium and from low production within five study areas to represent the sample. All the herbages that fell within the quadrant were cut off about 5cm height from ground level and measured by balance to know fresh biomass. Then after sample herbages were dried using overnight oven at 105^{o}c within 24 hours and DM amounts of species was estimated through calculation. Similarly, fodder trees/shrubs samples were taken to measure their amount

in age class, from each household then forage biomass yield was measured by calculating the number of legume trees X productivity of each plant kg/year from literature X frequency of harvest per year.

Figure 2.field measurement A= alfalfa, B=local grass harvested from 1m*1m size of plot area and the final(C) photo shows cultivated alfalfa sample forages on the study districts 2016

3.3.4. Secondary data collection

Secondary data contribute a lot to meet the research objective. Secondary data were collected from various reading materials such as published books, articles, journals, maps and bulletins from relevant organizations and institutions. Annual report of bureaus and offices as well as policy documents about agricultural development, climate resilient were among the secondary data collected and utilized in the research process.

3.4. Data analysis procedures

Computer Excel program was used for data arrangement and management. The obtained data were analyzed using SPSS version-20 software (2013) for the use of all data coding and to analyze descriptive statistics (mean, standard deviation, standard errors, range, percent, frequency, etc.) and Stata version 11was used to analyze determinant factor of green feed adoption the econometric analysis by using probit models were used.

The identified fodder species, constraints of fodder production and merits of green fodder were prioritized using preference index. Ranked data were computed using Microsoft Excel as an Index (for example for three levels of rank I = sum of ranks (3 X rank 1 + 2 X rank 2 + 1 X rank 3) given for an individual reason (attribute) divided by the sum of ranks (3 for rank 1 + 2 for rank 2 + 1 for rank 3) for overall reasons, criteria or preferences.

Tables, figures and graphs were used to summarize and present findings. Econometric models were employed to analyze the determinant factor for improved feed adoption from the collected data. It was used probit model to determine the association between variables. Mean differences of both discrete and continuous variables among adopters and non-adopters were computed using X^2 and *t* – tests, respectively.

3.4.1. Descriptive statistics

Descriptive statistics such as mean, percentage, frequency and ratio supported by test statistics for the variables demographic and socioeconomic, and institutional characteristics of sample respondents were applied to analyze the access of green feed production and green feed utilization for dairy production.

3.4.2. Econometrics data analysis

Limited Dependent Variable models have been widely used in technology adoption studies. Probit and logit models are commonly used in studies involving qualitative binary choices. The logit model uses the cumulative logistic function. But this is not the only cumulative distribution function that one can use. In some applications, the normal cumulative distribution function has been found useful. Estimating model that emerges from normal cumulative distribution function is popularly known as the probit model. The probit specification has advantages over logit models in small samples (Fufa and Hassan, 2006). Then taking logit or probit model is matter

of choice of the candidate and also to the data has normal distribution it need to analyze by probit model.

As the selection equations that are determinants or independent variables whether particular observation was in the sample used to estimate equation.

X_1 = Education of the house hold head;

X_2 = Sex of the house hold head;

X_3 = Age of household

X_4 = Land holding size

X_5 = Distance to development centers (DISDEV):

X_6 = Access to get training (FTC)

X_7= Access of seed

X_8= Access of extension services

X_9= labor/family size

X_{10}= mass media

X_{11}= dairy production experience

3.5. Variable definitions

The data covered information necessary to make farm level indices of social, economic and demographic character. In order to investigate the research questions of the study, the following variables are hypothesized to determine irrigated feed adoption.

3.5.1. Dependent variables

Green feed utilization participation decision

The dummy variable that represents the decision of green feed utilization participation of the household were estimated in the first stage of the Heckman's and the Heckman's two-stage

selectivity model was used to investigate the factors that influence the probability of being participated in green feed management and utilization estimation procedure. Additionally, an econometric model probit was used to identify factors determining access of green feed management and utilization participation decision

This model was analyzed using the probit equation below.

$$Yi = \beta 0 + \sum_{i=1}^{m} \beta i\, xi + \varepsilon i$$

Where:

i = 1, 2… m

Yi is a dummy variable indicating the probability of getting access that is related to the equation as

Yi = 1 if a farmer has access to the services, Yi = 0, otherwise.

βi = are the coefficients to be estimated,

xi' = are explanatory variables in the Probit regression model,

εi = is random error term

3.5.2. Definition and hypothesis of independent (explanatory) variables

Variables were assumed to influence green feed management and utilization entry decision. Selection of independent variable needs to born in mind that the omission of one or more relevant variables or inclusion of one or more irrelevant variables may result in error of specification which may reduce the capability of the model in exploring the economic phenomena empirically.

Education level of the Household Head (HHEDUCA): Intellectual capital or education, measured in terms of categorical schooling of household head, has an effect on the green feed utilization participation decision. Sometimes, because of cultural and socio-economic

characteristics, education has opportunity costs in alternative enterprises (Lapar et al., 2002). Therefore, education level of the household is assumed to increases the participation or adoption of green feed increases.

Age of the household head (AGE): This is a continuous variable and measured in years. Age has proxy measured of farming experience of household. Aged household are believed as wisely resource users, and it would be expected to have a negatively effect on adoption of green feed utilization participation. Because most of times old persons use traditional knowledge and use extravagance. They are not easily adopting new technology.

Sex of the household head (SEX): The dummy variable taking one for male headed and zero for female headed households. In mixed farming system, both men and women take part in livestock management. Generally, women contribute more labor input in area of feeding whereas access to institutional credit, access to extension service, may affect women's participation and efficiency in livestock production (Tangka *et al*., 1999).

Land holding size: It is a continuous independent variable measured in hectare. As input for dairy production, land is very important for forage and pasture development to feed dairy cows. It expected that as size of land increases, proportion of land allocated for feed development and improvement increases. The hypothesis can be affected the adoption of utilization of green feed participation positively for dairy.

Distance to development centers /FTC (DISftc): This is a continuous variable measured in kilometers from the households' residence. Farmers' exist in far from the FTC may not frequently contact with extension agents, as a result extension information less utilized; therefore, constrains to get knowledge and improved inputs.

Access to extension service: is dummy variable that expected to have attending dairy product extensional advices from agricultural office worker has contribution in smallholder dairy irrigated feed utilization participation.

Total Livestock in TLU (TLSTLU): This is the number of live animals measured in tropical livestock unit. This variable is expected to get impact on smallholder dairy production and cultivated irrigated feed utilization participation

Dairy farming experience: is a continuous variable measured in number of years' respondents engaged in dairy farming activities. This experience in dairy production influences on increasing knowledge and management of dairy inputs and adoption of new technologies.

Access to seed: It is a dummy variable 1 for get seed and 0 otherwise. Then the availability of seed has an effect to cultivate green feed for their cattle. This variable is expected to have positive effect on the participation of green feed utilization.

Media access: is dummy variable taking the value 1 if the household head gets information by Radio, TV and/or mobile and 0 otherwise. These information source materials may play a significant role in creating awareness about new technologies in a fastest possible time.

Family size /Labor access: Labor access also play a role in whether farmers adopt forages or not, and household size was shown to influence adoption of forage/browse legumes in this study. The times when labor is required for forages/browses, it is often already occupied by other crop activities. Hence, labor constraints may continue to be a factor influencing adoption of improved forages. Farmers rely on hired labor for farm operations such as weeding and fodder conservation while family labor is used for land preparation, planting and harvesting (Mapiye *et al*., 2006a).

CHAPTER 4: RESULTS

This chapter presents the findings of descriptive and econometric analyses. In the first section, descriptive results of demographic, socio-economic and institutional factors of adopters and non-adopters are presented. Furthermore, identification and estimation of green feed; production, management and utilization of green feed; constraints and opportunities of green feed utilization; and impacts of green feed utilization for dairy milk production, body condition and health condition results are also addressed. In the second section, determinant factors for adoption of green fodder by sample dairy producer identified and presented.

4.1. Demographic and socioeconomic characteristics of sample dairy producers

The sample household heads age ranged from 20 to 72 years. The mean age of sample household heads was about 45.845±8.596 years with almost similar between adopters (46.04±8.566 years) and non-adopters (45.64±8.626 years). The average family size of sample household was 6.42±2 persons per household, Non-adopters had smaller productive members (6.25±1.7) than adopters (6.59±2.39). Sampled households were consisted of 86.5% male-headed and 13.5% female-headed; gender difference was an issue between adopters (82% male) and non-adopters (91% male). About 66.5% of the sample household heads were literate and the rest 33.5% were illiterate. About 81% of adopters were literate compared to 52% of non-adopters. Thus, educational status between adopters and non-adopters was statistically significant ($P<0.01$). The mean dairy production experience of non-adopters and adopters was 8.45 and 9.06 years, respectively with minimum and maximum experience of 1 and 28 for non-adopters and 1and 48 years for adopters. It was not statistically different. About 83% and 80% of non-adopters and adopters started their dairy keeping activity through buying cow from

markets and the rest 17% and 20% of the non-adopters and adopters, respectively through inheritance and given from parents. The breed of dairy of non-adopters and adopters were HF (46,42 %), Jersey (28,33%), Begait (15,14%) and the rest were local breed (Table5).

Table 2. Demographic and socioeconomic characteristics categorical variables of sampled dairy producers in three districts of central zone (n= 200)

Characteristics		Adopters(n=100)	Non-adopters (n=100)	Overall mean		χ^2 -value	p-value
		N	N	N	%		
Sex	Male	82	91	173	86.5	3.47[a]*	0.063
	Female	18	9	27	13.5		
Educational status	Illiterate	17	57	74	33.5	42.27[a] ***	0.000
	Primary school	79	36	115	57.5		
	Secondary	1	6	7	3.5		
	Diploma	3	1	4	2		
Marital status	Married	90	94	184	92	2.2 [a]	.528
	Single	2	1	3	1.5		
	Divorced	4	4	8	4		
	Widowed	4	1	5	2.5		
Main income Level	Farming	82	64	146	73	17.38 [a] *	.026
	Trader	1	8	9	4.5		
	Civil servant	3	7	10	5		
	Farmer and civil servant	2	1	3	1.5		
	Tiller	2	0	2	1		
	Daily labor	0	3	3	1.5		
	Farmer and trader	10	16	26	13		
	Tella maker	0	1	1	.5		
Labor access	Yes	84	2	86	43	137.17 [a] ***	0.000
	No	16	98	114	57		

Source: survey output, 2016 ***, ** and * represents 1%, 5% and 10% significance level, respectively
N – Number of observations % - percentage of observations

Table 3.Experience in dairy production and source of foundation stock (n=200)

Variable	Value	Non-adopters (n=100)	Adopters (n=100)
Dairy experience (year)	Mean	8.45±5.45	9.06±8.3
	Minimum	1	1
	Maximum	28	48
Source of dairy cattle	Bought	83	80
	Inheritance and Given	17	20
Dairy cattle breed	Holstein Friesian cross	46	42
	Jersey	28	33
	Begait	16	14
	Local and others	11	11

Table 4. Demographic and socioeconomic characteristics of sampled dairy producers of central zone Tigray (n= 200)

Characteristics	Non-adopters		Adopters		Overall mean	t-value	p-value
	Mean	STD	Mean	STD	Mean±STD		
Age	46.96	8.43	44.92	7.8	45.94±8.12	1.776*	.077
Total family size	6.25	1.76	6.59	2.39	6.42±2.1	-1.148	.253
Total farmland size	0.42	0.22	0.51	0.23	0.463(0.225)	-3.955***	.000
Dairying experience	8.45	5.52	9.06	8.4	8.76±6.96	-0.608	.544
Total livestock	5.27	2.15	5.43	2.32	5.35±2.24	-0.493	.623
Total gross income birr/HH/yr.	36584	24828.02	34231	17797.7	35407.5±13302.885	0.770	.442
Off/non-farm income birr/HH/yr.	6924	23295.1	3160.32	8473.4	5042.16(15884.25)	1.518	.131
Agricultural income birr/HH/yr.	31507	20029.9	31036.4	14430.2	31271.7(17230.05)	0.191	.849

*** and * represent 1% and 10% significance level, respectively STD = standard deviation

4.2. Livestock ownership

The study showed that the mean number of livestock kept per household was 5.43± 2.32 TLU for adopters and 5.27±2.15 TLU for non-adopters with no significant difference (P>0.05) (Table 4). Even though statistically it was insignificance, this result indicates that adopters have slightly more livestock number than non-adopters. This is probably due to the fact that adopter farmers can occasionally sell some of their livestock and the money obtained from sales can be used to buy seeds and other inputs for production of new crop and for the green fodder technology. The number of cattle (4.145) was more when compared with other livestock species. Cattle were followed by donkeys (0.61), goats (0.30) and sheep (0.25) in number. Most of the non-adopters are trader for that matter the total income of non-adopter is higher than that of adopter mostly they have trade activities as additional income source.

Table 5. Livestock holding size of the sampled respondents in three districts of central zone of Tigray (TLU/HH) (n= 200)

Livestock type	Non-Adopters					Adopters					Overall
	HH owner		TLU/HH	Max.	Min.	HH owner		TLU/HH	Max.	Min.	mean±SD
	Yes	No				Yes	No				
Total LS	100	0	5.282±2.15	11.90	1.2	100	0	5.428±2.324	12.1	1	5.355±2.23
Cattle	100	0	4.08±1.56	8	1	100	0	4.21±1.65	9	1	4.145±1.6
Sheep	37	63	0.207±.34	1.4	0	50	50	0.307±.38	1.5	0	0.257±0.36
Goat	39	61	0.289±.471	2.3	0	42	58	0.327±.48	2.2	0	0.308±0.47
Poultry	61	39	0.037±.063	0.5	0	76	24	0.059±.077	.60	0	0.048±0.07
Donkey	61	39	0.648±.629	2.4	0	53	47	0.584±.632	1.6	0	0.616±0.63
Camel	3	97	0.048±.29	2.4	0		100	0	0	0	0.024±0.20

Source 2016 survey result

4.3. Purpose of keeping dairy cattle

According to the respondents, cattle are kept for different purposes such as land ploughing, income source, breeding, manure, food source, asset building and other socio-economic functions. The respondents tried to rank these purposes as breeding, income source, home consumption, ploughing source, asset building and social values according to their importance. The purpose of cattle keeping in case of non-adopters is for ploughing (3rd), home consumption

(4th), and sale for income generation (2nd), breeding purpose (1st), asset building (5th) and social value (6th). Whereas adopters keep cattle for the purpose of land ploughing (4th), home consumption (3rd), sale for income generation (2nd), breeding purpose (1st), asset building (6th) and social value (5th). Livestock perform serious functions and play multiple roles for both poor and non-poor livestock-keepers. Livestock production can also be taken as job opportunity (investment) for a lot of people since human population and demand of livestock product is increasing through a period of time.

Table 6. Purpose of cattle keeping in in three districts of central zone (n=200)

Livestock purpose	No adopters					Adopters					Rank	Over all I	Over all rank
	High	Medium	Low	Index	Rank	High	Medium	Low	Index				
Land ploughing	48	8	7	0.183	3	32	14	2	0.136	4	0.16	4
Home consumption	27	27	20	0.170	4	30	20	29	0.171	3	0.17	3
Income source	46	30	10	0.228	2	45	37	6	0.231	2	0.23	2
Asset building	18	17	2	0.099	5	23	13	1	0.103	6	0.10	5
Breeding purpose	46	37	8	0.241	1	50	32	8	0.239	1	0.24	1
Social value	16	5	13	0.078	6	25	9	18	0.119	5	0.10	5

Source: survey data 2016

4.4. Land holding and land use

Land is an important production asset for the smallholder farmers. Results from this study indicated that the average land holding per household in the adopters and non-adopters was 0.51 and 0.398 ha, respectively which included arable land, private grazing, irrigated land and forage land. The overall results showed that most of the households (78.5 %) possess land below 0.5 ha and 16.5% household own 0.51-1.00 ha of land. Only 1.5 % of the households have total land of greater than 1.5 ha. There was significant difference ($P<0.001$) in land holding among the adopters (0.51ha/HH) and non-adopters (0.42 ha/HH). The classification of the household land use patter is indicated in Table 7. Cultivated land (0.405±0.23 and 0.405±.19), grazing

land (0.0077±0.039 and 0.0074±0.052), forage land (0.0076±0.035 and 0.039±0.133), irrigated land (0.057±0.108 and 0.12±0.107), fallow land (0 and 0.004±0.028), shared out (0.005±0.05 and 0) and shared in (0.067±0.2 and 0.048±0.2), respectively for the non-adopters and adopters. Even the land size of the adopters and non-adopter show small, adopters shared for forage production and for crop production efficiently, whereas the non-adopters prioritize for crop production. This indicates that land is a scarce asset and this might be due to the increasing human population pressure. This has formed serious scarcity of cropland and forage farm as well as grazing land.

Table 7. Total farm size and farm use of sample dairy producer (Ha/HH) in three districts of central zone of Tigray (n=200)

Farm type	Non-Adopters	Adopters	Overall mean
	Mean(STD)	Mean(STD)	Mean(STD)
Total farm size	0.416(0.22)	0.509(0.23)	0.463(0.225)
Cultivated land	0.405(0.23)	0.405(0.19)	0.405(0.21)
Grazing land	0.0077(.039)	0.0074(0.052)	0.007(0.045)
Forage land	0.0076(.035)	0.039(0.133)	0.023(0.084)
Irrigated land	0.057(0.108)	0.12(0.107)	0.089(0.107)
Fallow land	0.00(0.00)	0.004(0.028)	0.002(0.014)
Shared out land	0.005(0.05)	0.00(0.00)	0.002(0.025)
Shared in land	0.067(0.2)	0.048(0.2)	0.057(0.200)

Source: survey output, 2016 STD = standard deviation

4.5. Access to Extension services

4.5.1. Extension

Extension services of the respondents vary among adopters and non-adopters. Nearly 44% of the non-adopters and 84 % of the adopters get agricultural extension services at FTC and at districts level. The rest do not get extension services and this might affect the adoption ability of the farmers. According the respondent's response non-adopters were rather than went to FTC they went to others works like working at *Almeda fabric*, off farm activity and other personal

activities do not participate on the meetings takes place at FTC. Extension service is known to catalyze awareness, organization, information exchange and technology adoption among farmers.

Access to information is very important for adoption of improved technologies. About 51% of the adopters have access to media (Radio and TV) while most of the non-adopters do not get information about green feed management and utilization practices. Even they listen about forage production and utilization their priority was for the other trade and off farm options. Training is a special skill about one discipline. About 78% of the adopters got training on forage production and management while no one of the non-adopters got the same training. Because training is given purposively more for model farmers. Forage seed supply is important for adoption of forages. Here in this study, majority of the adopters (69%) got forage seed to grow in their private land. The forage seeds are obtained from governmental offices (extension and research) and non-governmental organizations (like REST, FARM Africa).

Table 8. Access to extension services by sampled respondents for discrete variables in in three districts of central zone of Tigray (n=200)

Characteristics		Non-adopters		Adopters		Overall		χ2-value	p-value
		N	%	N	%	N	%		
Extension	Yes	44	44	84	84	128	84.6	34.72[a] ***	0.000
contact	No	56	56	16	16	72	36		
Media Radio and	Yes	1	1	51	51	52	26	64.97 [a] ***	0.000
TV	No	99	99	49	49	148	74		
Getting training	Yes	0	0	78	78	78	39	127.9 [a] ***	0.000
	No	100	100	22	22	122	61		
Forage seed	Yes	9	9	69	69	78	39	75.66 [a] ***	0.000
supply	No	91	91	31	31	122	61		
Planting material	Yes	0	0	9	9	9	4.5	24.2 [a] ***	0.000
	No	100	100	91	91	176	88		

Source: survey output, 2016; ***, **and * represents 1%, 5% and 10% significance level, respectively N – Number of observations % - percentage of observations

Table 9. Other institutional characteristics of sampled dairy producers for continuous variables (n=200)

Characteristics	Non-adopters	Adopters	Overall	t-value	p-value
	Mean(STD)	Mean(STD)	Mean(STD)		
Distance to Districts agriculture office	11.97(5.06)	13.14(4.28)	12.56(4.67)	-1.765*	.079
Distance to market	11.67(5.48)	13.1(4.34)	12.38(4.91)	-2.053**	.041
Distance to FTC	5.28(1.93)	2.3(1.91)	3.79(1.92)	10.99***	.000

Source: survey output, 2016; ***, **and *represents 1%, 5% and 10% significance level, respectively; STD = standard deviation

Farmers trade part of their agricultural products immediately after harvest to cover their costs of production, social duty and crucial family expenses in the nearby market. The result indicates that the average distance of farmers' residence from the nearest market place was 12.38 ±4.91km. Non-adopters' residence (11.67km) was the nearest market than that of adopters (13.1km) ($P<0.05$). Infrastructure is another key service for farmers, as it helps them to sell their farm products. The average distance of the farmers' home from district agricultural office was 12.56 ±4.67km; however, there was little significant difference in residences distance from main roads between adopters (13.14km) and non-adopters (11.97km). The FTC has been established before a decade at each *Tabia* to serve as nodes, which could provide extension service (packages), training (short term and modular), demonstration and centers of exhibition and information, as a result, disseminates agricultural technologies (Gebremedhin et al., 2006). The average distance of farmers' home from FTC was 3.79 ±1.92km. The difference between average distance of adopters (2.3 km) and non-adopters (5.28 km) home from FTC was seen to be significant ($P<0.001$) (Table 9).

4.6. Livestock feed resources

The major livestock feed resources in dry and wet periods are presented below (Table 10). Overall, the most vital feed resources to livestock in the study areas during the dry season are crop residues, hay, green feed and weeds, Attela, improved forages and browse trees. Among these feed resources, crop residues and hay contribute the largest share of feed to livestock. Whereas during wet season the major feed sources are weed and green feed, crop residues, browse legumes, Atella, herbaceous legume and grass and hay. Natural grazing as a major livestock feed resource is weakening from time to time due to the high degree of chronic degradation and shrinking of grazing land in size. Each and every feed source has its own unique constraints for utilization and improvement.

Improved feed as source of feed in the study area during wet season from the overall respondents 16% of total feed source shared from improved forages. While during dry season 12.3% of the feed resource from improved forages.

4.6.1. Feed availability during wet and dry season

The study areas receive limited amount of rainfall with unimodal from mid-June to early September. In the wet period of the year major livestock feed resources are ranked as weeds and green grasses, crop residues, browse legumes and grasses, Atella (residue of local beverage), improved herbaceous forages plants, household wastage, industrial by products and natural pastures consecutively. While in adopters in wet season, it was ranked as weeds and green grasses, crop residues, browse plants, improved herbaceous forages and Atella in that order (Table 10). In the wet season, non-adopters feed their cattle with weeds and green feeds, crop residue, hay, Atella and household wastage. Usage of natural pasture is not common in the study area because the areas are closed rather they access the hay from protected grazing areas via cut and carry system. Green grasses and weeds are good feed resources for animals in wet seasons in both respondent groups. Relatively better feed is available during the wet season

(July to September). During this period animals gain body weight and body condition for the improved feed supply. But later on, as the long dry period proceeds the body weight of the animals reduce. Months of March to June are feed shortage especially during drought time for animals.

During the dry period of the year the major livestock feed resources in the study areas were ranked as crop residues (1st), hay (2nd), Attela (3rd), weed and green feed from irrigation (3rd), crop aftermath (4th), improved forages (5th), herbaceous legumes, household waste and industrial by products according to the order of their importance. Crop residues are fed often starting from November to June. Hay is given mainly for ploughing oxen during the months of February to May as well as for milking cow in addition to the green feeds and concentrates throughout their lactation period. Attela, mill wastes and food leftover are fed to animals occasionally based on the availability. The availability of Attela is linked with social and religious festivals and holidays. Crop residues and hay are fed to cattle while shoats are made to graze themselves.

Table 10. Raking index of feed resource available during wet season in the study area (n=200)

Feed types	Non-adopters		Adopters		Overall	
	index	Rank1	index	Rank2	index	Rank
Natural pasture	0.036	7	0.036	8	0.04	8
Crop residue	0.279	2	0.195	2	0.24	2
Crop aftermath	0.002	9	0.008	10	0.01	9
Hay	0.101	3	0.045	6	0.07	5
Browse legume plant	0.012	8	0.173	3	0.09	3
Weed and green feed	0.337	1	0.287	1	0.31	1
Household wastage	0.084	5	0.024	9	0.05	6
Atella	0.093	4	0.063	5	0.08	4
Industrial by products	0.053	6	0.037	7	0.04	8
Improved herbaceous legume and grass	0.000	10	0.130	4	0.07	5
Urea treatment	0.002	9	0.002	11	0.00	10
Beles (cactus)	0.000	10	0.000	12	0.00	11

Source survey 2016

Table 11. Raking index of feed resource during dry season in the study area (n=200).

Feed type	Non-Adopters		Adopters		Overall	
	Index	Rank	Index	Rank	Index	Rank
Natural pasture	0.028	8	0.032	10	0.03	7
Crop residue	0.309	1	0.233	1	0.27	1
Crop aftermath	0.080	4	0.069	7	0.07	4
Hay	0.265	2	0.195	2	0.23	2
Browse legume plant	0.011	9	0.135	3	0.07	4
Weed and green feed	0.059	7	0.092	5	0.08	3
House hold wastage	0.075	5	0.023	6	0.05	6
Atella	0.103	3	0.060	8	0.08	3
Industrial by products	0.061	6	0.051	9	0.06	5
Improved herbaceous legume and grass	0.002	10	0.102	4	0.05	6
Beles (Cactus)	0.006	11	0.008	11	0.01	8

Source: (own survey 2016)

4.7. Crop types and crop residues

The main annual crops grown by the farmers in the study area were listed as *Teff*, sorghum, maize, *Hanfets* (mixture of barley and wheat), barley, wheat, and finger millet. About 82% farmers had grown *Teff* whereas 66 %, 11%, 3%, 7%, 9%, 8% and 15% of the farmers had grown wheat, barley, *Hanfets*, legumes, maize, sorghum and millet, respectively, in the non-adopters. Adopter farmers had grown 90% *Teff* whereas 63%, 10%, 7%, 34%, 1% and 34% had grown wheat, *Hanfets*, legumes, maize, sorghum and millet, respectively. The area of crop and conversion factor of crop residue is listed in table 12. In the mixed cereal dominated crop and livestock farming system of the Ethiopian highlands, crop residues provide about 50% of the total ruminant livestock feed resource. Green feed management is integrated with crop production activities

Based on the below table, a household can collect about 20.376 quintal crop residues annually. In the past 2015/2016 summer the rainfall amount was not enough in the study area even in regional level this might decrease the production of both yield and crop residue production. Out of the total crop residues produced at household, majority is obtained from *Teff straw (6.85*qt*/HH),* wheat straw (5.65qt/HH) and barley straw (2.98qt) followed by maize Stover (1.75qt), finger millet straw (1.43qt), sorghum Stover (1.37qt), legume straw (0.27qt), *Hanfets* straw *(0.0089qt)* in that order. This shows that Teff, wheat and barley are staple crops in the area and preferred by farmers.

Table12. Crop residue production from each crop type in the study areas (n=200)

Crop type	n	Non-adopters				Adopters					Overall				Index	Rank
		Land cover ha/HH	grain yield/yr./ha	Conversion factor	Crop residue yield (qt/ha)	n	Land cover ha/HH	Crop yield	Conversion factor	Crop residue yield (qt/ha)	n	Land cover ha/HH	Crop yield	Conversion factor	Crop residue yield quintal/ha		
Wheat	66	0.146	25.43	1.5	5.57	63	0.149	25.43	1.5	5.68	129	0.1475	25.43	1.5	5.653	0.28	2
Barley	11	0.104	19.6	1.5	3.058	10	0.099	19.6	1.5	2.91	21	0.1015	19.6	1.5	2.98	0.15	3
Hanfets	3	0.0063	19	1.5	0.18	0	0	19	1.5	0	3	0.00315	19	1.5	0.089	0.004	8
Teff	82	0.27	15.75	1.5	6.38	90	0.31	15.75	1.5	7.32	172	0.29	15.75	1.5	6.85	0.34	1
Legumes	7	0.014	18.9	1.2	0.318	7	0.01	18.9	1.2	0.23	14	0.012	18.9	1.2	0.27	0.013	7
Maize	34	0.013	34.29	2	0.89	9	0.038	34.29	2	2.61	43	0.0255	34.29	2	1.75	0.086	4
Sorghum	1	0.045	23.69	2.5	2.67	1	0.0013	23.69	2.5	0.077	2	0.02315	23.69	2.5	1.37	0.067	6
Finger Millet	34	0.026	20.17	2	1.049	34	0.045	20.17	2	1.8153	68	0.0355	20.17	2	1.43	0.07	5
Total		0.6243			20.108		0.6523			20.64					20.376	1	

Source survey 2016, (conversion factor from FAO, 1987, crop yield from CSA data 2007/08

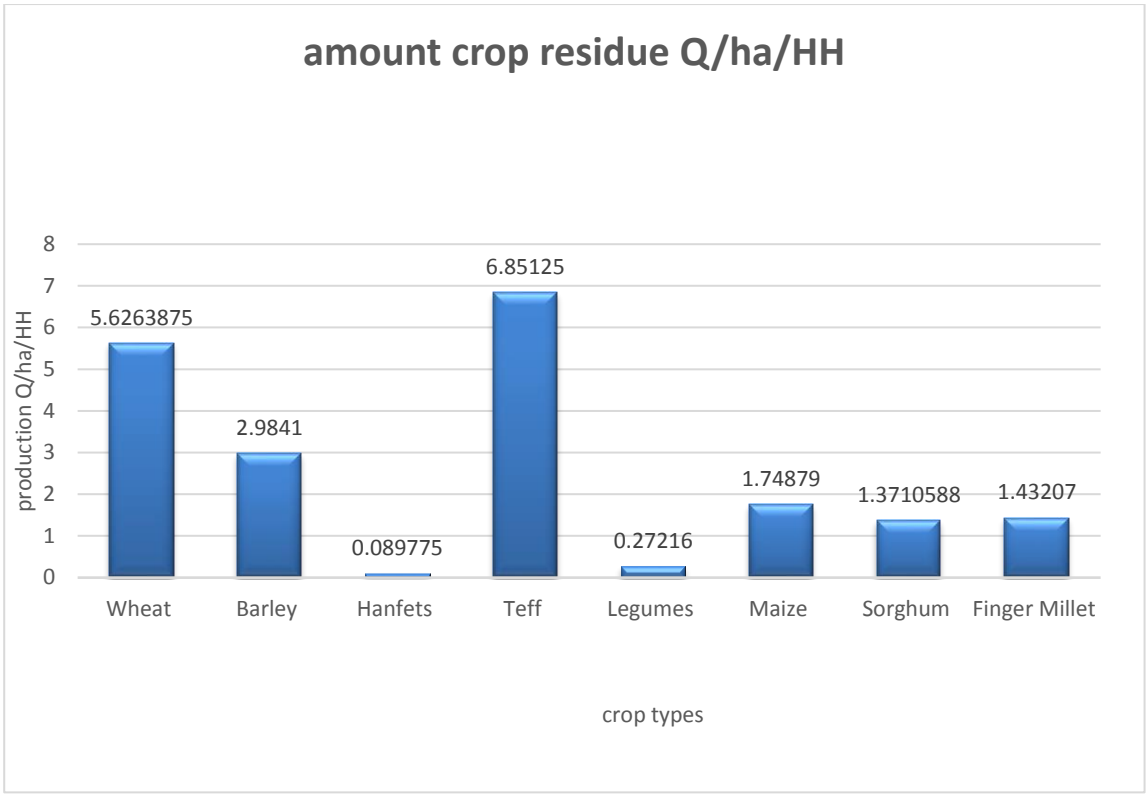

Figure 3.Crop residues produced in quintal from each crop with in household

4.8. Common green fodder available in the study areas

Common green fodder available in the study areas are presented below. Forage production has been promoted in the study areas for long time. A large number of annual and perennial forage and fodder species have been introduced in the midland and highland zones of the districts both under rain-fed and irrigated conditions. Some of these introduced forage species are well adapted to the areas and accomplish better forage yield or herbage yield. Leuceana, sesbania, alfalfa, lablab, cowpea, pigeon pea, and forage grasses such as elephant grass, Rhodes grass and local grass have been produced in the study areas. Forages like sesbania, elephant grass, alfalfa and leuceana are extensively produced in all study areas. These improved forage species and varieties were largely introduced to the study districts by the government via the forage extension packages. In addition, attempts have been undertaken in forage development programmers by different non-governmental organizations like REST, ILRI and FARMAFRICA and others across different time with the aim to mitigate the livestock feed shortage problem.

Table 13. Common green fodder species ranked by adopters in irrigated study area (n=100)

Species available	Non-adopters (%)	Harvesting frequency Per year	Mean land size ha/HH	Mean number of tree legume	Adopters forage owner (%)	Rank
Alfalfa	-	9.04	0.036	-	71	2
Rhodes	-	0.58	0.0054	-	6	9
Elephant grass	-	5.8	0.025	-	65	3
Lablab	-	0.46	0.010	-	15	6
Cowpea	-	0.38	0.008	-	20	5
Local grass	-	0.38	0.007	-	12	7
Leuceana	-	2.6	-	15.13	35	4
Sesbania	-	6.8	-	47	78	1
Pigeon pea	-	0.06	-	2	7	8

Source survey 2016;

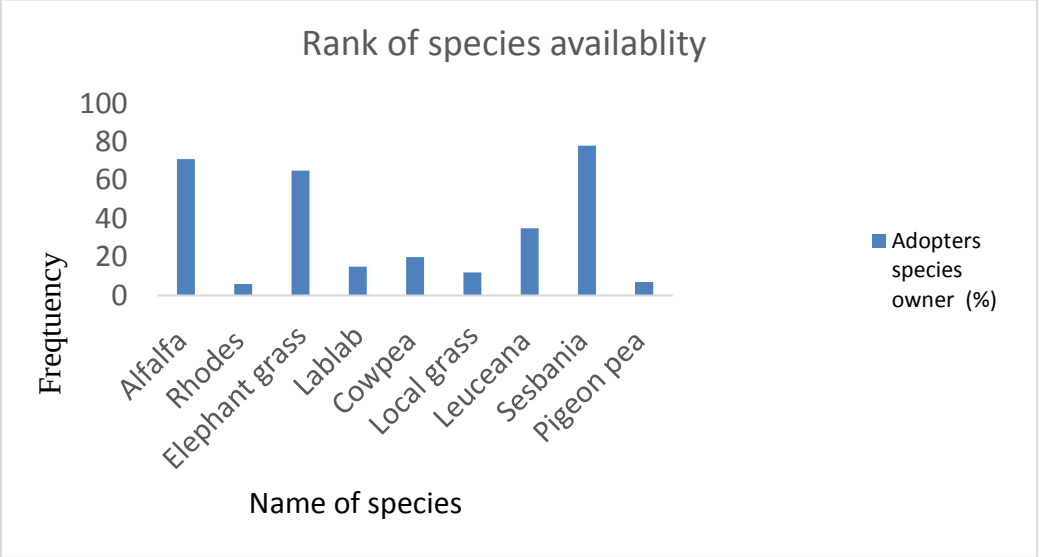

Figure 4. Availability of green feed of adopters in the study areas

4.9. Production, Management and Utilization of Green Feeds

Improved green fodders have been introduced in the study districts for long time. Common annual and perennial forages have been introduced in the study districts both in rain-fed and irrigation conditions. The most important forage species produced under irrigation scheme in the areas are listed in Table 14. The production level, management practices and utilization mode of the cultivated forages was investigated through respondents' interview. Based on the reply of the respondents, sesbania, alfalfa, elephant grass, leucaena, lablab, local grass, cowpea, pigeon pea and Rhodes grass are the available forage species in the areas. Of these introduced forage species, Alfalfa and sesbania are dominantly produced by the growers and followed by elephant grass, leuceana, cowpea, lablab, local grass, Rhodes and pigeon pea in that order. Cowpea, lablab, Rhodes and pigeon pea often used for seed production and marketing. The mean dry matter forage yield of the common green feeds is presented in Table14. On average about 6921 kg DM is harvested at household level. The forage is largely contributed by elephant grass (60.2%), followed by alfalfa (26%), sesbania (12%) and Leucaena (1.8%) in that order.

Table 14. Forage DM production for common green fodder (Kg DM/HH)

Forage species	Number of producer HH	%	Measurement Land size ha/HH	Number of plants/HH	DM yield Kg/ha/harvest	Frequency of harvest/yr.	Forage production (Kg DM/HH)	Index	Rank
Alfalfa	71	71	0.036±.0.0054	-	3619	9.04	1799.63±338.3	0.262	2
Elephant grass	65	65	0.025±.0049	-	16205	5.88	4163.67±943.6	0.607	1
Lablab	15	15	0.010±.004	-	4000	0.46	0.53±.19	0.000	6
Local grass	12	12	0.007±.0050	-	5475	0.38	0.533±.14	0.000	5
Leucaena	35	35	-	15.13±2.923	.5kg/plant	2.6	61.2200±13.1	0.009	4
Sesbania	78	78	-	47±7.145	2kg/plant	6.8	833.9±140.6	0.122	3
Pigeon pea	7	7	-	2±.83	.04kg/plant	0.06	0.079±.033	0.000	7
Total							6920.742	1.000	

4.10. Introduction strategy of forage species

There are different strategies for forage production development. This depends on availability of land, scale of production, interest of farmers and other factors. In this study, the forage species were found to be cultivated under irrigation areas as the study purposively targeted on the irrigated green fodder under the dairy producers in milk shed areas. Alfalfa, sesbania, leucaena, elephant grass, lablab and local grass were identified during the survey. According to the respondents', these investigated forage species are grown around irrigation areas to get water source as well as intercropping system. Next to irrigation areas, forage species were grown as alley farms, backyards, intercropping, over sowing, area closure and soil and water conservation structures. For instance, farmers produce lablab and cowpea with maize in the space between rows.

Table 15. Introduction strategy of forage species by adopters frequency of producing strategies in the study area (n=100)

Forage species	Backyard	Irrigation	Alley	Backyard, Irrigation back yard and irrigation	Backyard, irrigation back yard, intercropping and over sowing	Backyard, irrigation back yard and irrigation	Irrigation, Irrigation backyard and area closer	Backyard and oversaw	Backyard irrigation, closed area and soil and water conservation structures
Alfalfa		58		1	4	5	1	1	1
Elephant grass		38	15	1	2		2	1	4
Lablab		6	2	1		1	2	4	
Local grass	11	1							
Leucaena	2	33							
Sesbania	1	59	17				1		

4.11. Management practices of green feeds

Thee common green species, which are cultivated in the study area and their managements are listed in table 16. The different species have their own propagation way and managed differently based on their growth habit and nature. Alfalfa, cowpea, lablab and Rhodes are established by direct sawing. Leuceana and sesbania can be also planted by using direct sowing and planting seedlings. The seeds of leucaena and sesbania are hard and thus boiled and crashed. Most of the respondents use stratification treatment for alfalfa seed before planting to facilitate germination and establishment to minimize from high density. Elephant grass is planted by vegetative propagation (cutting and splitting root).

Table 16. Planting method of green feeds from the sample survey (n=100)

Species practices	Adopters	Management practice								
		Planting type				Treatment of planting material				
		NA	Seed	Cutting	Seedling	NA	Boiling	Crashing	Stratification	No treatment
Alfalfa	71	29	71			36	2		56	6
Elephant	65	35	0	61	0	35	0		0	41
Cowpea	20	80	20		0	80	7	1	0	12
Lablab	15	85	13		0	85	2	2	1	10
Leucaena	35	65	8		26	65	3	3	4	25
Sesbania	78	22	25		46	27	4	3	5	61

NB: NA =not applicable (not participate on the management)

4.11.1. Agronomic practices for green fodder

The common agronomic practices for irrigated green fodder being employed in the study areas include land preparation, water supply, fertilizer use, weeding practice and harvesting. These are practiced to improve the forage production in order to get enough green feed to dairy cattle. About 92.7% of the forage growers prepare land for forage production while the rest 7% do not

so. Likewise, about 87.6% of the respondents irrigate their forage plantation with water, and the 13% did not water their forage fields. Out of the respondents 96% use organic fertilizer and the least 4 % did not use fertilizer. About 88 % of respondents weed their forage plantation and 96% of the respondents grow the green feeds under protection in closed areas.

Table 17. Agronomic practice for common green feed (n=100)

Forage species	Adopters	Land preparation	Watering	Fertilizing	Weeding	Fencing
Alfalfa	71	69	68	69	68	68
elephant grass	65	62	57	66	59	66
Cowpea	20	20	20	20	20	20
lablab	15	13	12	11	12	11
Leuceana	35	34	32	35	32	35
Sesbania	78	66	60	72	60	72
Average		92.9	87.6	96	88	96

4.12. Utilization of irrigated fodder species

All the interviewed dairy producers have started feeding fodder to their animals. The farmers use the fodder in different ways and majority of respondents (48%) give the grass fodder alone to animals after some roughage feeds are eaten. And some (17.5%) mostly alfalfa give in combination with roughage feeds. About 26% of the dairy producers replied that they utilize the fodder in both ways and few of them (8%) allow their animals to directly graze on the forage plantation. Regarding the feeding management of green fodder, the farmers responded that they use the fodder directly in fresh form with no any treatment (47%) and some of them (25%) use the herbage in wilted form to avoid health problem on animals. And the remaining farmers feed the fodder to animals in both options. The feeding form and feeding management of the respondent vary among them as presented in table 18.

Table 18. Form of feeding and feeding management of irrigated fodder species (n=100)

Feed species	n	Form of feeding						Feeding management					
		NA	Feed alone	Mix with others	Mix and alone	Direct grazing	All	NA	Feeding fresh	Feeding wilt	all	Fresh and wilt	Fresh and dry
Alfalfa	71	29	21	39	11			29	15	50	2	4	
Elephant	64	36	33	5	26			37	29	13		21	
Cowpea	20	80	2	1	17			80	11		1	8	1
Rhodes	8	92	5	3				89	8	1		1	1
Lablab	11	89	7	1	3			88	9	3			
Vetiver	0	100											
Leucaena	34	66	18	3	13			65	17	7	2	9	
Sesbania	77	23	41	11	24		1	23	35	18	1	23	
local grass	92	8	54	3	3	3	5	10	53	4	12	18	3
Sum		523	181	66	97	3	6	421	177	96	18	84	5
%			48	17.5	25.73	.8	1.6		46.95	25.5	4.8	22.8	1.3

n=number of respondent having forage species

4.13. Animal health conditions related with green feed

According to the respondents, using the green fodder may or may not cause health problem on animals depending on the feed type and feeding management. Of the dairy producers, majority of them (68%) did not face any health problem occurrence while the rest producers (32%) face the problem. Diarrhea (2%) and bloating (30%) were identified as the major health problems which often caused due to poor feeding management of the fodder. This indicates that bloating is a serious problem in animal feeding. The reasons for occurrence of bloating were mentioned to be due to poor feeding management such as feeding without wilting (29%) and consuming fodder before roughage (3%). The farmers use traditional medication to treat their bloated animals' worth mentioning salt solution, soup solution, liquor (*Areqi*), mix solution of salt and oil, filtered local brewed drink *(local liquor)*, trochorizing the rumen of the bloated animal and exercising the animal.

Table 19. Health problems faced during feeding green feed to animals (n=200)

Health problem		Non-adopter	Adopters
occurrence	No disease	2	68
	Yes	1	32
	NA	97	0
perceived health problem	NA	97	0
	Diarrhea	1	2
	No disease	2	68
	Bloating		30
Reason for health	NA	99	68
problems	Feeding forage and water	1	2
	Feeding before wilt		29
	Feeding forage alone		1
Management mechanism	NA	99	68
	Using salt	1	1
	Using soap		4

Filtered local brewed drink	1
Salt and oil	1
Running animal, salt, *tsray swa*, oil and areqi	8
Salt, oil and areqi	14
Using tambock for treatment	1

4.14. Determinant Factors for Green Feed Adoption

To address the problem of who established the green feed adoption practice and who did not among smallholder farmers depends on different demographic and socio-economic characteristics of the smallholder farmers. The econometric model used to analyze this problem was the probit maximum likelihood estimation. The probit model used to analyze determinants of green feed adoption was found significance at less than 1% probability level and at chi-square value of 171.42. This result implies the independent variable included in the model correctly predicts adoption status.

The dependent variable in this analysis is a dummy variable, taking the value one if a farmer adopts on green feed and 0, otherwise; whereas the explanatory variables comprises both continuous and discrete. A total of eleven explanatory variables were considered in the model, of which six variables were found to significantly influence smallholder farmers' participant on the green feed adoption practice. Marginal effect (for continuous explanatory variables) indicates that the effect of one unit change in an explanatory variable on the dependent variable, while for the dummy variables the values reported are changed in the dependent variable in response to a change in the binary variable from zero to one.

The probit model result shows that sex of the household head had negative and significant influence on extension service access at (p=0.019). Given other factors constant, as the sex of household head becomes male probability of the farmer access to green feed adoption reduced by 24.7%.

Farm land holding had positively and significant effect on green feed adoption participation. As farmers' farm size increase by one hectare his/her probability of access to extension service increased by 199%. Because green feed production needs land to cultivate feed for animals. It is farm activity that required enough land and it is usually true that small land holders and landless farmers do not practice or decrease practice. Hence, farmers with large farm size might be participated in improving green feed management activities than others.

Education level has positive significant difference on the green feed adoption at (p=0.002). As the respondents' increase level of education, the adoption capacity of the respondents increase by 24.7%.

The other highly significant variable in this model is distance of farmers' residence from the Farmers Training Centre. This is in fact farmers resides far from the FTC have less attended in extension programs such as dairy visit, workshop and trainings regarding green feed management for dairy improvement than those who resides near to FTC in which the distance of the home from farmers training center is far decrease the adoption of green feed by 13.4%.

Moreover, farmers also acquire extension information and knowledge regarding dairy and feeding improved fodder through mass medias, for instance in this case, by possessing Radio,

TV and mobile. Farmers who owned minimum one of these three information source increased the probability of access to adoption of green feed by 47.6%.

The seed supply one from the explanatory variables which is positively highly significant at 1%, this indicates as seed supply increase the probability being adopter becomes increase by 47.8%.

Table 20. Maximum likelihood estimation of probit model for green feed adoption

variables	Coef.	Std. Err.	t- value	Marginal Effect
Sex	-.834	.458	0.068*	-.247
Age of household	-.0005	.0175	0.97	-.0002
Education level	.685	.223	0.002***	.246
Total family size	.0425	.075498	0.573	.0153
Land size	1.77	.6317	0.005***	.638
Total livestock unit	-.0859	.0693	0.216	-.0309
Experience of dairy	.0366	.0238	0.124	.0132
Seed access	1.543	.405	0.000 ***	.478
Extension service	.255	.324	0.432	.093
Media access	1.839	.668	0.006 ***	.476
Distance of home to FTC	-.371	.079	0.000 ***	-.134
_cons	-.744	1.14	0.512	

Number of observation =200, Probability > chi2=0.0000, LR chi2(12) = 171.42,

log likelihood=-52.919 and Pseudo R2=0.6183 ***, ** and * represents 1%, 5% and 10% significance level, respectively,

4.15. Constraints for green feed adoption in the study area

The major constraints to adoption of green feed on the study area were identified to be shortage of land (first), shortage of water (second) and shortage of forage seed which are ranked third by the non-adopter respondents based on their importance. In addition to this, shortage of labor,

shortage of capital, shortage of input, low forage production and poor credit access were mentioned by the non-adopters as causes for not growing green fodder plants. The respondents blamed their poor awareness and knowledge on the importance of improved fodder species as reason for not participating in forage cultivation. On the other hand, the adopter households were asked to list and prioritize the reasons for less adoption intensity of improved fodder despite the great efforts exerted by governmental and non-governmental organization in forage development activities. The respondents identified the constraints as shortage of land, shortage of water, shortage of capital, poor knowledge and awareness, low forage yields, labor scarcity, shortage of input, forage seed scarcity, free grazing (i.e. animal damage on forage plantation) and lack of credit access in the order of their importance from first to ninth. All this and that, limit the wide spread of improved fodder species adoption in the study areas.

Table 21. Constraints for green feed adoption in the study area (n=200)

Constraints	Non-adopters		Adopters		Overall	
	Index	Rank	Index	Rank	Index	Rank
Shortage of land	0.158	1	0.132	1	0.14	1
Shortage of knowledge	0.053	3	0.098	4	0.08	5
lack of seed	0.158	1	0.084	7	0.12	2
Shortage of labor	0.105	2	0.088	6	0.10	3
Shortage of capital	0.105	2	0.098	4	0.10	3
Shortage of input	0.105	2	0.090	6	0.10	3
Low production	0.105	2	0.096	5	0.10	3
Lack of credit	0.105	2	0.080	9	0.09	4
Bloating	0.105	2	0.101	3	0.10	3
Shortage of water	0.158	1	0.122	2	0.14	1
Free grazing	0.000	4	0.011	8	0.01	6

4.16. Institutional support for green fodder production

The green fodder growers are getting support from both governmental and non-governmental organizations in relation to forage production and utilization. These supporting organizations are involved in proving planting materials (seed, cutting, seedling, splitting etc) and inputs like fertilizer, training, advise and technical support. The office of agriculture is the main actor in doing these supports in its forage development extension program. Relief Society of Tigray (REST), Farm Africa and ILRI are amongst the non-governmental organizations involved in the same business to support the dairy producers in forage production. These NGOs also involve in other forage integrated programs like soil and water conservation structures, reforestation, livestock destocking (to focus on productive animals), fodder bank, forage seed multiplication sites, forage nursery and introduction of improved dairy cows and improved reproductive technologies like AI. All these are good opportunities for forage development in the areas and dairy farmers can be encouraged for better adoption of forage species.

4.17. Perceptions of farmers on the green fodder

The study indicated that the dairy farmers have positive perception toward forage production and utilization. They appreciated the improved fodder for better milk production, growth performance in short period of time, improve disease resistance, animals show early sign of heat to breeding, increase soil fertility, improve pest resistance and reproductive ability increment. These benefits of improved fodder were prioritized by the local farmers based on their importance and accordingly milk production (97%) was ranked first and followed by animal growth performance (i.e. animal fattening), improve breeding (94%), improving soil fertility (85%) and improved disease resistance (78%).

Table 22. Perception of farmers toward green feed adoption (n=100)

Benefits	Adopter				Rank
	Yes	%	No	%	
Milk yield increment	97	97	3	3	1
Increase body growth	97	97	2	2	1
Disease resistance	78	78	22	22	4
Increase breeding	94	94	6	6	2
Improve tilling	65	65	35	35	5
Soil fertility	85	85	15	15	3
Pest resistance	57	57	43	43	6
Relatively give better result than crop	78	78	22	22	4

4.18. Impact of Green feed and dairy production

According to the respondents, green feed increases the potential of production and reproduction performance of dairy cattle. This indicates that proper feeding of animals improves milk production, body condition and health condition and this varies with the observation level of farmers from very good to low. To summarize the impact of green feed for dairy production, the green fodders were ranked through the respondents' observation on their dairy cattle.

4.18.1. Green feed on the milk production

Milk production during dry period and after feeding green feed have different yield. This indicates during dry season non-adopters get 1.3±1.8 litres/day/cow and during wet season 2.4 ±2.14liter/day whereas adopters during dry season 3±2.7 and during wet season 6 ±3.5 litre/day according to the respondents of the study area. From the common green feeds used for dairy cattle, respondents put their priority rank according to the use of feed to their cattle. From the

adopter respondents; green forages improve productivity, even if all are useable for milk production increment, the level of increasing was ranked as very good (45%), good (42%) and moderate (13%). This indicates that the forage adopters have positive attitude toward the introduced fodder plants, implying the need for wider adoption in the future.

Table 23. Perception of farmers toward improved green fodder in milk increment (n=100)

Perceived rank	Adopters	Non-adopters
Very good	45	-
Good	42	-
Moderate	13	-
Not available	-	100

Not available =Not observe the impact of green feed from their dairy

4.18.2. Green feed and body condition of dairy animals

The farmers appreciated the importance of improved fodder in improving the body condition of animals. All the respondents agreed with the importance of the fodders in the animal feeding system. The respondents ranked the forage species in improving the body condition of their animal as very good (43.8%), good (46.5 %) and moderate (9.5%).

Table 24. Perception of farmers toward improved green fodder in body condition (n=100)

Perceived rank	Adopters	Non-adopters
Very good	43.8	-
Good	46.5	-
Moderate	9.5	-
Not available	-	100

4.18.3. Green feed and health condition of dairy animals

The respondents confirmed also that improved fodders with good feeding quality improve the health condition of animals. Animals with improved body condition can resist any diseases

from the external environment. It implies that animals get balanced feed which are source of minerals to control from external and internal disease outbreak. The observation of respondents on controlling disease through feeding green feed were ranked as 28% of very good perception, 50% good and 10.9% moderate while 11.1% did say nothing.

Table 25. Perception of farmers toward improved green fodder in animal health improvement (n=100)

Perceived rank	Adopters	Non-adopters
Very good	28	-
Good	50	-
Moderate	10.9	-
Not available	11.1	100

CHAPTER 5: DISCUSSIONS

5.1. Descriptions of Respondents

The average age of dairy producers was 45.94±8.12 years. The age of the producer is one of the factors which affect the decisions and actions made. Even though most of the dairy cattle keepers range from 30-60 years old, there was significant ($P<0.001$) difference in ages between respondents in the study area. The study revealed that the majority of the respondents were males, and they were mostly involved in dairying enterprise (Table 2). About 13.5% of the respondents were female producers indicating that smallholder dairy farming provides self-employment for women and therefore, contributes to the improvement of the living standard in this particular group. Most of the dairy management practices are done by women as men are involved in other additional income generating activities. Results show that the majority of the respondents were married couples. The advantage of the family in dairy enterprise is to provide family labor to dairy cattle like milking and feeding in the absence of hiring labor so that production level can be maintained.

The majority of the respondents (63%) were literate, which is good for improved technology adoption and dissemination. Educational level of respondents increases farmers' ability to acquire innovation easily. Due to higher literacy level, community is more likely to violently participate in looking for skills regarding their dairy cattle management as a means of improving milk yield. Education is an important tool to bring fast and sustainable development and has roles in affecting household income, adopting technologies, health management and as a whole the socioeconomic status of the family as well. This might be a good contribution to adopt technologies to the study area. Level of education is also related to have the ability of

farmers to keep farm records on production, management and utilization of forage and plan improvement actions.

The mean family size of the respondents for non-adopters and adopters were 6.25±1.76 and 6.59±2.39, respectively, which is comparable with the finding of Gregory (2010) the mean household size of the adopters and nonadopters was 6.6 and 5.9 persons, respectively in Tanzania, The household family size found in the current study was greater than the finding Berihun (2014) (6.29) and Tesfay (2014) (5.67 ± 0.142) in highland Tigray. It was also greater than that of Melesse *et al*. (2014) with mean family size of 5.83±0.23 and 5.63±0.29 persons per household in Ada'a and Lume destricts of East Shewa of Oromia region.

5.2. Land holding size of the respondents

The overall average landholding per household was 0.463±0.225 ha, which is smaller than Berihun (2014) (1.49 ha/HH), the national average (1.18ha/HH), regional average (1.08ha/HH), and that of Gatwech (2014) 2.59 ha per household in Gambelia, south west Ethiopia. The proportion of land allocated for crop production, irrigated land, forage land and grazing land was 0.405, 0.089, 0.023 and 0.0076 hectare of the total farm size, respectively. This indicates that the major proportion of the land owned by the households is used for crop production. This implies that farmers are not willing to allocate land for forage cultivation due to the limited land size rather give priority to food crops.

5.3. Livestock holding size of the respondents

The average livestock herd size in the districts were estimated to be 5.28 TLU/HH and 5.428 TLU/HH for non-adopter and adopters, respectively. The overall average TLU of cattle, sheep, goat, poultry, donkey and camel were 4.15, 0.257, 0.308, 0.048, 0.616 and 0.024, respectively. For non-adopter households, the livestock holding was 4.08, 0.207, 0.289, 0.037, 0.068 and 0.048 TLU for cattle, sheep, goat, poultry, donkey and camel, respectively. Whereas, for adopters it was 4.21 (cattle), 0.307 (sheep), 0.327 (goats), 0.0592 (poultry), and 0.584 (donkey). respectively. The current finding was smaller than that of Yadessa (2015) with 7.97, 0.74, 0.46, 0.78, 1.44, 0.8 and 0.07 TLU for cattle, sheep, goats, donkeys, horses, mules and poultry, respectively.

In contrary to the current study, average TLU of cattle (5.35), sheep (0.49), goats (0.03), donkeys (0.22) and poultry (0.02) were reported by Eba (2012) in Jeldu district of Oromia region. Comparable with current study Total livestock (6.15), cattle (4.45), sheep (0.52), goat (0.24), donkey (0.64), horse (0.28), mule (0.02) and poultry(3.04) in the Central Highlands of Ethiopia (Hassen *et al*., 2010).

Livestock production is an important component of the farming system. Livestock are kept as sources of draft power; milk, meat, skin and hides, and they are also the main sources of income and are closely linked to the social and cultural lives of the community. The major reasons responsible for declining livestock number are shortage of grazing land, population growth, expansion of crop land and shortage of feeds and water.

5.4. Purpose of cattle keeping

Cattle are kept by farmers for different purposes. The purpose of cattle keeping was indicated at table (6). The same thing was reported by Yadessa (2015) the main purpose of cattle rearing in the study district was for draught power and income generation (100%) and this was similar

with Menbere *et al*.(2008) in Tigray region. Similarly, Gebreyohannes and Hailemariam (2011) indicated that the most qualities of keeping livestock purposes in Tigray were for income and trade, food, savings (livestock have better rate of return than interest from banks or credit and savings institutions), risk management (buffers to withstand crises), wealth creation, animal traction (drawn plough), social capital, manure and accessing communal lands.

5.5. Feed resources for cattle

Most vital feed resources to livestock in the study areas during the dry season were found to be crop residues, hay, green feed and weeds, Attela, improved forages and browse trees. Among these feed resources, crop residues and hay contribute the largest source of feed to livestock in the study areas, which is similar with the finding of (Tesfay, 2014).

Whereas during wet season or irrigation time the major feed sources are found as weed and green feed, crop residues, browse legumes, Atella, herbaceous legume and grass and hay. In general, the amount of production in wet and dry season was not enough for the available livestock within the household. Because there was scarcity of water during the summer of study conducted. According to Kechero *et al*.(2013) the main sources of feed for livestock were natural pasture (30.39%), aftermath and road side grazing/browsing (19.34%), fodder trees and shrubs (17.12%) and crop residues (17.67%) in Jimma zone, south west Ethiopia .

Similarly, Birhan and Adugna (2014) said in Ethiopia the source of animal feed are natural pasture, crop residues and agro-industrial by products. Also Tesfay (2014) reported that the most vital feed resources to livestock in Tigray region were found to be crop residues, natural pasture, hay, stubble grazing (crop aftermath), browse trees, industrial by products, cactus, improved forages and Attela. And the total DM production of crop residue within household were 20.3 tone.

The crop residue production of present study was greater than 8.74 t DM at *Adami Tullu Jiddo Kombolcha* District which was reported by (Assefa and Nurfeta, 2013). The dominant crop type

in the study tabias were teff ,wheat and barley whereas in other studies Maize and sorghum are the dominant crops grown in the low altitude zone of central Ethiopia (Hassen *et al.*, 2010)**.**

5.6. Green fodder production and productivity

Forage species like elephant grass, alfalfa, sesbania, Leucaena, lablab, pigeon pea and cowpea are cultivated in the study areas. According to Abera *et al*. (2014) different forage species such elephant grass, vetch, *Sesbania sesban*, and *Cajanus cajan* have been tested and were found to be well adapted, productive and accepted by the farmers. In addition to the forage species, various forage technologies such as hedgerow, backyard, soil bund particularly associated with the natural resource conservation has been demonstrated. Based on the results of Tesfay (2014) among the growing improved forage species sesbania, alfalfa, and leucaena are primarily produced by the smallholder farmers as first, second, and third in Tigray. Likewise, Tesfay *et al*. (2016) stated that from legumes the most frequent species are sesbania (*Sesbania sesban*), leucaena (*Leucaena leucocephala*), and alfalfa (*Medicago sativa*) in Tigray region.

In this study elephant grass (4.16 t/HH/yr), alfalfa (1.7 t/HH/yr), sesbania (0.8 t/HH/yr) and leuceana (0.062 t/HH/yr) are dominantly produced by the farmers. The productivity of these was estimated as 3.6t/ha/harvest for alfalfa, 16 t/ha/harvest elephant grass and 5.5t/ha/harvest local grass. The productivity of local grass in the study from irrigated area (5.5t/ha) was higher than that of Wondatir (2010) reported about 3.4 tone/ha grasses can be harvested from grazing area. On others studies Yields of elephant grass depends on soil fertility, moisture, temperature and management**.** DM yields of 10-30 t/ha/yr. is common. Exceptionally high yields up to 85 tone DM/ha have been cited when high rates of fertilizer were applied per hectare per year (Skerman and Riveros, 1990). 12.50 t/ha was harvested from Bana grass, green gold and elephant grass respectively under low rainfall condition without application of fertilizers (Pieterse and Rethman, 2002).

All the improved forage interferences have been realized to reduce feed shortage in the areas. Improved forages can improve the productivity of pastures by improving the fertility status of the soil. They can also improve the feed value of native pastures since they have more protein content than naturally happening grass grasses.

5.7. Green fodder production, management and utilization

The forage production from the study districts was low. Since the time of during the study was regionally affect by drought then forage production which was obtained from the study site was also affects by shortage of water. The green feed management and utilization of study areas were different from farmer to farmer. Ethiopian utilization of the improved forage as livestock feed is very limited. Dairy cows compared to other farm animals produce large amount of milk, hence require sufficient quantity and quality feeds with all necessary nutrients, including energy, protein, minerals and vitamins. In the study area, the available green feed utilization is somewhat better than previous time; they use cut and carry system, then mix with crop residues, wilted before giving to their animal to minimize external parasites from the feed source. This is almost similar with Chaussa (2013b) where various improved legume and grass forages like alfalfa and elephant grass are fed to dairy cows to satisfy their nutrient demand. According to Tesfaye (2010) utilization of improved forages is based on cut-and-carry system and targets only to selected classes of livestock such as lactating cows, replacement heifers, and fattening sheep. Improved forage production is not well integrated into the farming system, the level of management applied is expectedly low. Existing stands receive little attention in terms of water management, harvest schedules and soil nutrient management requirements.(Tesfay *et al.*, 2016).

Legume forage crops can improv the utilization of low quality roughages and they are being used widely in the study districts. Similar with other studies various production systems

legumes are capable of enhancing both crop production through sustained soil fertility and livestock production through increased accessibility of high quality feed (Assefa and Ledin, 2001). On the average, crop residues provide 10-15% of the total feed intake in the mixed crop-livestock producing areas in the central highlands of Ethiopia (Alemayehu, 2004).

5.8. Determinant factors for green fodder adoption

Adoption depends on better targeting of extension to farmer needs as successful outcomes will depend on the participation of the farmers and stakeholders in the livestock industry (Mapiye *et al*., 2006b) . Out of the determinant factor of green feed adoption, a total of eleven explanatory variables were considered in the model; of which six variables were found to be significantly affecting the adoption of fodder. Sex and distance to FTC are negatively and significantly determining the forage adoption while education level, land size, seed access and access to media influencing smallholder farmers' participant on the green feed adoption practice positively significant. Other variables do not contribute to the farmers' sustained adoption decision behavior of green feed technology in the study area.

Gender of the respondents implies negative sign at 10 %. That means participation of being males decrease the green feed adoption. This disagree with the result of Berihun (2014) and off-farm participation is positive and statistically significant at 1% level.

The probit result of the study found that education level of the respondents is positively significantly at 1% level. The positive sign indicates that literate farmers have 68.4% of higher probability of participation on the green feed adoption. This is similar with the finding of (Berihun, 2014) who reported that the magnitude of positive sign those literate HHs, keeping other things constant, have 23.14% higher probability of participation unlike their counter parts. Also similar with the finding of Tiamiyu *et al*.(2014) the positive sign on the education

variables implies that those farmers with higher education level adopt more quality enhancing technologies.

The farm size of the study is positively significantly at 1% level. This implies that large land size can really increase the probability adoption on green feed production. Land size as independent factor, a unit increase would increase the probability of participation on green feed adoption by 177 %. In line with Berihun (2014) reported that large land holding size is found to be imperative for producing a relatively higher crop yield. And comparative with study of Oyewole *et al*. (2014) the coefficient for farm size (0.501) was positive and significant at 1 percent, implying that increase in farm size would lead to an increase in output of rice.

Access of forage seed supply also highly significant at 1% for the adoption of green feed. That implies when the supply of farmers selected seed was present cultivation of green feed increase at the available land similar with study Wondatir (2015) of to increase production and productivity of crop and livestock, input utilization is important. Inputs such as improved seed, fertilizer, pesticides, insecticides, irrigation facilities, livestock feed and improved cattle breeds were mentioned by the respondents.

In the current finding distance to farmers training center has been negative significant at1%. This indicates as the farmers' house far from farmers training center the probability of adoption decreases by 37% because they might not be participated on trainings, agricultural extension services and other at farmers training center on time. The FTC has been established before a decade at each tabias to serve as nodes, which could provide extension service (packages), training (short term and modular), demonstration and centers of show and information, as a result, distributes agricultural technologies (Gebremedhin *et al*., 2006). Extension service which get from FTC is crucial in uptake and adoption of improved technologies (Yadessa, 2015).

Access to get media whether by radio, television. or personal communication was also another positively significant at 1%. having access for one of the media access might be increase the adoption of green feed development by 47.6%. The result was similar with the finding of Gecho and Punjabi (2011) the radio ownership affected significantly and positively the probability of adoption of improved maize technology.

5.9. Constraints of green fodder adoption

In both adopters and non-adopters, the most constraints for less adoption of improved fodder plants are land scarcity, shortage of water, animal health problem (having bloating), lack of knowledge and awareness, limitation of capital and low forage yield. Shortage of land was identified as the first and most constraint for forage production and the same finding was reported by Tesfay (2014) in eastern Tigray. Comparable to findings of this study, several studies cited high cost of resources, low yield, lack of persistence of legumes, lack of capital, land shortage and labor scarcity as major constraints for adoption of forage legumes (Mapiye et al., 2006a)

Constraints on any of the factors of production such as land, labor and capital can inhibit uptake of forage technologies (Kabirizi J, 2004). The finding of Kechero *et al*. (2013) showed that feed shortage, poor access to improved extension services, lack of improved cattle breeds, distance to marketing points and poor administrative mechanisms were identified as constraints to restore range ecosystem ($p<0.05$). The respondents (both adopters and non-adopters) tried to rank the constraints based on their importance. Non-adopters are largely influenced by shortage of land and water to produce green fodder. Similarly, land scarcity, shortage of water, bloating, poor knowledge and awareness, shortage of capital and low forage production are the existing problem in case of adopters, limiting the wide spread and dissemination of forage technologies.

Other studies Yayeh *et al*. (2014) revealed that constraints for dairy production were animal disease, lack of crossbred genotype animal, feed shortage, milk market, land (space) shortage and water shortage.

5.10. Perception of respondents towards green fodder

According to the respondents, green forages mainly legumes, besides feed resource of dairy animals, they can improve the productivity of crop yield and pastures by improving the fertility status of the soil. They can also improve the feeding value of roughages since they have more protein content. The benefits of improved fodder were prioritized by the local farmers based on their importance and accordingly milk production was ranked first and followed by animal growth performance (i.e. animal fattening), improve breeding, improving soil fertility and improved disease resistance. The same benefits were mentioned in the survey work of Gebreyohannes and Hailemariam (2011). And also this result is agreement with the previous reports of Welle *et al.* (2006) who indicated that *desho* grass has valuable role in soil conservation. And study of Eba (2012) said feed resource improved soil and water conservation.

5.11. Effect of green fodder on animal performance

Green feed as one element from the factors of dairy production, in this study others components as constant, green feed has positive impact on the dairy production performance and body condition. The average milk yield was estimated to be 1.3 litres/day/cow and 2.4 litres/day/cow during dry and wet seasons, respectively in the case of non-adopters. Similarly, the milk yield was estimated to be 3 litres/day/cow (dry season) and 6 liters/day/cow (wet season) in case of forage adopters. This shows that fodder adopters get higher milk yield than that of non-adopters with the same cow breed, which could be attributed to many factors including the utilization of

improved fodder. The average milk production of the study area was comparable with the study of Yayeh *et al*. (2014) average daily milk yield of 1.50±0.68 litres and average lactation length of 8.87 ± 1.55 for local breed cows. According to the respondents' days open might be at good time when animals fed on quality feeds during wet season. Whereas during dry season, when shortage of green feed occurs, days open becomes longer and calving interval gets longer (Duguma *et al.*, 2012). The same authors added that feed shortage, silent estrus and difficulties to heat detection might have contributed considerably to the long days open. Likewise, longer calving interval could be due to poor heat detection and less access to AI services and poor feeding practices (Gebremichael, 2015).

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

The current study generated information on production, management and utilization of common green feed in the study districts. It has also identified the existing and emerging opportunities and constraints and perceptions of farmers on green feed adoption in the areas. There are various forage species and varieties introduced to the areas by government, and NGO's. The introduced common forage plants include sesbania, alfalfa, elephant grass, leucaena, pigeon pea, lablab, Rhodes grass, and others local grasses. These species are well adapted to the environmental conditions. They are used as animal feeds with other multi-functions. Backyard/homestead forage, irrigation, alley cropping and area enclosures are commonly employed forage development mechanisms. The forage development programs are integrated with relevant programs like dairying, animal fattening, cropping, natural resources managements and irrigation schemes. From the result of the adoption study of green fodder was determined by eleven explanatory variables; of which six was significant to influence green feed adoption. Four of the eleven factors positively influenced green feed adoption while two negatively influenced adoption. This research conceptually shows that the potential for growing of improved forages in mixed crop–livestock systems can be advisable due to high level of opportunity for exploiting crop–livestock interactions and the potential of dairying production farmers. This as it is, the forage production and utilization adoption is contracted by various factors. Most common constraints of improved forage utilization are land and water scarcity, low access to improved technologies and training as well as land allocation for crop cultivation.

In general, irrigated green feeds have great role on increasing milk production, preserving normal health condition and increase the body weight of the animals, based on the findings, recommendations are drawn out below.

6.2. Recommendations

Based on the current results, below listed interventions have been recommended for improvement of green feed production, management and utilization in the future.

- Common forage species found in the study area are small in size and thus it needs to scale up for other areas and increase the adoption rate for the non-adopter through training, awareness creation and more extension services and give demonstrations from adopters' work, enough supply of forage seed,
- Strengthen the utilization modes such as cutting at proper forage growth stage and feeding mechanisms (chopping, mix with dry feeds and offering to target animals).
- Build capacity of FTC's and nursery sites for knowledge sharing of forage seed, seedlings, cuttings and splitting forage varieties among householders' and demonstration purposes.
- Improving relation of forage production with market oriented commodities helps smallholder farmers to shift in livestock composition and generate better income from forage selling.
- Strengthen forage development of government attention and NGOS to improve the adoption of green feeds more than the present.

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8. APPENDICES

Annex1: Questionnaires for household survey

Department: Animal, rangeland and wildlife sciences postgraduate program in Livestock Production and Pastoral Development.

Survey questionnaire on green feed management and utilization for dairy production of smallholder farmers in Ahferom-Adwa-Laelay maichew districts.

General Information

Questionnaire number(Code) _____Enumerator name……. Date……
Name of respondent…….……...District……
Tabia……. Village……

A. Household Demographic Information

1. Head of household a. Sex: M☐ F.☐ b. Age_____
   c. Marital status: 1) Married ☐ 2) Single ☐ 3) Divorced ☐ 4) Widowed ☐
   d. Level of education: 1) Illiterate ☐ 2) elementary ☐ 3) secondary ☐ 4) degree ☐
   5) Other___
2. Source of income:1) farmer ☐ 2) trader ☐ 3) civil servant ☐ 4) other…….
3. Household size?

Sex	Adult (>18 years)	Young (12-18)	Children (<12)
Male			
Female			
Total			

4. How much land do you own (Tsemad)? ……
   for grazing (ha)_____ for cropping_____ For forage _____ For fallowing_____
   For irrigation_____ for rent out_____ for others_____
5. If there are off farm activities or sources of income, then what is the contribution of each?

No	Types of off-farm activities	Tick	Contribution to the livelihood per month		
			Ethiopian birr	Grains	Others
1	Daily laborer				
2	Petty trading				
3	Local brewing				
4	Carpentry				
5					

1. Do you have enough labor for accomplishing farming activities of forage on time?
1) Yes 2) No

2. If the answer is no, which activities are most affected by labor shortage?
1) land preparation (Plowing) 2) Planting (sowing) 3) Weeding
4)Harvesting 5) in all times 6) others (specify)

B. Cattle Herd Composition

1. Total livestock population and their benefits score (1=for1st ,2=for 2nd, and 3=for minimum contribution)

Animal type	Number	Draft power	Consumption (meat, milk)	Cash income	Breeding	Social values	Live animal saving
Cattle							
Ox							
Sheep							

Goat							
Poultry							
Cock							
Donkey							
Mule							
Horse							
Camel							
Others							

C. Dairy farming

1. Do you practice dairy farming? 1) Yes 2) No
2. If yes, when did you start? ……
3. How did you acquire your first dairy cattle? (1) Inherited ☐ (2) Given ☐ (3) Bought ☐ (4) other (Specify)…….
4. What breed of dairy cattle do you keep? 1) Holstein Friesian ☐ 2) Jersey ☐ 3)Local ☐ 4) Crossbreed (type) ☐

5. Dairy cattle herd and breed composition

Cattle class	Number	Local	HF	Jersey	LxHF	LxJ	Others
Dry Cow							
Lactating cow							
Pregnant cow							
Heifer							
Bull							
Female Calf							
Male calf							

D. Feed resources for the dairy animals

1. Feed resources and feeding calendar

Feed type	Dry season		Wet season		Duration of months
	Tick	Rank (1-3)	Tick	Rank (1-3)	
Natural pastures					
Crop residues					
Crop aftermath					
Hay					
Browse plants					
Weeds and green grasses					
HH wastes*					

Attela					
Industrial by-products					
Improved forage					
Other feeds					

*Food leftover, mill by-products, kitchen wastes etc

2. What is the amount of hay produced from each of the following areas by your Specific household per year (source of fodder) ……?

No	Strategies	Area by tsimad(ha)	Amount of hay by donkey load
1	Pasture land		
2	Backyard		
3	Area closure		
4	Soil and water conservation		
5	irrigated fields		

3. Amount of feed produced from crop residues

No	Crop residue type	Cultivated ha	Crop production /ha	Crop residue/ quintal	Price of crop residue/tsor
1	Wheat				
2	Barley				
3	Teff				
4	Legumes				
5	Maize				
6	Sorghum				
7	Finer Millet				

4. How is the grazing land management?

Do you have private grazing land?	Tick	Improvement options used on the private grazing lands use tic		Tick
Yes			Fertilization	
No			Over sowing	
If yes, specify the size (ha)			Firing	
Months when animals are allowed to graze			Rotation grazing	
			Weeding	
			Over sowing improved seed	

A. Forage production

1. Do you produce irrigated fodder? 1) Yes ☐ 2) No ☐
2. If yes, for what purpose? 1) for milk/dairy ☐ 2) For fattening ☐ 3) For sale ☐ 4)For maintenance ☐ 5) Others……
3. Experience in growing forage? 1) < 1 years ☐ 2) 1- 5 years ☐ 3) 5-10 years ☐ 4) > 10 years ☐
4. What are the common green fodders used for your dairy cattle or other animals? 1) Pasture ☐ forage crops
   2) Improved herbaceous legume ☐ 3) Improved grasses ☐ 4) Forage legume tree ☐
   5) Others……
5. Where did you get these forage seed? 1)Gov't ☐ 2) NGO ☐ 3) Private ☐
   4) Others …….
6. List the common cultivated green feed available and area coverage?
   Strategies: Backyard=1, irrigation=2, irrigated backyard=3, alley=4, intercropping=5, under cropping=6, enclosures=7, swc structures=8 etc.

No	Species	Strategy of introduction	Area coverage	Season of harvest	Stage of harvest (1=at early growth stage, 2=at50%flowering, 3=at full flowering, 4=seed stage)	Frequency of harvest/year	Estimated yield (kg/ha)
1	Alfa-alfa						
2	Rhodes						
3	Elephant grass						
4	Lablab						
5	Vetiver grass						
6	Local grass						
7							

*Estimated yield (t DM/ha) = Area coverage x Forage yield (t/ha) x frequency of harvest per year

Species	Strategies	Number of trees<3year	Trees 3-5 year	>5 year	Season of harvest	stage of harvest	frequency of harvest	estimated Yield per tree /year*		Total forage yield	
								<3	3-5	>5	
Sesbania											
Leucaena											
Tree lucern											
Calendria											

Fodder tree biomass estimation

*Estimated yield (t DM/ha) = Area coverage x Forage yield (t/ha) x frequency of harvest

F. Forage management

1. Do you manage your irrigated forage properly? 1) Yes 2) No
2. How is the propagation practice of irrigated feed?

Propagation and treatment before sowing

Propagation practices					
No	Species	Type of planting (material (seed, cutting, strips, seedlings)	Seed treatment (1=boiling, 2=crashing, 3=stratification)	Survival rate (1=v/good,2=good, 3=moderate,4=low)	Others
1	Alfa-alfa				
2	Elephant- grass				
3	Cowpea				
4	Rhodes				
5	Lablab				
6	Vetiver				
7	Leuceana				
8	Sesbania sesban				

3. Which agronomic practices for each and every species do you use?

No	Type of species	Watering frequency	Land preparation (yes/no)	Fertilization (yes/no)	Weeding (yes/no)	Safety/fenced (yes/no	Others
1	Alfa-alfa						
2	Elephant- grass						
3	Cowpea						
4	Rhodes						
5	Lablab						
6	Vetiver						
7	Leuceana						
8	Sesbania sesban						
9							
10							

4. How do you compare each of the forage types according to the give criteria (1=v/good) (2=good) (3=moderate) (4=low)?

Forage type	Milk let-down	Palatability	Early re - growth	Multii-purpose criteria	Ethno-medicine	Shading and shelter	Drought resistance	Disease and pest resistance	Tilling ability	Resistance to grazing	Resistance to cutting/lopping	Rank species by all these criteria	Remark
Alfa-alfa													
Elephant-grass													
Cowpea													
Rhodes													
Lablab													
Vetiver													
Leuceana													
Sesbania sesban													

G. Utilization of forage

1. Have you started feeding fodder to your dairy animals? 1) Yes 2) No
2. If yes, how do you utilize them?

Forage type	Which Mode of green feed utilization do you use?						What type of green feed improvement do you use		Time of feeding (wet, dry season)
	Form of fodder feeding			Feeding management of fodder (Tic)					
	Feeding alone	Mixing with other feeds	Direct grazing	Feeding as fresh	Feeding after wilting	Feeding after drying	Silage making	Adding salts	
Alfa-alfa									
Elephant-grass									
Cowpea									
Rhodes									
Lablab									
Vetiver									
Leuceana									
Sesbania sesban									

3. For which animal, do you give priority during fodder feeding?

Animal class according their feeding priority (Rank them according their importance)			
Oxen		Calves	
Milking cow		Steer	
Pregnant cows		Shoats	
Heifers		Equine	
Dry cows			

H. Health condition

1. Have you faced any animal health problem when feeding fodder? 1) Yes 2) No
2. If yes, list them ……
3. What do you think the reason……?
4. How do you manage the problem? ……

I. Impact of forage on animal performance

1. How do you describe the impact of feeding green forage on your animals (1=very good,2=good,3=moderate,4=low)?

No	Species	Impact on animals' production		
		Production level		
		Milk amount increasing	Increasing Body condition	Health condition of cow
1	Alfa-alfa			
2	Elephant- grass			
3	Cowpea			
4	Rhodes			
5	Lablab			
6	Vetiver			
7	Leuceana			
8	Sesbania sesban			
9				

J. Animal feed conditions

1. Do you face feed shortage for your animals? 1) Yes 2) No
2. If yes, how do you solve the feed shortage problem?

Feed shortage solving mechanisms	Dry season	Wet season
Reduce animal number		
Buy feed from own income		
Buy feed from loan		
Buy feed from animal sales		
Move animals to feed at plenty areas		
Browsing		
Conserving feed at plenty to use at scarce		
Others (specify)		

K. Perception of farmers on irrigated fodder

Did you perceive any advantage?		If yes, in what term? Tic on the provided space	
Yes		Increased milk yield	
No		Increased growth/fattening	
		Improved disease resistance	
		Improved breeding	
		Improved work/draft	
		Improved reproductive capacity	
		Soil fertility improvement	
		Pest control	
		Competition with food crops	
		Others	

L. Input, Technical support and Media for adoption of forage production and utilization

Type of support	do you get supports (yes/no)	Trainer/ support provider	Number of training / support	Changes in forage productivity
Training				
Forage seed				
Planting material				
Financial				
Advice				
Media access				
Others				

M. Distance of your home

1. How far your home from extension service?.....km
2. Distance of your home from your District ..... km
3. Distances of your home from market .....km

N. Constraints for forage production management and utilization

1. Do you face problem in forage production, management and utilization? 1) Yes 2) NO
2. If yes, list and rank them according to their importance. (in the table below)

Constraints for forage production management and utilization for dairy	Rank	Opportunities or other mechanisms	Remark
Land shortage			
Shortage of knowledge & awareness			
Seed shortage			
Labor demanding			
Lack of capital			
Lack of input			
Low production			
Lack of credit			
Health bloating			

O. Demerits of forage species

1. What are the negatives effects of forage species?

Species				demerits of plants (1=very high; 2=high; 3=medium; 4=low; 5=very low)						
	low biomass	affected by pests	Unpalatable	High management	toxic	Resistant to drought	Costy	bloating	Competition with food crops	others
Alfa-alfa										
Elephant- grass										
Cowpea										
Rhodes										
Lablab										
Vetiver										
Leuceana										
Sesbania sesban										

Annex2. List of questions for group discussions

Name of tabia/site_____Date_____

Numbers of participants_____males_____females_____

1. What type of dairy production system you practice? What determines the choice of production system?
2. For what purpose, you cultivate green feed? Explain.
3. Which type of green feed suitable to your local area concerning agro ecological zone? And why?
4. Is there any critical problem not to use green feed? If yes, specify_____
5. Where do you get the seed of green feed for first time to start dairy? Specify the source
6. How many times you harvest the feed from pasture or from improved foraged within one year?
7. What are the major constraints in green feed utilization production practices? Rank them according to their importance.
8. What opportunities do have to invest/start green feed utilization for dairy practices?
9. Who are the actors that support you to engage in dairy production with green feed? How? List them with their function.
10. What are the basic input materials to start green feed production practices?
11. Explain the advantage of green feed for dairy animals?
12. Does green feed production trend increase/decrease from time to time? Explain the reasons for increasing/decreasing.
13. What factors do you consider for green feed in local market? Explain
14. What is your suggestion about green feed utilization and dairy population in the local area?

Annex3. Secondary Data Collection Format

Region _____District: _____

Data Collection Date_____ Data collector's name _____

1. Location (latitude and longitude) and distance from prominent town/cities (like Mekelle)

Location	Degree, Minute, Second	Distance	Km
Latitude		From Mekelle	
Longitude		Nearby town _____	

2. Topography

Topography	Tic (Percent if possible)	Agro-ecology	Percent (Tic)
Plain/flat		Kolla	
Rugged		Dega	
Mountainous		Weina-Dega	
Valley			

3. Altitude and Climatic conditions

Altitude (masl)		Rainfall (mm)		Temperature (^{0}C)		Humidity		Wind speed	
Minimum		Minimum		Minimum		Minimum		Minimum	
Maximum		Maximum		Maximum		Maximum		Maximum	
Range		Range		Range		Range		Range	
		Average		Average		Average		Average	

4. Day length, rainfall conditions and soil conditions

Day length (Hours)		Rainfall conditions		Soil colourTick		Soil texture	%	Soil type	%
Minimum		Erratic		Red		Clay		Vertisol	
Maximum		Stable		Black		Sandy		Cambisol	
Range		Unimodal				Loam			
Average		Bimodal				Silt			

5. Land mass cover (ha or km2) _____
6. Land use pattern

Land type	**Area (ha/km2)**	**Percent**
Cultivated lands		
Grazing lands		
Sown pastures		
Fallow lands		
Natural forest		
Reforestation		
Settlement areas		
Total		

7. Farming system (mixed farming, pastoral, agro-pastoral etc) _____

8. Major feed sources ----------
9. Area of irrigated land ----------ha, area of irrigated forage…….

Feed sources	Area	Production quintal /year	

10. Livestock population

Livestock type	**Number**	**Livestock type**	**Number**
Cattle		Pigs	
Sheep		Chicken	
Goats		Mules	
Donkeys		Camels	
Horses			

11. Human population

Human population	Number		Households	Number
Male			Male HH	
Female			Female HH	
Total			Total HH	

12. Vegetation types ----------

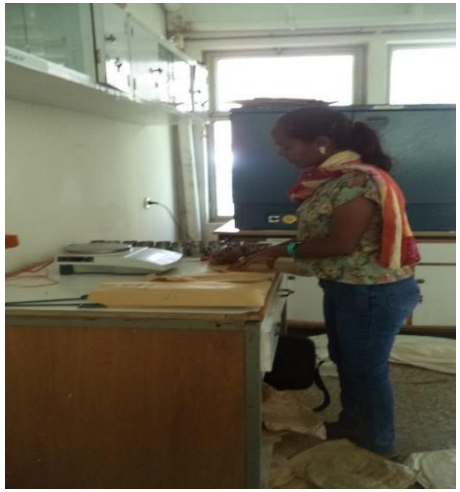
Annex 4. photos during takin sample for common herbaceous legume and grass species

Alfalfa cutting per 1m*1m

during local grass harvesting per 1m*1m

elephant grass cutting and weighted fresh wt.

Elephant grass belt by rope to be weighted



During laboratory weighting and using plastic paper for oven drying

Annex 5 Probit regression output from the stata version 11 software

probit adoption green feed sex, age, Education level total family size, land size, total Livestock HH TLU ,Experience of dairy, Seed access Do you get extension, Media access Distance of home Ftc

Iteration 0: log likelihood = -138.62944

Iteration 1: log likelihood = -56.764513

Iteration 2: log likelihood = -53.188625

Iteration 3: log likelihood = -52.920119

Iteration 4: log likelihood = -52.919049

Iteration 5: log likelihood = -52.919049

Probit regression Number of obs = 200, LR chi2(11) = 171.42 , Prob > chi2 = 0.0000 , Log likelihood = -52.919049 and Pseudo R2 = 0.618

---

adoptiongr~d	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
Sex	-.8342069	.457741	-1.82	0.068	-1.731363	.0629489
Age	-.0005044	.0175354	-0.03	0.977	-.0348732	.0338644
Education level	.6840683	.2230816	3.07	0.002	.2468365	1.1213
Total family size	.0425051	.0754384	0.56	0.573	-.1053515	.1903617
Land size	1.770532	.6312493	2.80	0.005	.5333057	3.007758
Total Livestock	-.0858563	.0693384	-1.24	0.216	-.2217571	.0500445
Experience dairy	.0365583	.0237673	1.54	0.124	-.0100248	.0831413
Do you get seed	1.54318	.4047627	3.81	0.000	.7498595	2.3365
Extension service	.2544623	.3239896	0.79	0.432	-.3805456	.8894702
media access	1.839165	.6675926	2.75	0.006	.530708	3.147623
Distance to ftc	-.3706368	.0786893	-4.71	0.000	-.524865	-.2164086
_cons	-.7442744	1.136172	-0.66	0.512	-2.97113	1.482581

Note: 0 failures and 1 success completely determined.

. MFX Marginal effects after probit

y = Pr (adoptiongrefed) (predict)

= .67409176

---

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.]		X
sex*|	-.247015	.10568	-2.34	0.019	-.454154	-.039876	.865
agecon~s		-.0001818	.00632	-0.03	0.977	-.01257	.012206	45.965
edulevel		.2464873	.08043	3.06	0.002	.088838	.404137	1.705
totalf~e		.0153157	.02728	0.56	0.575	-.03816	.068792	6.42
landsize		.6379678	.2367	2.70	0.007	.174051	1.10188	.462178
totLSH~U		-.0309362	.02525	-1.23	0.220	-.080424	.018552	5.35
exrien~y		.0131729	.00852	1.55	0.122	-.00352	.029865	8.755
doyoug~d*|	.4779809	.09885	4.84	0.000	.28423	.671732	.39
doyoug~n*|	.0929086	.12042	0.77	0.440	-.143112	.328929	.64
doyou~ia*|	.4757714	.08038	5.92	0.000	.318223	.63332	.26
dishom~c		-.1335499	.02715	-4.92	0.000	-.186759	-.08034	3.83352

(*) dy/dx is for discrete change of dummy variable from 0 to1