

**ANALYSIS OF THE PERCEPTION AND ADOPTION OF SMALL-
SCALE DAIRY FARMERS TOWARDS IMPROVED FORAGE AND
PRODUCTION IN SELECTED DISTRICTS, NORTH WOLLO ZONE,
ETHIOPIA**

Mohammed Ahmed Siraj

MSc THESIS

May, 2024

Mersa, Ethiopia

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SCALE DAIRY FARMERS TOWARDS IMPROVED FORAGE AND
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ETHIOPIA**

Mohammed Ahmed Siraj

**A Thesis Submitted to the Department of Animal Sciences, College of
Agriculture Woldia University**

**In Partial Fulfilment of the Requirements for the Degree of
Master of Science in Animal Production**

**May, 2024
Mersa, Ethiopia**

APPROVAL SHEET

As thesis research advisor, we hereby certify that we have read and evaluated this thesis prepared, under our guidance by Mr Mohammed Ahmed, entitled with “ Analysis of the Perception and Adoption of Small-Scale Dairy Farmers towards Improved Forage and Production in selected districts of North Wollo Zone, Ethiopia”. We recommend that it can be submitted as fulfilling the thesis requirement.

Yared Alemayehu (Ph.D.)

Major Advisor

Signature

Date

As a member of the board of examiners of the master's thesis open defines review (M.Sc.), we have read and evaluated this thesis prepared by Mr Mohammed Ahmed entitled: Analysis of the Perception and Adoption of Small-Scale Dairy Farmers towards Improved Forage and Production in selected districts of North Wollo Zone, Ethiopia. We certify that by this; the thesis is agreed to meet the criteria for the award of the degree of Master of Science in Animal production.

Name of External Examiner

Signature

Date

Name of Internal Examiner

Signature

Date

Name of Chairman

Signature

Date

Final approval and acceptance of the thesis are contingent on the submission of the final copy of the thesis to the Council of Graduate Studies through the Departmental Graduate Committee of the candidate's major department.

DECLARATION

This is to certify that the thesis entitled: “ Analysis of the Perception and Adoption of Small-Scale Dairy Farmers towards Improved Forage and Production in selected districts of North Wollo Zone, Ethiopia ”, submitted in partial fulfilment of the requirements for the award of the Degree of Master of Science in Animal Production to the Graduate Program of College of Agriculture, Woldia University by Mr Mohammed Ahmed is an authentic work carried out by him under our guidance. The matter embodied in this project work has not been submitted earlier for an award of any degree or diploma to the best of our knowledge and belief.

Name of the Student: Mohammed Ahmed Siraj

Signature

Date _____

This M.Sc. thesis has been submitted for examination with my approval as

Name of Major Advisor: Yared Alemayehu (Ph.D.)

Signature.....

Date _____

Name of Co-Advisor: Wubshet Tefera (MSc.)

Signature.....

Date _____

DEDICATION

I dedicate this thesis to my wife she specified her time and resource during study.

STATEMENT OF THE AUTHOR

I declare that this thesis is a result of my genuine work and all sources of information used for writing, it has been duly acknowledged. I have followed all ethical and technical principles of scientific research methods in the preparation, data collection, data analysis, and compilation of this thesis. Any scholarly matter included in the thesis has been given recognition through citation.

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Name: Mohammed Ahmed Siraj

Place: Woldia University

Date of submission: May 2024

Signature: _____

BIOGRAPHICAL SKETCH

The author, Mohammed Ahmed, was born in 1975 E.C in Mersa town, Habru District, North Wollo Zone, and Amhara Regional State, Ethiopia. He attended his elementary education at Mersa from 1984 to 1991 and high school education from 1991 to 1993 at Desse General Secondary and Preparatory School, respectively.

He then joined the College of Alage in 1994 and graduated with Diploma in Animal Science on June 1996 and Bahir Dar University in 2011 graduated with Degree in Rural Development. He was then employed by Habru Woreda Agricultural office and served there for 18 years as expert. After that, he was employed by Habru Woreda as Agricultural expert until he joined the school of graduate studies of Woldia University on September 2022 to pursue a graduate study leading to a Master of Science degree in Animal Production.

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ABBREVIATIONS AND ACRONYMS

ACSI	Amhara Credit Service Institute
AIBPs	Agro Industrial by Products
ANRS	Amhara National Regional State
CSA	Central Statistical Agency
ETB	Ethiopians Birr
FAO	Food And Agriculture Organization
GDP	Gross Domestic Product

HHs	House Hold
IF	Improved Forage
ILRI	International Livestock Research Institute
m.a.s.l	Meter above sea level
MOA	Ministry of Agriculture
NGOs	Non-Governmental Organisation
NMSA	National Meteorological Service Agency
<i>NWZARD</i>	North Wollo Zone Agricultural Rural Development
NWZLDHO	North Wollo Zone livestock development and health office
TLU	Tropical livestock unit
USAID	United States Agency for International Development
USD	United States Dollar

Analysis of the Perception and Adoption of Small-Scale Dairy Farmers towards Improved Forage and Production in Selected Districts

ABSTRACT

Various forage technologies have been introduced and disseminated in Amhara regional state, North Wollo zone, and selected district. However, the level of adoption was not satisfactory. Therefore, studying on perception and adoption of improved forage technology is found to be significant to understand the gap and put directions to improve adoption. The objectives of this study were analysing the perception and adoption of farmers' decision to adopt improved forage technologies; level and intensity of adoption, and determinants related to forage adoption. The study used cross-sectional design. A multistage stratified sampling procedure was used to draw 177 sample households from three woreda and nine kebeles. Within the selected kebeles sample respondent households were stratified into two groups using a random sampling approach (adopters and non-adopters). In this particular study, both primary and secondary data were gathered. Interview, questionnaire, observations and focus group discussions were the main methods employed in data collection from sample households (76 adopters and 101 non-adopters). Descriptive statistics were employed to analyse the collected data. T-test and chi-test were used to determine factors affecting the decision of household towards adoption of improved forage technologies. The result of descriptive statistics revealed that out of 14 variables hypothesized, only 10, namely total landholding, forage material supply, rate of extension contact, training, participation on demonstration, age, education year, family size, number of livestock, and access to credit were found to be significantly affecting farmer's decision to adopt improved forage technologies ($P < 0.05$), while sex, marital status, membership to the local organizations and mobile ownership had not significant influence on adoption of improved forage ($P > 0.05$). Farm size, free grazing; and awareness on the importance of forage another factor that limits level/intensity of adoption of forage technologies in selected districts. The awareness of farmers towards improved forage practice was 67.32%, but majority (57.06%) of the farmers still not adopted improved forage practice in the study districts. Improved forage development strategies that are practice in the study districts are alley cropping, backyard, intercropping, and forage development in irrigation. The adoption of production and utilization of improved forage to animal feed is low, only 42.09% of respondents are adopt improved technologies; the main challenges associated with adoption of improved forage

technology are free grazing practice, small land size, lack of planting material/seed, and low access to irrigation facilities. The study recommended the supply of suitable forage varieties, training on how to produce forage without competing for scarce land, continuous follow-up on improved forage production, and access forage seeds with low costs.

Key word: Adoption, Improved forage, Perception

1. INTRODUCTION

Ethiopia, renowned for its vast agricultural landscape, is swiftly emerging as a pivotal player in the dairy industry within the African continent; the sector has great potential for growth (Gebreyohanes *et al.*, 2021). Ethiopia rich in a total of about 70 million heads of cattle and stands on top of the African countries list in terms of livestock population (CSA, 2021). Livestock-sector contributes to 17% of Ethiopia's gross domestic product (GDP) and 39% of its agricultural GDP. Milk accounts for 34% of the livestock contribution to the country's GDP (Zelalem Yilma and Alex Mounde, 2023). Livestock play a significant role as a source of animal food and income in addition to several other important economic and socio-cultural functions (Gezahagn Kebede *et al.*, 2024). The rural dairy small-holder system produces the largest share of total milk produced, contributing 98% of the milk supply. According to report by (CSA, 2021) showed that, local breeds constituting nearly 97% of the total cattle population with low productivity and production (CSA, 2021); due to poor quality and quantity of available feed (FAO, 2019). As a result, most parts of the country are deficient in feed supply. From the total cattle population 97% of them are local breeds characterized by poor production and productivity as stated by CSA (2021). In 2019, the report of Food and Agricultural Organization of the United States stated that the poor performance of local breeds is attributed to poor quality and quantity of available feed (FAO, 2019). The feed supply also varies seasonally (Azage Tegegne and Getachew Legese, 2020).

According to estimate of (FAO, 2018) indicated that the total annual potential biomass available in Ethiopia for animal feeding was 144.48 million tons out of which grazing biomass and crop residues contributed 57.09 and 52.7 million tons, respectively. However, the contribution of improved forages represents less than 0.35% of the diet (CSA, 2021). Improved forage species and varieties are too less in use and importance, but will be serious in the near future to sustainably intensify animal production (Alvarez Aranguiz and Creemers, 2019). Feed cost accounts for about 60 to 70% of the total cost of livestock production (Seyoum *et al.*, 2018). As a result, shortage of feed and escalating price of feeds is adversely affecting the productivity and profitability of livestock operations (Adugna Tolera *et al.*, 2012). These constraints need to be addressed and technological change be promoted to increase milk production (Mohamed *et al.*, 2004).

The adoptions towards improved forage and production have a tremendous contribution to improve and sustaining livestock productivity for the future (Bashe *et al.*, 2018). Diverse agro-ecology, soil types and production systems in Ethiopia provide good opportunity for the production of different types of improved forages for feeding livestock and also to develop forages as marketable commodity (Azage Tegegne *et al.*, 2013). Improved nutrition through adoption of sown forage and better crop residue management can substantially raise livestock productivity. National and international research agencies, including the International Livestock Research Institute (ILRI), have developed several feed production and utilization technologies and strategies to address the problems of inadequate and poor quality of feeds (Mohamed *et al.*, 2004). On-farm production of forage is being increasingly adopted along with the expansion of intensive management systems, but still it represents a very small fraction of total feed, on a national scale (Adugna Tolera *et al.*, 2012).

In spite of the critical shortage and low quality of the available feed resources, the rate of adoption of forage and pasture production and utilization is extremely low in Ethiopia due to various factors, which may include low economic incentives under subsistence production system, limitations in support service delivery and policy and institutional issues (Adugna Tolera *et al.*, 2012). Hence, this research was conducted with the aim to analyse the awareness, perception and adoption of small-scale dairy farmers towards improved forage in the study district.

1.1. Problem Statement

Ethiopia has a huge cattle population of about 70 million head; out of this the female cattle constitute about 56% (CSA, 2021). Unfortunately, milk production and consumption is very low. The current demand for dairy products has been found to largely outweigh their production in Ethiopia (World Bank, 2017). According to (Azage Tegegne, 2018), the average per capita milk consumption in Ethiopia was 20 litres, which is extremely lower than FAOs recommendation that the per capita consumption of milk be about 200 litres, meaning 22 billion litres of milk is required. At the current production rate, there's an annual shortage of about 18 billion litres. The per capita milk consumption has declined

from 26 kg per annum in 1980, to 22 kg in 1993, 19 kg in 2000 and 16 kg in 2009 (Mebrate Getabalew *et al.*, 2019). As a result, the country spends to import dairy products mainly concentrated (powder) milk is increasing year after year and will reach \$25 million in 2021. By the year 2028, an estimated daily deficit of about 3,185 million litres (29% deficits) of milk is expected (Zelalem Yilma and Alex Mounde, 2023). According to report by (World Bank, 2017) average milk yield in Ethiopia is 1.5 liters per day/cow, it is much lower compared with other countries in the region such as Kenya and Rwanda (3.6 kg per day). There are different constraints affecting milk production potential of dairy cattle in most parts of Ethiopia including shortage of quality and quantity feed (Bart Minter *et al.*, 2020), poor animal health, poor genetic makeup, market services (Gebreyohanes *et al.*, 2021), and low adoption of improved technologies (Azage Tegegne *et al.*, 2013).

Among factors that hinder the productivity of livestock in Ethiopia, nutrition contributes the largest share especially for small-scale dairy producers. Under smallholder management conditions, most of the animals depend on grazing communal lands (about 54.54%); followed by crops residue that is 31.13% (CSA, 2021). According to the (FAO, 2018), the total estimated annual potential biomass available in Ethiopia for animal feeding was 144.48 million tons out of which grazing biomass and crop residues contributed 57.09 and 52.7 million tons, respectively. Nowadays, due to the rapid increase of human population and increasing demand for food, grazing lands are steadily declining by being shifted to arable lands for crop production (Sinishaw, 2005) and land degradation associated with over grazing and erosion (Woldewahid *et al.* 2013), results poor pasture productivity to feed livestock. Through crop residues are providing a considerable quantity of dry season feed in most farming areas of the country, most of it is poor quality, highly affected by seasons and low in quantity (Muluye Fekade, 2019). Supplementary feeds, like cereal bran and oil cakes, are either too expensive or in short supply (Azage Tegegne, 2018). According to (Ulfina *et al.*, 2013), funding inadequate supply of quality feed is the major factor limiting dairy productivity in the region. Funding unavailability of feed probably limit the milk production potential of cows with good milk producing ability more than any other single factor and is the most serious constraint to improve dairying (Dereese, 2008).

According to report made by (Bhramar *et al.*, 2021) said that, during dry season, the cost of manufactured feed increases by around 20% due to high competition for feed ingredients in the market, and cost of transport of hay/bale is much more expensive, resulting in shortages and reduced accessibility of feed for smallholder livestock producers. At the beginning of rainy season cultivation land is ploughed and animals are restricted from access to grazing land in which cultivation land is covered by crop (Muluye Fekade, 2019). However, livestock are suffered due to feed shortage during dry season and the beginning of rain. As a result, livestock productivity and reproductive efficiency in the region become very low. The present feed shortage in the country is not only undermining the livestock productivity, but also claiming animal lives upon which the economic growth of country heavily depends (Regassa Bekele & Solomon wendia, 2023).

As feed shortage is the main problem in livestock production, alleviating feed shortage will increase animal productivity. This in turn results in more meat and milk production. This will contribute for better nutrition of the household. As there is malnutrition problem in the region, better nutrition of animals will result in better nutrition of humans (Ensew *et al.*, 2015). One of the interventions strategies to alleviating feed shortage is practicing development of improved forages. Proper uses of improved forages can help not only mitigate livestock feed shortages but also help to reduce pressure on natural pastures, support system substantially and enhance natural assets and system reliance (Endalew, *et al.* 2016). Furthermore, the costs of nutrients from cultivated forages are up to 15-fold lower than those from the conventional feed resources and decrease the cost of feed for milk production four fold (Bhramar *et al.*, 2021). The utilization of cultivated forages could significantly reduce methane emissions with abatement value would range from \$1,350 to \$2,400 per 1 million liters of milk production for the dairy sector (MoA, 2020). Introduction of improved forage technologies would be necessary to alleviate problems related with quantity and quality of livestock feeds produced (Diribi Mijena, 2022). However, many types of improved forage have been released through research centers to alleviate this feed shortage in milk production. The introduction of these improved forage is, therefore, an important farm innovation which when used by farmers can significantly improve milk production.

In the long history of Ethiopian forage/seed production, different dairy development initiatives have been made many efforts to under took forage/seed production in the country in past and present. Among these involving Smallholder Dairy Development Program (SDDP), Fourth Livestock Development Project (FLDP), National Livestock Development Program (NLDP), Growth and Transformation Plan (GTP) and Ministry of Livestock and Fishery resources have been working on strategies to bridge the gap between the demand and supply of milk in Ethiopia (Eshetu Yimer and Teklu Kidane, 2015; Mengistu *et al.*, 2016). Some of the main strategies have been the distribution of improved heifer breeds, milk processing equipment and activities in forage seed production, introduction of appropriate fodder production, seed quality control and training of professional and smallholder farmers involved in fodder and forage seed production. However, the dairy sector has not been able to take-off, and related to this, forage/fodder development has been very low (Alvarez Aranguiz and Creemers, 2019). In the past (1970 to 2020) few decades, research centers have been widely tested and introduced highly nutritive and low-cost 37 varieties of grasses, 25 herbaceous legumes and 13 browse trees and shrubs to local farmers of Ethiopia to improve cattle's protein intake and increase the productivity of dairy farms in Ethiopia (Diribi Mijena, 2022). Despite these efforts of past and present, the vast majority of farmers do not use improved forages. Even though demand for forage is increasing over time, but the knowledge or awareness of farmers on benefits of cultivating forage and adoption rate of improved forages at smallholder livestock farmers' level has remained very low (Alemayehu and Getnet, 2012).

However, the adoption of released forage technologies by smallholder livestock farmers has proven to be unsatisfactory. Poor rates of adoption for improved forage technologies have been reported in most parts of Ethiopia where they were introduced, only 0.57% improved forage was used as animal feed in the country (CSA, 2021). According to the survey carried out by the Central Statistical Agency (CSA, 2021) found that despite heavy effort applied on more nutritive improved forage technologies in Ethiopia, only 4.2% of smallholder farmers had started adopting them by 2019/20. According to Assessment of Improving Productivity and Market Success (IPMS) project indicated that only 0.15% of rural livestock keepers reported on-farm production of improved forages such as alfalfa and Elephant grass (Tefera *et al.*, 2010). The question is why forage technologies, which have the potential to greatly improve dairy farm outputs and even the livelihoods of a

people, do not seem to be meeting the targeted responses. Why are smallholder dairy farmers in Ethiopia (and Amhara region in particular) unable to adequately adopt the improved forage technologies introduced to improve the performance of the dairy cows? This study was focused on exploring avenues for answers to this question

1.2. Objectives of the Study

1.2.1. General objective

To determine the farmers' perception and adoption towards using improved forage and production in the selected districts

1.2.2. Specific objectives

- To analyse farmers' perception towards improved forage technologies and production among small-scale dairy farmers in the selected districts.
- To examine the level of adoption of improved forage technologies and production among small-scale dairy farmers in the selected districts.
- To examine constraints to adoption of improved forage technologies and production among small-scale farmers in the selected districts.

1.3. Research Questions

The main research question is 'what are the effects of farmer's perceptions and adoption toward improved forage and production among small-scale dairy farmers of the selected districts. This study is aimed at examining the following specific research questions:

- What are the current livestock feed resources in selected districts?
- What are the main fodder tree, herbaceous, and grass species in selected districts?
- What perceptions and adoption do small-scale dairy farmers in the selected districts hold towards improved forage and production?
- What is the level of adoption of improved forage and production among small-scale dairy farmers in the selected districts?

- What are the constraints to adoption of improved forage and production among small-scale dairy farmers in the selected districts?

1.4. Significance of the Study

The comprehensive literature review part of the study examines issues of general livestock production and forage adoption across the entire Ethiopia. The study therefore uncovers contextual influencing forces on the promotion and adoption of improved forage technologies in selected districts. Specifically, it examine the institutional, socio-economic, socio-demographic, psychological factors, local gender rules and conditions that are in place and how these all influence the adoption and diffusion process of improved forage technologies in the region, with a special focus on *Habru*, *Kobo*, and *Gubalafto* woredas smallholder farmers. Therefore, the results of this study would add information to the limited research done so far on the role of forage technology adoption and impact in the study area, contribute the knowledge gap regarding to impact and forage technology adoption, used as a reference for other similar areas for further study, and it provided required information for different policy maker to formulate appropriate policies with regard to farmers' adoption, and identifying major factors that influence the uptake of improved forage technologies as well as its impact on household income and dairy productivity.

1.5. Scope of the Study

The study was conducted with the aim of identifying opportunities and constraints for the adoption of forage technologies in smallholder dairy production systems in *Habru*, *Raya Kobo*, and *Gubalafto* (North Wollo), while the focus has been limited to the three North Wollo woredas of Amhara region because of limited resources. The major limitation of the study was mainly related to its limited area coverage within the region. Besides, it would cover only nine kebeles out of the total 114 rural kebeles due to inadequate budget and time to increase the number of the respondents and study area. This could limit the generalizability of the study to the whole region. As far as possible it was tried the study carries out at representative kebeles, the study findings would serve as a base for further research in the selected districts.

2. LITERATURE REVIEW

2.1. Smallholder Dairying in Ethiopia

Dairy production is an important component of livestock farming in Ethiopia. The large and diverse dairy animals genetic resources adapted to the wide and diverse agro-ecologies, varied and favourable agro-ecology for dairying, increasing demand for dairy products in urban and peri-urban areas, long-standing culture of dairy products consumption, relatively disease-free environment for livestock and favourable policy are indicators of the importance and potential of dairying in the country (Matawork Milkias, 2016; Azage Tegegne *et al.*, 2013). In Ethiopia, dairy production is generally a subsistence smallholder-based industry with relatively few small and medium dairy farms (Gebreyohanes *et al.*, 2021). In current situation, inadequacy and poor quality of feed resources for livestock is the greatest limiting factor for milk production in Ethiopia. Amazingly, the adoption rate of forage technologies to improve milk production has remained low among smallholder farmers in the country (Mekonnen *et al.*, 2022). There are different milk production system in the country, each of these systems is defined by its location, agro-ecology, their main production objective, resources and resource use, scale of production and management, market orientation, and access to inputs and services (Azage Tegegne *et al.*, 2013). Generally, smallholder dairy farming systems in Ethiopia could be classified into urban, peri-urban and rural dairy systems (Solomon Gizaw *et al.*, 2016; Tegegne *et al.*, 2013); characterized by agro-ecology, objectives, sources of feed and feeding system, breeds, and integration with crop.

2.1.1. Rural dairy system

The rural smallholder dairy system is the dominant dairy production system in the mixed crop–livestock area, and also the largest system in terms of the number of dairy cows and total milk production in the country (Solomon Gizaw *et al.*, 2016). Mixed crop livestock production systems is a subsistence-oriented farming system concentrated in the mid and high-altitude agro-ecological zones, where cereals and cash crops are the prevailing farm activities. Cattle are primarily kept to supply draft power and for milk production. The average herd size is around four heads, typically of indigenous breeds (FAO, 2019).

Pastoral and agro-pastoral production systems are mainly found in the lowlands and largely rely on natural or semi-natural vegetation. The typical herd comprises 10–20 indigenous cattle, though herds of over 200 heads are common (FAO, 2019), which has limited access to urban centres where fluid milk is demanded. Besides dairy, animals are also kept for manure and castrated male animals are kept for draught power (Azage Tegegne *et al.*, 2013) the system in general, have access to land and practice mixed crop–livestock farming, which produces part of the feed in the form of crop residues and grazing.

The rural dairy system produces the largest share of milk, contributing 72% of the total milk supply from 65% of the milking animals (FAO, 2017), 49.33% of the total milk production was used for household consumption while 9.45% of the total milk production was used for sale, only 0.55% was used for wages in kind and the rest 40.67% was used for other purposes (CSA, 2021). The average herd size of the farms in the mixed crop–livestock system was 4.4 heads. Age at first service of indigenous cows was highest in rural areas (Solomon Gizaw *et al.*, 2016), with average length of lactation is 6.5 months (Yin Li *et al.*, 2023), and average milk yield per cow per day is about 1.482 liters (CSA, 2021), ranged from 1.24 in the rural lowland agro-pastoral system to 2.31 in the rural highland system (Azage Tegegne *et al.*, 2013); lactation length of indigenous animals was shorter in rural lowland transhumance system than in the rural highland dairy system.

2.1.2. Peri-urban small-scale dairy system

Peri-urban milk production system is developed in areas where the population density is high; which have relatively better access to urban centres in which dairy products are highly demanded and agricultural land is shrinking due to urbanization (Mebrate Getabalew *et al.*, 2019). Peri-urban small-scale farmers and landless households also fatten few animals for slaughtering. The average herd size is around 5-10 heads, including indigenous Zebu, crossbred and high-grade animals (FAO, 2019). Sale of fluid milk and some local butter are the main production objectives in this system, milk marketing is dominant being higher in urban than peri-urban system. Besides dairy, animals are also kept for manure (fuel production and fertilize the soil) and castrated male animals are kept for draught power. Similar to urban dairy, in this system too, milk production in general is mainly based on cattle both improved and indigenous (Azage Tegegne *et al.*, 2013), and

contributed only 2% of the total milk production of Ethiopia. The main source of feed is both home produced and purchased hay to get additional cash income from milk sale (Mebrate Getabalew et al, 2019). The average daily milk production for crossbred dairy cows was higher in urban (10.21–15.9 litres/head/day) than peri-urban (9.5 litres/head/day) systems (Azage Tegegne *et al.*, 2013).

2.1.3. Urban small-scale dairy systems

Market-oriented dairy farms are capital intensive and concentrated in the central highland plateau. The average herd size less than 30 (small-scale) heads, mainly consisting of exotic and high-grade animals (FAO, 2019), and focuses on production and sale of fluid milk, with little or no land resources, using the available human and capital resources mostly for dairy production under stall feeding conditions. As compared to other systems they have relatively better access to inputs and services provided by the public and private sectors, and use intensive management (Azage Tegegne *et al.*, 2013). The herd is dominated with improved/cross breed dairy cattle and the production system is market oriented and milk production is for sales (Mebrate Getabalew et al, 2019). Cows in the urban dairy systems have a higher milk productivity of 15–20 L per day and a lactation of 6.7–12.7 months (Yin Li *et al*, 2023). Urban dairy system with combination to peri-urban and urban small-scale dairy farmers produces 2% of the total milk production of the country (Mebrate Getabalew *et al*, 2019).

2.2. The Role of Livestock Production in the Economy and Livelihoods in Ethiopia

2.2.1. The role to the national economy

Ethiopia has the largest livestock population in Africa, with nearly 70 million cattle, over 42.9 million sheep and 52.5million goats, and 57 million chickens in 2019/2020 (CSA, 2021). The livestock is an important sub-sector within Ethiopia's economy in terms of its contributions to both agricultural value-added and national GDP. Cattle production is one of the main agricultural industries in Ethiopia, and the sector contributed up to 40 % of agricultural GDP, nearly 20 % of total GDP, 20 % of national foreign exchange earnings in 2017 (The World Bank, 2017), 5% of the overall manufacturing GDP (Behnke, 2010), and supporting the livelihoods of a large share of the population (FAO, 2019). Cattle

contribute about 80 % of the livestock value added. Ethiopia produces over 3.8 billion litres of cow milk and about 1 million tonnes of beef per year, valued at USD 2.5 billion and USD 5.1 billion, respectively (FAO, 2019). The sector provides employment to over 30% of the agricultural labour force (Policy Studies institute, 2024). Cattle are a very common asset in Ethiopian households; 12.5 million households, or 70% of the total population, depend fully or partly on cattle for their livelihoods. Out of the 14 million households keeping livestock, more than 12 million own at least one cattle, which support livelihoods through the provision of meat, milk, cash, draft power, hauling services, insurance and social capital (FAO, 2019).

2.2.2. The role in the livelihood of most Ethiopian farmers

Household income: At the household level, livestock plays a critical economic and social role in the lives of pastoralists, agro-pastoralists, and smallholder farm households. Cattle keeping can generate revenue through milk production (and derived products), beef production and sale of live cattle. According to (FAO, 2019), 12.5 million households keep cattle, which contribute from 31 to 48 % to total household income; in pastoral and agro-pastoral (65%), and urban/peri-urban systems (47%). In the mixed crop-livestock system, livestock is the second most important source of income (34%) after crop activities. In the case of smallholder mixed farming systems, livestock provides nutritious food, transportation, farm outputs and inputs, and fuels for cooking food. In the case of pastoralists, livestock represents a sole means to support and sustain their livelihoods (Negassa *et al.*, 2011). For rural smallholders, livestock also perform important economic functions as repositories of household savings, as assets that provide interest-free credit, and as insurance to mitigate risk (Behnke, 2010).

Food and nutrition security: Milk and milk products play a very important role in the feeding of the rural and urban people. Milk produced by smallholders is predominantly used for home consumption in the mixed crop-livestock and a pastoral / agro-pastoral system. In the urban dairy sector, however, milk is produced for market and the average annual net income from milk production is substantially higher (92%) than in the other production systems (FAO, 2018). Cattle contribute to food security and nutrition through the provision of beef, milk and other product to the population, and owning livestock is associated with a 20% increase in potential caloric nutrition at the household level (Policy

Studies institute, 2024) and 2–13% of household protein requirements (Azage Tegegne and Getachew Legese, 2020). Milk also provide essential micronutrients that are less available in plant-based foods particularly valuable for infants in their first 1,000 days of life, from conception to 2 years old and enhance human health in developing countries by providing nourishing foods, which are the foundation of good health and help the body protect itself against, and recover from, disease (ILRI, 2019). It was revealed that only 54% of households in Ethiopia regularly consume animal source food. Milk consumption is highest in the pastoral and agro-pastoral systems, and more than 70% of their consumption coming from their own animals (FAO, 2018).

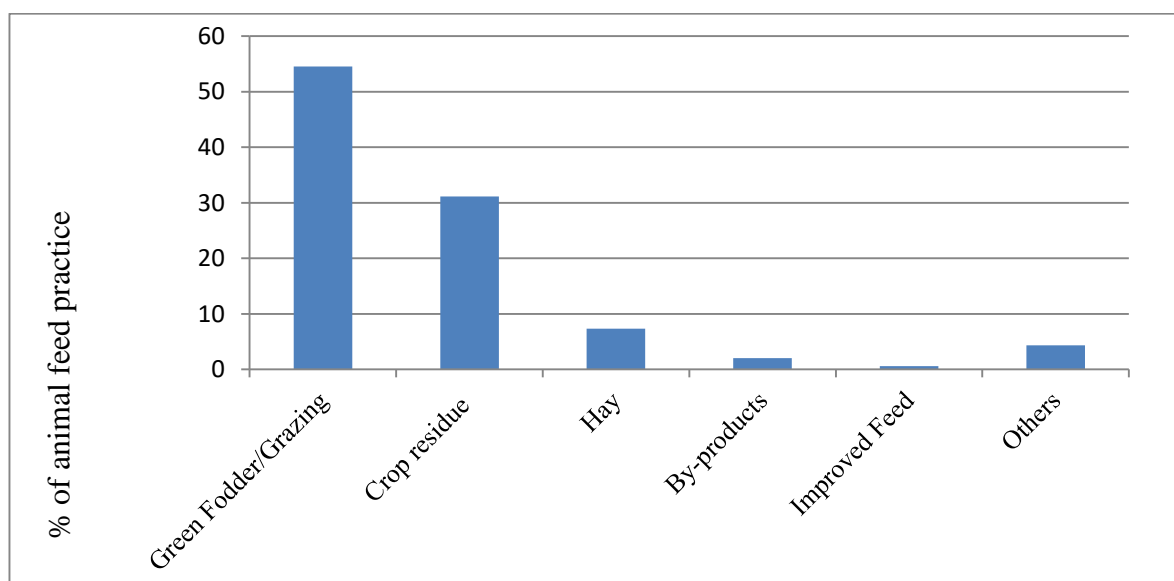
Crop production and soil fertility: Livestock plays a crucial role beyond food production. They contribute to the agricultural sector by providing draught power for the cultivation of the smallholdings and for crop threshing virtually all over the country and are also essential modes of transport (CSA, 2021), about 80% of Ethiopian farmers use animal traction to plough their fields; the value of the animal draught power input into arable production can be estimated at 26.4% of the value of annual crop production (Behnke, 2010). Draught animal power is critical for all farming systems (USAID, 2011). Consequently, 14 million households, or 70% of the population, keep livestock for various purposes (Policy Studies institute, 2024), and also serves as an input for agro-processing industries and provides manure for crop cultivation (Negassa *et al.*, 2011), and cooking fuel (FAO, 2018). Dung valued at an estimated 1.4 billion ETB (138.4 million USD) was used by producer households for soil fertility and fuel (Behnke and Metaferia, 2011).

Developing livestock value chains creates huge opportunities for job creation, particularly for youth and women. In Ethiopia, over two-thirds of the labour requirement for livestock herding in traditional smallholder mixed farming systems and urban and peri-urban dairy systems is provided by children. Women are also involved in the management of farm animals, milk processing and marketing (Azage Tegegne and Getachew Legese, 2020).

2.3. Dairy Cattle Feed Resources, Availability, Quality, and Feeding System in Ethiopia

Feed is the main input and the major cost in livestock production. Depending on the farming systems there are different sources of feeds including; rangelands /grazing lands,

crop residues, cultivated forage crops, agro-industrial by products, formulated concentrates and other non-conventional feeds (Kindu Mekonnen *et al.*, 2021). The availability and the nutritional quality of the available feeds are the most important factors that influence the productivity of livestock (Ahmed *et al.*, 2010). According (FAO, 2018), the total estimated annual potential biomass available in Ethiopia for animal feeding was 144.48 million tons, out of which grazing biomass is the major type of feed (54.59%) and followed by crop residues contributed 31.60% of the total feeds (CSA. 2018). Hay and by-products were also used as animal feeds that comprise about 7.35 and 2.03 % of the total feeds, respectively. Non-significant amount of improved forage (only 0.57 %) was used as animal feed and other types of feed that accounted for about 4.37 % were also used in the country (CSA. 2021). The contribution of these feed resources, generally, depends up on the agro-ecology, the type of crop produced, accessibility and production (Ahmed *et al.*, 2010). As a result providing a proper nutrition to animals, especially during the dry season when pasture and cereal residues are limiting both in nutritional quality and quantity remain to be the problem faced by livestock producers in the tropical countries (Federal TVET Agency, 2019).



Source: CSA, 2020/21. Agricultural Sample Survey

Figure 1. Estimated contribution of different feed resources to annual livestock feed supply

2.3.1. Feed resource

Natural pasture

Natural pastures are naturally occurring grasses, legumes, herbs, shrubs and tree foliage that are used as animal feed (Adugna Tolera *et al.*, 2012). Natural pasture is the dominant feed resources for dairy animals in peri-urban and rural production systems (Azage Tegegne *et al.*, 2013). Under rural livestock management condition (particularly, pastoral and agro-pastoral), the main feed resources available in areas are natural pastures herbaceous vegetation composed mainly of grasses and forbs, and browses such as shrubs, tree leaves and pod's and Acacia species for browsing (Management Entity, 2021). Livestock grazing is the predominant form of land use in pastoral areas, which is low in quantity and quality for sustainable animal production and which exhibit considerable temporal and spatial variability (Federal TVET Agency, 2019). Adequate feed is available during the rainy season, but pastures are depleted during dry seasons when pastoralists have to feed leaves and branches of trees to their animals. Haymaking during feed surplus season is not common, but some rangeland areas are often fenced and reserved (standing hay) for dry seasons (Management Entity, 2021). A basic shortcoming of the natural grasslands as a source of feed for ruminant livestock are low production of dry matter and nutritive value due to a combination of the negative effects of inadequate rainfall and soil nutrients (Federal TVET Agency, 2019), although natural pasture seems abundant during the wet season. The high climate variability and seasonal changes also produce fluctuations in feed availability. Feed resources could drop by up to 56% in the dry season due to inadequate rainfall (Njarui *et al.*, 2012).

The intensity of cropping determines the area of land available for grazing and browsing. In the densely populated areas of the Ethiopian rural highlands, the better soils are used for cropping and the steep slopes and the seasonally waterlogged foothills are allocated for grazing (Adugna Tolera *et al.*, 2012). The size of land allocated for grazing is very small compared to the land allocated for crop production in rural highland dairy production system since crop production is the dominant production system in the area. In general, pasture/grazing is either small or is degraded with low biomass production (Azage Tegegne *et al.*, 2013). In some places grazing lands are managed privately, however, communal grazing is widely utilized in the majority of the months of the year (Kindu

Mekonnen *et al.*, 2021). The role of grazing as a source of livestock feed has begun to decline from time to time due to shrinking grazing land size (FAO, 2018), cannot produce sufficient forage to meet the requirements of the livestock population for most part of the year (Adugna Tolera *et al.*, 2012). However, dairy farms in rural lowland system allocated relatively better size of land for grazing. Roadside grazing was common in the urban dairy system, which has limited land resources.

Crop residues

Are important source of feed commonly used by dairy animals across all the production systems. According to the report done by (CSA, 2021) on feed usage experience of holders in the rural areas of the country, crops residue remained the second major source feed that accounted 31.13%. There are different types of crop residues produced in the country. The major once are cereals (straw and chaff of cereals), followed by legumes (Kindu Mekonnen *et al.*, 2021). Nowadays, due to the rapid increase of human population and increasing demand for food, grazing lands are steadily declining by being shifted to arable lands for crop production (Sinishaw W, 2005); and land degradation associated with over grazing and erosion (Woldewahid *et al.* 2013). Due to, in Ethiopian highlands crop-livestock systems, crop residues have become the dominant ruminant feed resources accounting up to 30-80% of the diet (Funte *et al.*, 2009). Significant number of holders (about 13.77 million) in the rural areas of the country also reported that they used to feed crops residue for their animals (CSA, 2021). Among crop residues used, *teff*, wheat and barley straw, and maize Stover are mostly stacked and feed to livestock during the dry season in the rural highland, while sorghum Stover is the limited feed resources in the rural lowland (agro-pastoralist) dairy system. In the peri-urban dairy system, maize Stover is the most commonly used feed resources and most of the households use it during the wet and dry seasons (Azage Tegegne *et al.*, 2013). Crop residue is the most important source of feeding, after pasture. However, Crop residues, mainly cereal stalks, are either poor in quality or less adequate to support profitable animal production (Alemu *et al.*, 2013).

Conserved feed/hay

Hay making is appropriate and cheaper means of conserving forage to ensure year-round feed availability. Hay was also used as animal feeds that comprise about 7.35% of the total feeds (CSA, 2021); moreover, about 5.76 million holders Ethiopia reported to use hay. In the rural lowland with agro-pastoral system, hay making was not common (natural pasture left as standing hay as an alternative feed conservation strategy). In the urban and peri-urban dairy system, hay and crop residues stacking were a common practice to conserve feed for dry season (Adugna Tolera *et al.*, 2012). Hay stacking was practised by 35.8% of the urban dairy producers (Azage Tegegne *et al.*, 2013). Hay making from exclusion areas farm boundaries, school and church compounds becomes very common in peri-urban and rural dairy system (Kindu Mekonnen *et al.*, 2021).

Agro-industrial by product

Agro-industrial by-products are the by-products of the primary processing of crops. They include flour mill by-products, oilseed cakes, brewery by-products, and molasses. These feed ingredients are the main constituents of concentrate feeds (Adugna Tolera *et al.*, 2021). In urban and peri-urban dairy areas, the most widely utilized agroindustry by-products are flour mill by products (wheat bran), oil seed cakes and brewery spent grains (Kindu Mekonnen *et al.*, 2021). However, the contribution of agro-industrial by-products to the livestock feed supply is remained low (2.03%) of the total feeds (CSA, 2021); and mostly limited to commercial livestock operations and smallholder livestock producers in urban and peri-urban areas (Adugna Tolera *et al.*, 2012), due to its accessibility and keeping of improved genotypes (Azage Tegegne *et al.*, 2013). The available concentrate feeds are mainly used by urban and peri-urban market-oriented dairy producers, however, dairy and feedlots partly use formulated feeds and partly home-mixed feeds (Kindu Mekonnen *et al.*, 2021). Generally, currently the use of food grains as livestock feed in the rural smallholder farmers is generally country is insignificant. High cost, limited access, low milk off take, and lack of awareness are the major reasons for the low utilization of agroindustry by-products in the rural dairy system (Azage Tegegne *et al.*, 2013).

Cultivated forage

Successful and integrated forage production is becoming popular in different parts of Ethiopia. The primary benefits are to produce high amount of quality forage to be used as feed for farm animals. And also they complement crop production through maintaining soil fertility by fixing nitrogen or when used as mulch (Adugna Tolera *et al.*, 2012). Forage crops mainly legumes are grown through intercropping and under-sowing with cereal crops especially maize and sorghum. The use of improved forage crops is limited to areas where market-oriented livestock production is practiced such as the case of crossbred dairy production by smallholder farmers and commercial dairy farmers who have access to land, only 0.57% improved feed was used as animal feed in the country (CSA, 2021), about 0.65 million holders used improved feed during the 2020/21 period. Government institutions like research centres and dairy enterprises also produce and use some forage crops such as oats/vetch and Rhodes grass mainly as conserved feed in the form of hay (Fekede Feyissa *et al.*, 2022). In the typical mixed crop-livestock farming system, the household has two integrated enterprises, crop and livestock production. Since in mixed systems households can grow and feed forages for their own animals without recourse to forage markets, this system holds the highest potential for adoption of improved forages. Also, forages prove useful in this system to support livestock during periods of low availability of crop residues and natural pastures, such as during the cropping season (Mohamed *et al.*, 2004).

Non-conventional feed resources

The availability of non-conventional feed resources varies depending upon the production system and agro-ecology. The most common feed resources under this category are pulse hulls, *enset* leaf and *chorm*, crop thinning, pseudo stem and leaf of banana atella (residue of local brewery). Dairy producers in high land and peri-urban areas use non-conventional feed resources such as, *atella*, *enset* leaf/ *chorm*, and local flour mills by products like pulse hulls to supplement dairy animals (Azage Tegegne *et al.*, 2013). Sweet potato and cassava tops and vines, sugarcane tops and by-products are also becoming very important in small-scale livestock production systems (Adugna Tolera *et al.*, 2012).

2.3.2. Variability of feed and feeding in different production systems

In Ethiopia, the main sources of animal feed are natural pastures, crop residues. The total area of grazing and browse is estimated to be between 61 and 65 million ha, of which 12% is utilized for mixed farming and the rest are pastoral areas (Malede and Takele, 2014). Seasonality of agriculture production, inadequate natural pasture and cultivated fodder production, along with the inefficient use of available feed resources greatly impacts animals' nutrition and subsequently their productivity (Gelayenew *et al.*, 2016). In most areas of the country, the supply of fodder increases during the rainy season, pasture and browse regenerate and this improves the relative availability of forage for grazing and browsing animals (Harinder *et al.*, 2018). During the rainy seasons the pasture availability and quality are high (Keba *et al.*, 2013) and generally achieve satisfactory livestock productivity.

Depending on the part of the country where the dairy farms are located, feeding could either be 'zero-grazing' or pasture grazing and mixed-feeding in a few parts that still have communal grazing lands (Hycenth *et al.*, 2017). In the pastoral and agro-pastoral zones of Ethiopia the feeding strategies in dry seasons are largely dependent on naturally available forages which include grazing pasture and browses. Crop residues and conserved hay, if available, are used in small amounts as supplements (Harinder *et al.*, 2018). In the long dry (*tseday*) season, the dominant feeding strategy in rural and peri-urban dairying system is livestock grazing on private or communal pasture lands and protected areas, and on crop aftermath (Harinder *et al.*, 2018). In the dry seasons, the quality of grazing pastures is very poor, with digestibility of approximately 40% to 45% and crude protein content of less than 5% (Talore *et al.*, 2013). The crop residues used as supplement are also low in crude protein 3% to 4% (Feedipedia, 2018); much lower than is required even for maintenance (7%). While stall feeding dominates in landless urban dairy production system (Azage Tegegne *et al.*, 2013); Zero-grazing feeding with hay, and crop residues and green grass in the dry season as the main feeds, typically twice a day. Supplementation of dairy animals depends on the level of production in case of urban and peri-urban systems but on vulnerability of the different classes of animals and season in case of rural dairy production system (Azage Tegegne *et al.*, 2013); in the urban and peri-urban system, supplementary feed is mainly given to lactating cows only.

2.4. Livestock Innovations

2.4.1. Feed

There is large livestock resource base in the country Ethiopia, the productivity and economic contribution of the livestock sector are below potential due to technical and non-technical constraints (Adugna Tolera, 2012); demand for animal products in Ethiopia outpace supply. One of the major technical constraints limiting productivity of livestock is shortage of quality and quantity feed (Bart Minter *et al.*, 2020). Shortage of feeds is exacerbated by the increase in human and livestock population and expansion of croplands, resulting in decrement of grazing lands (Federal TVET Agency, 2019). According to the study of (FAO, 2018), showed that, Ethiopia has a deficit of 27 million MT of animal feed per year and needs to fill this huge gap in order to ensure feed security. From annual feed deficit in the country, cultivated forage deficit accounts 5.6 million MT (Dey *et al.*, 2022). The country rich in diversity of production systems, significant biodiversity and wide range agro-ecology, the development of Ethiopia's feed systems have the potential to build more sustainable feed systems when supported by advances in technologies and research.

Therefore, the need for application of different feed technologies to improve the feed value of low quality feed resources across the different dairy production systems, either through improvement of the basal diet (introduction of improved forages, rehabilitation of natural pasture and over sowing, urea treatment of crop residues) or supplementation (use of AIBPs, non-conventional feed resources, urea molasses block) (Azage Tegegne *et al.*, 2013) and improving the efficiency of production systems is necessary given constraints on land and resource availability and the relatively small land plots in most of Africa (Lowder *et al.*, 2016). Improving production efficiency is necessary to meet the growing demand for food (including animal sourced foods) but is also an environmental imperative (Sheryl *et al.*, 2021).

Given the increasing demand for livestock products and the associated increases in the domestic and export markets for feed, if so, the production of cultivated improved forages are highly profitable innovations for dairy producers (Azage Tegegne and Getachew Legese, 2020). In such situation, improved forage options that address yield and nutritive

value issues are needed to increase livestock productivity (Federal TVET Agency, 2019). Introduction of appropriate small-scale technologies for improving crop by products or making hay or silage can effectively smooth out seasonal feed shortages and avoid dry-season shortages of fodder and milk (ILRI, 2019). And also can mitigate this food and feed competition through the development of feeds from sources that cannot feed people and that do not compete with food crops for land.

2.5. Improved Forage Production in Ethiopia

Feed is the most important input in livestock production and its adequate supply throughout the year is an essential prerequisite for any substantial and sustained expansion in livestock production to support the livelihood of millions of smallholders, pastoralists, and others people across the developing world that depend on livestock rearing (Federal TVET Agency, 2019). However, the main feed resources for livestock in Ethiopia are natural pasture and crop residues (CSA, 2021). The role of natural pasture grazing as a source of livestock feed has begun to decline from time to time due to shrinking grazing land size as a result of increased areas of cultivation, increase in human and livestock population and changing patterns of land use (Federal TVET Agency, 2019). Crop residues are also poor in quality, highly affected by seasons and low in quantity (Muluye Fekade, 2019). In addition, the contributions of agro-industrial by-products (cereal bran and oil cakes) to the small-scale dairy cattle feed are either, too expensive (Azage Tegegne, 2018) or in short supply (0.8%) and mostly limited to commercial livestock operations (Adugna Tolera et al., 2012). Adoption of cultivated forage crops in the farming system is very low (Melkamu Bezabih et al., 2021). Only 0.15% of livestock keepers in rural areas produce improved forages on farm (Tesfaye *et al.*, 2010).

As a result, providing a proper nutrition to animals, especially during the dry season when pasture and cereal residues are limiting both in nutritional quality and quantity remain to be the problem faced by small-scale livestock producers in the tropical countries (Federal TVET Agency, 2019). In such situation, it is possible to overcome the severe feed insecurity problem in Ethiopia through the production and proper utilization of cultivated improved forages. The diverse agro-ecosystems of Ethiopia also make it possible to produce cultivated forages, using different forage development strategies, for small-scale

dairy farmer throughout the year (Azage Tegegne and Getachew Legese, 2020). Farmers in mixed crop-livestock sites grow different forage plants to supplement feeding of dairy cows (Mekonnen *et al.*, 2022); however, uptake of improved forages varies from site to site due to various factors. In terms of the current situation, forage crops are the primary option; these could provide a high-quality basal diet or be used as a supplement to crop residues (Abule *et al.*, 2023) and contribution to economic and environmental sustainability.

Ethiopia has a huge potential for fodder production; ~31% of the country (~350,500 km²) is highly suitable (at a suitability score of more than 80% threshold) for desho (*Pennisetum glaucifolium*) production, Napier (20%), and Alfalfa (13%), significant water resource potential to scale fodder production in Ethiopia using small-scale irrigation (Management Entity. 2021). A number of important improved forage has been generated by the research systems over the last years in the country (Federal TVET Agency, 2019). Different species of cultivated forage crops have been evaluated for their various uses and their production in the different agro-ecologies of Ethiopia (Melkamu Bezabih *et al.*, 2021); these forage crops are broadly categorized as forage grasses, legumes and browses. With the current scenario of very critical feed shortage in Ethiopia, use of cultivated forage crops is not a choice but is a must. Different forage strategies developed and successfully implemented by the FLDP in Ethiopia evolved from experiences in other countries and an understanding of the importance of matching forage systems to agro-ecological zones. The key forage production strategies are conservation based and promote the use of legumes as improved forage (Federal TVET Agency, 2019). However, cultivation of forage crops, particularly by smallholder farmers, is feasible when various appropriate options of forage production strategies are practiced (Melkamu Bezabih *et al.*, 2021), the key strategies are divided into on-farm strategies and common land strategies (Federal TVET Agency, 2019).

2.5.1. On-farm strategies (Cultivation of forage crops in arable lands)

Backyard forage production, under sowing and inter planting, contour forage strips, and agroforestry are all examples of ways to integrate livestock and cropping systems. Cultivated forages provide multiple benefits to smallholder livestock keepers in the mixed crop-livestock system. Although their primary production is to obtain high quality feed,

their integration in the farming system can contribute to increases in crop yields through control of soil erosion, improvement in moisture infiltration, nitrogen fixation and land rehabilitation (Kindu Mekonnen *et al.*, 2021). One of the strategies to produce a small-scale but high-quality forage production is cultivation of forages in and around the backyards. Backyards of smallholder farmers are usually small but with high soil fertility (Melkamu Bezabih *et al.*, 2021). It is a strategy of growing grass, legume and browse species within farmer's house compounds and around their boundaries (Teshale Tigistu, 2021). This is the most important initial strategy since it is developed in the farmer's household, and is very convenient for intensive feeding of dairy animals or fattening of meat animals (Federal TVET Agency, 2019) and did not compete with crop land (Teshale Tigistu, 2021). Woody leguminous browse species are particularly suited to this strategy because of their multipurpose benefits and rapid growth rates; they provide a range of incentives for farmers to adopt this strategy (Federal TVET Agency, 2019). This strategy aids to acquire larger biomass yield from small plots of land in good management; which has positive impact in enhancing livestock (Teshale Tigistu, 2021); and provides the most suitable approach to rapidly increasing on-farm forage supplies over a large number of farmers. The other option to introduce forage production could be intercropping of forage species with other food crops. More intervention is needed for better forage adoption and use by farmers (Abule *et al.*, 2023). This is normally the second strategy has been adopted by farmers. The use of legumes in this system will contribute to the improved fertility and structure of cropping soils. Under sowing with legumes produces large quantities of high quality forage for utilization by either postharvest grazing or cut and carry systems (Federal TVET Agency, 2019). The strategy is particularly suited to the production of tall growing cereals such as maize, sorghum or millet but also works with other cropping systems (Teshale Tigistu, 2021). Forage strips are broad based mixtures of herbaceous and tree legumes, and grasses planted on contour bunds or in narrow strips along the contour without any physical structures. This is a multipurpose strategy providing forage, shelter, soil stabilization, and fuel wood. Contour forage strips are particularly successful when perennial, thick rooted grasses are mixed with woody leguminous species; this strategy integrates forage production in cropping areas.

Agroforestry, it is the combination of trees and agriculture in an integrated and sustainable farming system. Many of the forage production strategies can be developed as agroforestry systems. Agroforestry maximizes the use of land by adding a third dimension to the above

and below ground areas of utilization; important for farmers with limited land resources. Because many agroforestry strategies include leguminous species, they are also attractive to farmers facing problems of declining soil productivity. Forage crop rotation, involves introducing annual forage legumes into the traditional cropping pattern. In the central highlands, to which the system is more applicable, the cropping sequence is cereal pulse. In between any two cereal crop phases, annual fodder crops like clovers, medics or lablab may be sown, harvested and conserved as hay for strategic feeding during the dry season (Federal TVET Agency, 2019). Forage crops can also be cultivated under irrigation where such areas are protected from livestock grazing. Under such conditions, highly productive annual and perennial forage crops can be cultivated and used either in a cut and carry or conserved and fed to animals (Melkamu Bezabih *et al.*, 2021).

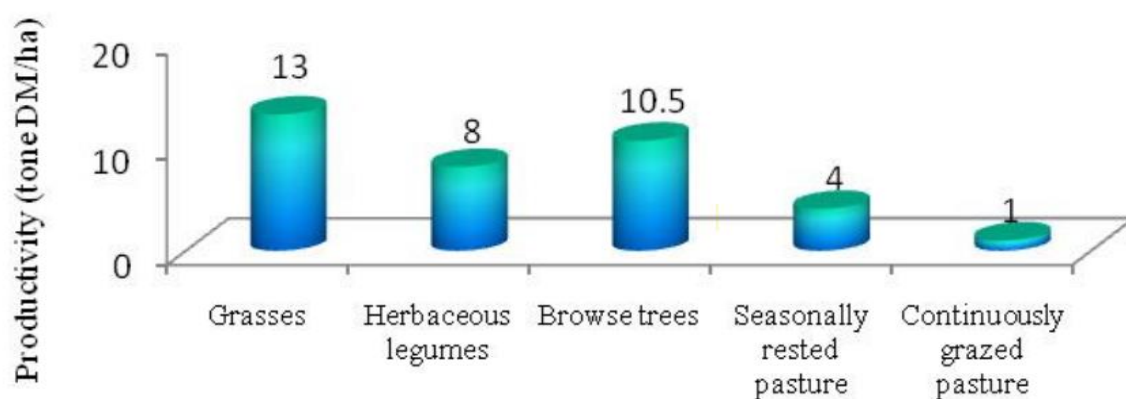


Figure 2. Average productivities of improved fodder crops in comparison to natural pasture in Ethiopia

2.5.2. Common land strategies

Over sowing common razing areas, stock exclusion areas/forage banks, and permanent pastures, promote sound soil and water conservation in denuded and bare grazing lands. Currently, the government is also prioritizing soil and water conservation projects at watershed level throughout the country. Terraces have been built on sloping areas to minimize soil erosion and improve water percolation and infiltration into cropping and grazing lands. These physical structures (terraces and soil bunds) need biological reinforcement to serve their purpose for extended periods and realize their benefits. Planting of multipurpose fodder trees and perennial grasses on these niches can create a

synergy to protect the environment and at the same time increase the feed biomass available to improve livestock productivity (Mekonnen *et al.*, 2022). Forage crops have an important role in natural conservation practices. Using forages in conservation activities have the advantage of protecting the land from soil and water erosion and could also provide forage as feed source to livestock (Melkamu Bezabih *et al.*, 2021).

In areas where communal grazing is practiced and if there is communal after-math grazing then forage crops cultivated should preferably be annuals like oats, vetch, lablab, Sudan grass, cowpea etc. Such forage crops should be grown in the normal cropping seasons usually under rain fed conditions, harvested and conserved as hay or silage (Melkamu Bezabih *et al.*, 2021). Rehabilitation of the communal natural grazing land following community-based weed clearance and enclosure for one rainy season have improved carrying capacity of the pasture and biomass dry matter yield (Azage Tegegne *et al.*, 2013).

Stock exclusion areas are particularly important for the conservation of highlands but are only accepted by farmers where they see sufficient benefits to organize grazing management groups or pastoral associations to control stock exclusion areas and voluntarily keep stock out. The introduction of browse species, productive legumes and improved grasses can rapidly increase the productivity of exclusion areas (Federal TVET Agency, 2019). Permanent pastures are most useful for dairy farmers who rely on optimal productivity of their livestock investment for their livelihood. Permanent dairy pastures should include a mix of legumes and grass species with high palatability and productivity.

2.6. Impact and Adoption of Improved Forage Technology by Smallholder Farmers

2.6.1. Effect of improved forage adoption on dairy cattle Productivity

The role that improved cultivated forage could play in bridging that gap, as well as enhancing economic benefits by reducing cost of feed and providing environmental benefits through reductions in greenhouse gas emissions (Dey *et al.*, 2022). The cultivated forages grown under farmers' fields and management conditions provided high biomass yield of good nutritional quality. The improved forages, such as fodder beet, alfalfa, and vetch provide 8–10 times more yield than naturally growing pastures

(Mekonnen *et al.*, 2022). It proved possible to obtain more than 8 ton/ha average annual dry biomass yield of tree lucerne under farmer management conditions in the Ethiopian high lands (Froche, 2016). Protein is a limiting nutrient in livestock nutrition in the smallholder systems of Ethiopia, the legume forages including lablab, vetch, sweet lupin, tree lucerne and alfalfa had high crude protein concentration in the range of 16–22%, with matter digestibility of 63–80%, makes it a suitable supplement to both fattening and lactating animals under smallholder conditions (Mekonnen *et al.*, 2022). However, in the mixed farming system, poor quality crop residues with low protein (5%) and digestibility (less than 50%) have become the major source of diet for livestock by mixing with cultivated forages (Mengesha *et al.*, 2017); and improve animal productivity.

Animal response trials showed an increase in milk yield of 30–50% with supplementation of oat–vetch mixture and fodder beet (Mekonnen *et al.*, 2022), with high economic incentives to invest in such innovations. The same results by (Hailesilassie, 2016) who reported that, milk yield of lactating cow after supplementation of 2kg oat–vetch mixture hay in the *Endamehoni* site, results increase milk yield by 50–70%. A 1 kg supplement of dried tree lucerne leaf feed to a lactating dairy cow can give up to 1.2 liters of extra milk (Melkamu Bezabih *et al.*, 2021). Demonstrated through agronomic and cattle feeding studies that replacing 30% of typically used expensive concentrate mix with pigeon pea leaves increased milk yield and 4% fat-corrected milk yield by 12% and 19%, respectively (Management Entity. 2021). Supplementary feeds, like cereal bran and oil cakes are either too expensive or in short supply to smallholders (Azage Tegegne, 2018); on-farm produced oat–vetch fodder provides an alternative option to improve the productivity of their animals (Mekonnen *et al.*, 2022), by reduce cost of production (Dey *et al.*, 2022); concentrate feed is expensive and generally contains grains and soybean that compete with human food. Desho provides a small business opportunity for Ethiopian farmers, sale of the cut and planting materials (Melkamu Bezabih *et al.*, 2021). Farmer produced silage from oat and vetch mixture to sell to dairy owners in the nearby town for 400 ETB/quintal (Abule *et al.*, 2023).

2.6.2. Factors Affecting the Adoption of Forage Technologies with Small-holder Dairy Farmers

Planting forage to feed animals is not a common practice in Ethiopia and faces many challenges. A number of important improved forage has been generated by the research systems over the last years in the country (Federal TVET Agency, 2019); and appropriate agronomic practices have also been developed for selected species (Adugna Tolera *et al.*, 2012). Their uptake in resource poor areas can yield benefits such as: In increase in the milk output of existing cattle, a decrease in soil erosion and an increase in soil fertility, and higher income and improved capacity of smallholder farmers to poverty alleviation (Hycenth *et al.*, 2017).

Despite past and current research and extension efforts made to popularize and disseminate improved forage technologies, but the vast majority of smallholder farmers do not use cultivated forage as important sources of feed for their livestock (Mekonnen *et al.*, 2022). On-farm production of forage is being increasingly adopted along with the expansion of intensive management systems, but still it represents a very small fraction of total feed, on a national scale (Adugna Tolera *et al.*, 2012). However, adoption of improved forage production and utilization by the farming community has been very low (Fekede Feyissa *et al.*, 2022); with the consequent insignificant contribution to the annual livestock feed budget in the country. Even the adopters still looking forage seeds free of charge and are not cultivating improved forages on large plots to obtain significant economic return from their animals (Azage Tegegne and Getachew Legese, 2020). As a result, the promotion of technologies by different projects has not resulted in their wider adoption. Generally, the adoption of improved forages at the smallholder farmer level is very low (Alemayehu *et al.*, 2017). Study done by (Tesfaye *et al.*, 2010) on forage adoption by farmers has indicated that, only 0.15% of livestock farmers in rural areas produce improved forages on their farm. According to the report of (CSA, 2021), on the contribution of different feed resources to livestock feed supply indicated that, the share of cultivated forage crops is only limited at 0.57%. The use of improved forage crops is limited to areas where market-oriented livestock production is practiced (Fekede Feyissa *et al.*, 2022). Smallholder farmers have been reported to be the most resistant to adopt

these improved forages in Africa (Njarui *et al.*, 2012). Different reasons can be cited for the low adoption of cultivated forage crops of which the major ones include:

Nature of the introduced forages: The geographical differences between temperate regions, from which most improved forages, originate, and the tropical conditions in SSA are important (Hycenth *et al.*, 2017). The forage's growth period was characterized by an unexpected drought and excessive water logging which marred the process (ILRI, 2014). Prolonged dry season and the lack of irrigation setups also impose further limitations to the development and proper management of perennial forage crops (Fekede Feyissa *et al.*, 2022). Most forage species are perennials which once established can persist and provide continuous feed supply for more than five years with good management. However, the prevailing free livestock grazing systems limit the development and utilization of these forages by smallholder farmers (Fekede Feyissa *et al.*, 2022).

Economic factors: The access to seeds of improved forage varieties might be governed by the seed price. With roughly more than 50% of the people in Ethiopia living in poverty, the overall costs of forage technology play a significant role in its adoption. The costs include those used in purchasing seeds and farm inputs, hire labour, and the time involved (Hycenth *et al.*, 2017). The high cost of forage seeds and farm inputs are one of the limiting factors for the non-adoption of some improved forage by smallholder farmer in Ethiopia (Karta and Dey, 2022). Compared to the price of food crop seed, prices paid for forage seeds are very high. The average forage seed price at Eden Field Agri-Seed Enterprise, ILRI, and SNNPR ranged from 0.59 to 24.45, 2.93 to 9.78, and 0.88 to 36.19 USD per kg for oats and alfalfa seed, respectively. High seed price in some forage seed species relative to food crops (e.g., certified seed of wheat is 0.94 USD per kg) is usually attributed to the high cost of production and low seed yield of forage species that are bred for their herbage yield (Karta and Dey, 2022).

The level of involvement of the private sector is crucial for scaling market-oriented forage seed production. Private seed producers engaged in forage seed production are limited in number and supply, because, the demand pulls for forages is not well established due to the absence of strong market linkages, technical awareness of forage agronomics, and other factors (Karta and Dey, 2022). As a results, forage seed supply has become limited and out of the reach of smallholder dairy farmers in the country, and has negatively

affected the rate of forage adoption. Now a day, the demand for forage seed is mostly linked with government agencies and donor-supported projects than direct marketing demand from individual farmers.

Farmer's characteristics: The main reasons why low forage used by farmers could be due to shortage of land, lack of forage seeds and awareness about the importance of the improved forage species (Teshale Jabessa, 2023). Farmers in mixed crop-livestock production systems give priority to crop production, and forage production is given lower importance (Karta and Dey, 2022). Moreover, all the prime land is allocated to food crops and farmers` have low likely to devote land, labour and capital for fodder development, and livestock are supposed to depend on the crop by-products and degraded grazing lands as major source of feed (Fekede Feyissa *et al.*, 2022). Smallholder farmers and livestock owners have not yet developed the culture of purchasing seed as NGOs and region al agricultural bureaus often distribute the seed for free or at subsidized prices (Karta and Dey, 2022), collectively, they limits the rate of forage adoption. In addition, lack of awareness how to cultivate and use improved forage and capital limitations are the main challenges the adoption of improving forage development at the farmer level (Tolera et al., 2019).

Institutional factors: The main input and service provider in the country, especially for smallholder farmers, is the national extension service, focus on food crop production. It is critically important that extension services raise awareness of the likely benefits of feeding animals with improved forages, as well as on how to grow forage seed and plant material (Alvarez Aranguiz and Creemers, 2019). Although the extension system is structurally accommodating livestock production, the actual service is skewed to crop production in terms of input supply and technical support, while the livestock aspect has been remained subordinate and has not been adequately addressed in the national agricultural extension system (Fekede Feyissa *et al.*, 2022), resulted in limited awareness by the farming community on the role of improved forage crops.

Lack of a market-driven forage-seed industry is a key limiting factor to more and better-quality seed being produced and marketed (Eshetu Yimer and Teklu Kidane, 2015). Ethiopia also suffers from weak market linkages both on the input and output side. Linkages between agricultural outputs producers and processors are weak, and numerous

barriers exist that prevent quality products from reaching end users (USAID, 2011); and poorly developed seed marketing systems also impose further limitations to forage seed production and forage development particularly, in rural area of the country (Fekede Feyissa *et al.*, 2022), due to, farmers either cannot afford improved inputs or lack the knowledge to use them. Lack of access to credit is particularly challenging for women, since they often have fewer assets recognized as collateral by financial institutions, which hampers their ability to purchase necessary inputs and services (USAID, 2011). The current forage-seed system in Ethiopia is underdeveloped. Variety release, quality control and seed certification and standards are unclear and scattered, with limited to no traceability (Eshetu Yimer Teklu Kidane, 2015).

3. MATERIAL AND METHODES

3.1. Study Area

3.1.1. Location, area coverage, soil type and vegetation

This study was conducted in North Wollo Zone in Amhara Region northern Ethiopia. The study area was situated from 11⁰N-12⁰N Latitude and 39⁰E-40⁰E Longitude (NMSA, 1996). The altitude of the Zone varies from 913 to 4187 m.a.s.l. It has four agro-ecological zones, namely, lowland (*Kolla*) 500 to 1500 m.a.s.l 38%, Mid-altitude (*Woina-Dega*) 1500 to 2300 m.a.s.l is about 34%, Highland (*Dega*) 2300 to 3200 m.a.s.l is 21% and *Wurch* more than 3200 is about 7% of the Zone (NMSA, 1996). The zone is bordered to the south by South Wollo zone, to the west by South Gondar zone, to the north by Wag Hemra zone, to the northeast by Tigray region, and to the east by Afar region (NWZAOAR, 2017). The zone encompasses 13 districts (9 rural and 4 urban) and 260 *kebeles* (the smallest administrative units in Ethiopia).

3.1.2. Climatic condition and topography

Based on a 16 year data (2000 G.C to 2015 G.C) obtained from National Meteorological Service Agency (NMSA) of Ethiopia, North Wollo zone has minimum and maximum temperatures of 13°C and 26.4°C, respectively (NMSA, 2015). The mean annual rainfall of the zone is 700 mm. A bi-modal nature characterizes rainfall in most parts of north Wollo where the short rainy season occurs between February and April and the long rainy season occurs between June and September. In most cases, the highland areas are mainly dependent on short rain; whereas, the mid altitude and lowland areas depend on long rainy season for crop production. The long rainy season found to be the major source of moisture for production of agronomic crops, growth of herbaceous plants in pasturelands, and fodder crops in most parts of the zone (NMSA, 1996). Unfortunately, agricultural production and productivity in the zone had severely been affected by recurrent drought. Such unfavourable climatic conditions often resulted in acute decline in the food security status of the people in terms of both crop and livestock production and productivity (NWZAOAR, 2022).

The principal feature of rainfall in most parts of North Wollo zone was its seasonal character, poor distribution and variability from year to year. The zone receives average annual rainfall ranging from 500 to 1,300 mm in which the distribution was uneven and erratic in nature. Most of this zone is mountainous and characterized by steep slopes which includes flat land (31.2%), valley (19.12%), mountains (21.1%) and ups and downs (10.06%), water logged area (8.22%) and others which are unsuitable for agriculture (10.3%).

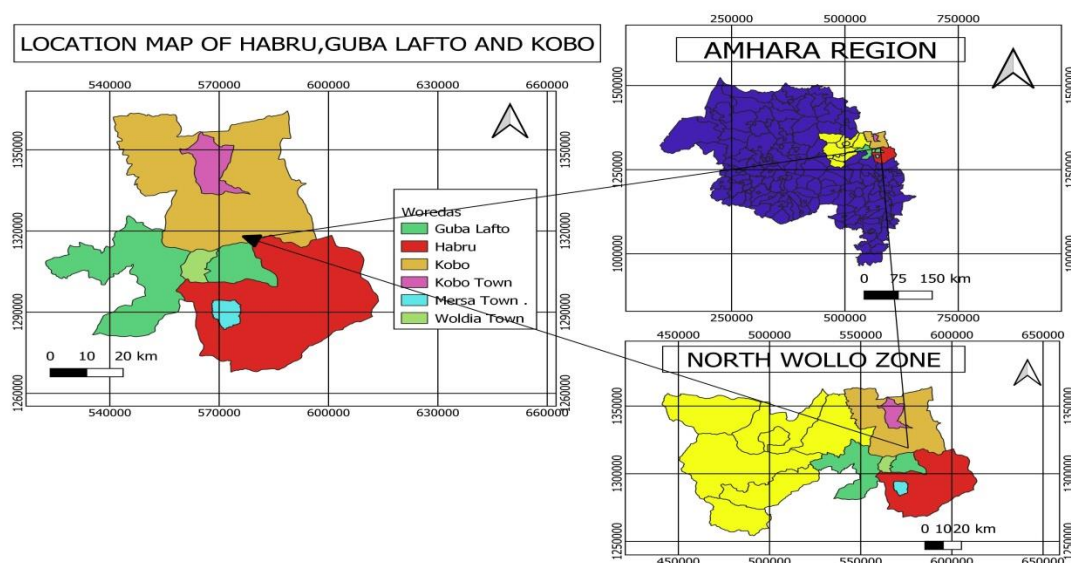


Figure 3. location map of study area

3.1.3. Human and livestock population

According to (NWZLDHO, 2022), this zone has a total human population of 1,643,250, of whom 823,118 are men and 820,132 women. The livestock population of the zone is estimated to be 2,705,634 out of which 1,078,788 cattle, 561,444 goats, 743,805 sheep, 149,198 donkeys, 26,230 horses, 12,357 mules, 24,812 camels and 1,060,000 chickens (NWZLDHO, 2022).

3.2. Population of the Study

The population of the study comprises of all farmers involved in small-scale dairy production in the selected districts. A list of 319 study populations of small-scale dairy

farmers in all the 9 kebeles was obtained from the district department of animal production.

3.3. Sampling Design

The sampling frame of the study is made up of small-scale dairy farmers they are involved in milk production. The sampling unit was households keeping lactating dairy cattle. The sampling size and sample household selection were done on representative approach. For sampling purposes a multistage sampling technique (purposive and random) was employed to select the study districts and households of the district. In the former stage, North Wollo Zone was selected purposively due to its high share of livestock from the region. At the second stage, in order to address the study objective three districts namely *Habru*, *Gubalafto*, and *Raya Kobo* woredas were selected from North Wollo Zone purposively based on the small-scale dairy potential relative to another woredas. Thirdly, nine kebeles (three from each woreda) were randomly selected from the woreda among potential improved forage producer *kebeles* in coordination with development agents of the respective *kebeles*. Finally, within the selected *kebeles*, the respondent households were divided into two categories: improved forage technology adopters and non-adopters. Adopters were households who are cultivating and continue using improved forage for feeding their livestock in addition to other common feeds. Non-adopters were households that are not involved in cultivation of improved forage, only they using other feeds for their livestock feed. The households in each of the two categories were selected at random. These sample kebeles were *Merto*, *Sirinka*, *Haro*, *Qalim*, *Aradom*, *Worqee*, *Ezeat*, *Sanqua*, and *Sibilkai*. At the end, systematic random sampling procedure was applied to select the sample household farmers in the nine sample *kebeles* from the list provided by NWZARD for *Habru*, *Gubalafto*, and *Raya Kobo* respectively. From total of 319 study population, 177 samples were selected and out of which 76 are adopters and 101 non-adopters farm households (*Habru* 59, *Gubalafto* 69, and *Raya Kobo* 49) involved in the process (Table 1).

The required sample size ($n=177$) was determined by using (Yamne, 1967) sample size determination formula where the exact number of households in each *Kebele* is known. A formula provided by (Yamne, 1967) to determine the required sample size at 95% confidence level, degree of variability.

$$n = \frac{N}{1 + e^2 N}$$

$$n = \frac{319}{1 + (0.05)^2 * 319} = \underline{177}$$

To determine respective samples from nine *kebeles* for each stratum, selected by using probability proportional to size of population, finally, representative sample for each stratum was selected by using probability proportional to size was applied across each category.

Where n is the minimum number of the sample size; N is the total population size is (319); e is the accepted error of margin (0.05). The total required sample for the three districts was (177) households, which were used for this study.

Table 1: Distribution of sample districts, kebeles, and households

S/n	District	Name of kebeles	Total HHs	Adopters HHs	Non-adopters HHs	Sample households
1	Habru	Merto	32	8	11	18
		Sirinka	44	10	13	24
		Haro	30	8	9	17
2	Raya kobo	Qalim	29	6	10	16
		Aradom	28	6	10	16
		worqee	31	7	10	17
3	Gubalafto	Ezeat	42	10	12	23
		sanqua	43	11	14	24
		Sibilkai	40	10	12	22
Total			319	76	101	177

Source: Computed based on data obtained from (NWZARD, 2022)

3.4. Data Sources and Method of Data Collection

3.4.1. Primary data

The data collection was conducted from 10st November 2023 until 12st January 2024 using questionnaire prepared specifically for this study. In order to complete this survey study, the researcher was used both primary and secondary data. The primary data was obtained

through discussion with key informants for baseline information and from respondents through face to face interview using a semi-structured questionnaire. In the first stage of the study, group discussion was done with key informants to investigate and have an overview about improved forage related issues in the study area. Based on the information obtained in the group discussion, questionnaire was developed for the formal survey.

Questionnaire

The questionnaire was designed to assess respondent's knowledge on improved forage, improved forage development and utilisation. The questionnaire was developed in English, for easy interviewing back-translated to Amharic, pre-tested with three farmers to know whether the questionnaire would be able to collect the required data to conduct the study. It was available on paper for face-to-face interviews. The questionnaire consisted of multiple-choice questions requesting: gender, age, education, marital status, family size, and income and questions regarding perceptions and adoption about improved forage, improved forage development, and determinants for improved forage adoption. Questionnaires were given to enumerators in all three districts of the North wollo Zone: Habru (55.6 % of total population), Gubalafto (55.2 % of total population), and Raya Kobo (55.7% of total population) and respondents were invited for interview in centred areas, in which primary data was collected. Here the respondents are improved forage adopters and non-adopters. The data were collected by ten graduated enumerators and the researcher. Enumerators were participated to help with administering the questionnaire; these were able to speak the local language. Enumerators were trained on the objective of the survey study, the contents of the interview and how to conduct questions. Proper training of enumerators and regular supervision during the data collection process improved the accuracy of the data.

Interview

The key informants in the study district was interviewed in order to get general Information about the farmers, especially the information related to factor affecting adoption of improved forage practice in the selected districts. Interviews were recorded by face to face asking of the respondents.

Direct observation

In order to be familiar with local people, the researcher was directly observed study district by direct observation, and understands about agricultural production of farmers and socio-economic characteristics of the farmers in the selected districts.

3.4.2. Secondary data

A combination of qualitative and quantitative data was collected from secondary sources. The secondary data was used in assessing land holding, land use, livestock population, feed resource, extension services, and implication on level of awareness and adoption of the improved forage from *Habru*, *Gubalafto*, and *Raya Kobo* districts office of livestock and agriculture. In addition, secondary was used in improving the discussion of the results of the study by reviewing research reports, published and unpublished writings, different journals, and internet websites.

3.5. Method of Data Analysis

The demographic, socio-economic, and institutional data of respondents were analysed using descriptive statistics and results were presented as frequencies, mean, standard deviations, and percentages. Chi-square and T-statistic test were used to compare different categories of the sample respondents (improved forage adopter and non- adopter groups) with respect to some independent variables using SPSS statistical software version 20. Chi-square is used to test the statistical significance of the values of the potential dummy variables, with comparison of the adopter and non-adopter households. The t-test was employed to test the statistical significance of the mean values of continuous variables. The results were reported using descriptive statistics like frequency; percentage and measure of central tendency (mean) and measure of central dispersion (standard deviation) through table and figure to describe and interpret the information obtain from the survey.

3.6. Measurement of Variables for Adoption

The variable for this study includes both the dependent and independent variables.

3.6.1. Dependent variable

It is a dummy variable in which the farmers perception towards the use of improved forage in milk production, area coverage of improved forage cultivated, and adoption of improved forage technology (household that cultivated improved forage crops otherwise household that did not cultivate improved forage crops) were considered as dependent variable in this study. Farmers perception was measured by developing a 5-point likert type scale ranging from 1=strongly disagree and 5=strongly agree. All respondent was asked to express his/her extent of agreement or disagreement by checking against any of the five statements. They are expressed in the model by yes/no for adopted and non-adopted respondents.

3.6.2. Independent variables

Variables that stand alone and are not changed by the other variables but cause change in dependent variable. The independent variables for this study are age of household head, sex of a household, educational level, total land size (land holding in ha.), income (farm and non-farm), cattle owned, extension contact, attend demonstration, attend in training, and mobile ownership are some of variables identified as independent (explanatory) variables for this study. Age of respondent were measured on the basis of actual length of his life and expressed in years. Household size was measured by the total number of family members including the respondent himself, children and other permanent dependents that lived to together as family. The total land area possessed by the farmer under cultivation and homestead were expressed in hectare. The family yearly income of the famers from different sources was the annual income of the farmers and it was expressed in birr (ETB).

The need for identifying variables that affecting farmers' decision to use improved forages is to analyse which factor influences the decision, how and by how much. In the current study, it was expected that probability of adoption and frequency of use of improved forage technologies are influenced by the multiple effect of different variables. The potential of independent variables which are hypothesized to affect the adoption and intensity of adoption of improved forages in the selected districts are listed in Table 2.

Table 2: Definitions and measurements of variables used

Definition of variables	Nature of variables	Expectation
Dependant variables		
Farmers perception toward improved forage	Dummy (yes/no)	
Adoption of improved forage		
Amount cultivated improved forage (if use)	Continuous (ha)	
Independent variables		
Sex	Male/female	+
Age	Years	+/-
Marital status	Dummy	+/-
Family size	Number	+
Educational status	Dummy	+
Livestock (TLU)	TLU	+
Land size	Ha	+
Mobile ownership	Yes/No	+
Training	Yes/no	+
Frequent contact with extension agent	Number of times	+
Participation in extension event	Yes/no	+
Access to credit service	Yes/no	+
Participation on demonstration	Yes/no	+
Social-participation related factors	Yes/no	+
access to forage seed	Yes/no	+/-

3.6.3. Conceptual framework

Improved forage is important in the rural areas due to their ability to improve livelihood for smallholder farmers through the provision of beneficial products and services. The adoptions towards improved forage and production have a tremendous contribution to improve and sustaining livestock productivity for the future (Bashe *et al.*, 2018). But, the contribution of improved forages represents less than 0.35% of the diet (CSA. 2021).

Adoption is dependent on socio-cultural, economic, institutional, and technology-specific factors. Moreover, farmers' perception of the effectiveness of the improved forage is paramount in fostering understanding about the willingness of farmers to adopt the technology (Figure. 3).

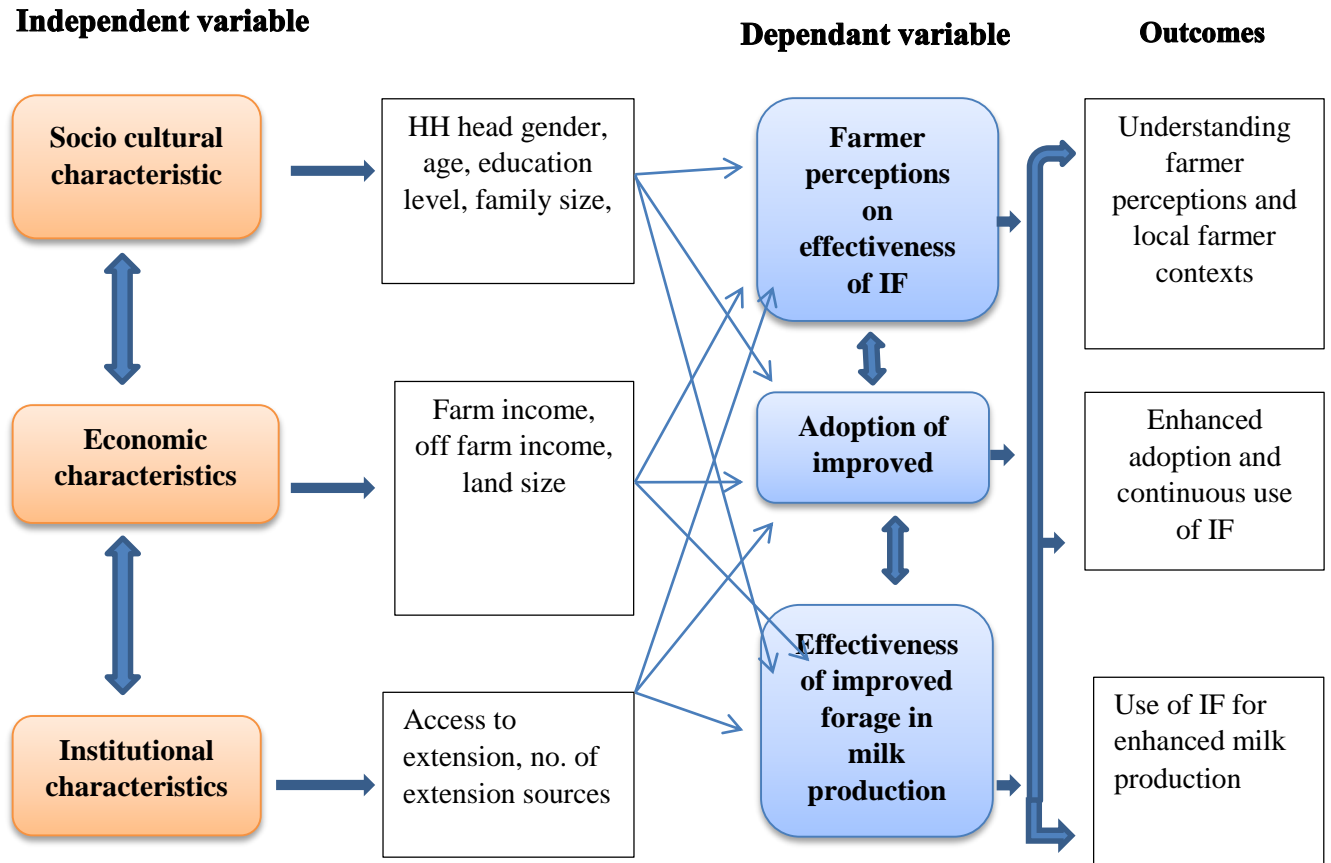


Figure. 4 Conceptual framework linking the variables of the study

4. RESULTS AND DISSCUSION

4.1. Results of Descriptive Analysis

4.1.1. Classification of small-scale farmers based on their adoption towards improved forages

Survey study conducted in November - January 2024, it was tried to classify the sample of 177 small-scale farmers exposed to improved forage, into two categories: improved forage adopters and non-adopters (Table 3). Adopters were farmers who after trying the technology had used it continuously for at least five years or more. Most of these farmers had slightly bigger pieces of land and therefore could afford to spare some land for the improved forage technology. They normally planted improved forage on a different portion of land each year. Based on this definition, from a total of 177, (42.94%) of the sample households adopt improved forage technologies and the rest 57.06% were non-adopters of the technologies. In the reverse, non-adopters were farmers who although had access to the improved forage technology over years and a few even having received seed and training, they tried the technology but no longer had practise it or never planted improved forage (Table 3).

Table 3: The adoption category of small-scale farmers in 2024

Adoption status	All=177 %	District		
		Habru=59 %	Kobo=49 %	Gubalafto=69 %
Non-adopters	57.06	55.93	61.22	55.07
Adopters	42.94	44.07	38.78	44.93
Total	100	100	100	100

4.1.2. Descriptive statistics for continuous independent variables

Age distribution of sample household

The survey results of this study indicated that, age category of respondent's was ranged from 27 – 64 years (Table 4). The respondents included in the survey had a mean age of 42.49 years with minimum and maximum age of 27 and 64 years respectively. Majority of

respondents (38.41%) were found in the age bracket of 31 – 45 years, followed by 29.94, 17.51, and 13.55% of respondents were found in the age brackets of 46 – 60 years, 15- 30 years and greater than 60 years, respectively.

Table 4: Age category of sample respondents

Type of variable	Adopter (n=76)		Non-adopter (n=101)		Combined (n=177)		T-value	P-value
	Mean	Std.	Mean	Std.	Mean	Std.		
Age	41.25	11.33	48.23	12.22	42.49		3.878	0.000**

Note: **, show significance at $p < 0.05$

Farmers who adopted improved forage group were characterized by young farmers with an average age of 41.25 ± 11 years old. In fact, from a total of 76, (more than 40%) of the respondents in this group found in age bracket of 31 – 45 years, while the rest 24.2, 17.58, and 9.9% of respondents were found in 15-30 years, 46 – 60 years, and more than 60 years old, respectively. Non-adopter of forage technology had relatively older household heads than adopters with mean age of 48.23 ± 12 years. Among the total of 101 farmers who not-adopted improved forage, majority (39%) of respondents found in age bracket of 46 – 60 years, while the rest 29.88, 17.24, and 13.79% of respondents were in the age class of 31 – 45 years, 15- 30 years, and more than 60 years old, respectively. The mean age of the adopters was less than the mean age of the non-adopters in technology adoption. Thus, the mean variation was found to have statistically significant value, this showed that there was significant difference on the mean age of the household head in the two groups at 5% level of significant. The mean effect of age of the household head was found to have a negative influence on farmers' decision to adopt improved agricultural technology. This indicates that, young farmers are more likely to be adopters of improved forage technologies than the old aged farmers. Young household heads are more likely to apply new technologies because younger household heads are less risk averse than older counterparts (He *et al.*, 2007).

Family size status of sample household

Table 5 shows the family size characteristics of respondents. Family size is the most important indicator of the labour status of a farmer, which is an important factor determine the adoption process. From a total of (177) sample respondents, about 86 (48.6%) of respondents had household size of greater or equal 5, while 77 (43.5%) and 14 (7.9%) had household sizes of 3 to 5 and less or equal 2, respectively. The mean household family size in the study district was 4.58 with minimum and maximum family size of 2 and 7, respectively, (Table 5).

Table 5: Family size of sample household

Type of variable	Adopter (n=76)		Non-adopter (n=101)		Combined (n=177)		T-value	P-value
	Mean	Std.	Mean	Std.	Mean	Std.		
Family size	5.64	1.87	4.9	1.95	4.58		2.556	0.011**

Note: **, show significance at $p < 0.05$

The mean family size observed for the adopter group was 5.64 ± 1 persons per household. From a total of 76 farmers who adopted forage, majority 41 (53%) of respondents had family size more than 5, while 31 (40.79%) and 4 (5.26%) of respondents were had household sizes of 3-5 and less or equal 2, respectively. While the mean family size for the non-adopter group was 4.9 ± 1 persons per household. Among the total of 101 farmers who non-adopter improved forages, 46 (45.54%) of respondents had family size range 3-5, while the rest 45 (44.55%) and 10 (9.9%) had more than 5 and less or equal 2, respectively. Generally, farmers who adopted forage technologies had relatively higher number family labour than non-adopters in the study site. The average household size of respondents between the adopters and non-adopters was found to be statistically significant ($P < 0.05$) and this shows that, household size per household head has a significant and positive effect on farmers' agricultural technology adoption decision. The size of a family matters as it provides a ready and cheap work force. Families with more members had access to a greater labour force, which eased their adoption of forage technologies (Hycenth *et al.*, 2017).

Education status of sample household

Education teaches farmers how to obtain and develop critical thinking and make independent decisions. Education allows the society to find a solution to their problems with the help of better techniques. Data on education of the respondents indicated that, respondent's level of education was ranged from illiterate to college; from the total of sample household heads, about 10.16% of them were illiterate while 42.37% were able to read and write; the rest 31.63, 14.68 and 1.12% were attended primary, secondary and college education, respectively (Table 6).

Table 6: Educational level of sample households

Type of variable	Adopter (n=76)		Non-adopter (n=101)		Combined (n=177)		T-value	P-value
	Mean	Std.	Mean	Std.	Mean	Std.		
Education year	4.32	4.57	3.02	3.65	3.63		2.033	0.04**

Note: **, show significance at $p < 0.05$

The results further showed that the mean year of education of the adopters is 4.32 ± 4 . The adopter group was characterized by a high level of education; in fact, 3.3% were College graduates. Among the total of 76 farmers who adopted forage, about 11% were illiterate, 39.6% were able to read and write, about 30% had attended primary school, 16.5% attended secondary school and the rest 3.29% of the total adopters had attended college level education. On the other hand, the mean year of education of the non-adopters group is 3.02 ± 3 . From total of 101 forage non-adopters 8% were illiterate, about 45% were could read and write, 34.5% were attended primary school, and 12.6% were attended secondary school. Furthermore, the two groups showed different educational characteristics, and also the mean difference was found to be statistically significant value, this indicated that there was significant mean difference in education status of the adopter and non-adopter groups at 5% level of significant. Adopters of improved forages had household heads with relatively better education level than non-adopters. This displays that, literate farmers are better in adopting improved forage technologies compared with illiterates. This finding is in agreement with study of (Hagos and Zemedu, 2015) who indicated that education level of the household head has a significant and positive effect

on farmers' agricultural technology adoption decision. Literacy enhances the level to which farmers can interpret and appreciate new methods and increases the likelihood of them adopting useful strategies (Njarui et al., 2012). The possible reason for this may be due to the capability of education in raising the awareness and information processing of farmers about new agricultural technologies (Solomon Estifanos *et al.*, 2021).

Livestock holding in TLU

Study results shows that, the overall mean of livestock holding per the sample household heads in the study district was 2.29 TLU (Table 7). The study shows, adopters of improved forage group had higher livestock assets than non-adopters. In comparison with improved forage adoption, the mean livestock ownership of the adopter households was 2.61 TLU with standard deviation of 0.44 and for non- adopter was 1.99 TLU with standard deviation of 0.37. Data in (Table 7) shows that, there is a significant mean difference between two groups at 5% significance level. Accordingly, the adopter household had more livestock owners than non-adopters. This finding is in line with study by (Ketema *et al.*, 2016) confirmed that livestock holding has a significant effect on farmer's decision to adopt agricultural technology. This is because households having large livestock unit will have better financial stand to afford and possess new agricultural technologies (Solomon Estifanos *et al.*, 2021).

Table 7: Mean livestock holding of sample households

Type of variable	Adopter (n=76)		Non-adopter (n=101)		Combined (n=177)		T-value	P-value
	Mean	Std.	Mean	Std.	Mean	Std.		
TLU	2.6	0.44	1.99	0.37	2.29		9.767	0.000**

Note: ** = show significance at $p < 0.05$, TLU = tropical livestock unit.

Cultivated land size

Farm size is a more important economic variable that is vital for agricultural production and livelihood improvement. The results of this study indicated that, the average farm size of sample respondents in the study area was 0.67 ha, which is smaller than reported by

(FAO, 2012) average approximately 1.4 ha. The average land size for adopter group was 0.74 ha with standard deviation of 0.2, while for non-adopter was 0.59 ha with standard deviation of 0.17. The mean difference of the two groups was found to statically significant at 5% significant level. This showed that farmers with larger farms were more likely to have adopted more production recommendations (high adopters) than farmers with small farm holding (John Abugri, 2017). The result is consistent with (Hasen, 2015) who confirmed the positive effect of farm size on farmer's decision to adopt agricultural technology. In the reverse, the study result disagrees with (Solomon Estifanos *et al.*, 2021) results who found that the likelihood of adopting new technology decreases in response to increase in land size.

Table 8: Mean land holding of sample households (t-test)

Type of variable	Adopter (n=76)		Non-adopter (n=101)		Combined (n=177)		T-value	P-value
	Mean	Std.	Mean	Std.	Mean	Std.		
land size	0.74	0.2	0.59	0.17	0.67		5.310	0.000**

Note: **, show significance at $p < 0.05$

Rate of extension contact

The survey results showed that, the total sample household's mean extension contact per year was 5.77. The mean extension contact per year for adopter's was 7.29 ± 1 whereas for the non-adopters it was 4.63 ± 1 . The mean difference of the two groups was found to statically significant at 5% significant level. Adopters of forage technology had better access to extension services than non-adopters. Similar finding of (John Abugri, 2017) indicated that, farmers with more extension contacts are more likely to adopt many of the production recommendations and be high adopters than those with less extension contacts.

Table 9: Extension service contact of sample respondents

Type of variable	Adopter (n=76)		Non-adopter (n=101)		Combined (n=177)		T-value	P-value
	Mean	Std.	Mean	Std.	Mean	Std.		

Number of extension contact	7.29	1.54	4.63	1.62	5.77	11.016	0.000**
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Note: **, show significance at $p < 0.05$

4.1.3. Descriptive statistics for dummy independent variables

Sex distribution of sample household

In the current study, from the total 177 sample households 142 (80.22%) were male households and the rest 35 (19.77%) were female households. The percentage of male households was 85.52% for adopters and 76.24% for non-adopters. However, the percentage of female households for adopters (14.48%) was smaller than the non-adopters which were 23.76% (Table 10). The chi-square test of sex distribution between the adopters and non-adopters was found to be statistically non-significant at 5% level and this indicates that, there is no significant relationship between sex of adopters and non-adopters in improved forage technology adoption.

Table 10: Sex distribution of adopters and non-adopters sample respondents

Variables	Character	Adopter=(76)		Non-adopter=(101)		All=(177)		χ^2 - value	p-value
		No.	%	No.	%	No.	%		
Sex of	Male	65	85.53	77	76.24	142	80.23	2.359	0.125 ^{ns}
	Female	11	14.47	24	23.76	35	19.77		

Note: ns, show non-significant at $p > 0.05$

Marital status of sample household

As showed in Table 11, about 89% of sample households were married, 5.64% were divorced, about 5% were widowed and 0.56% of sample households were singles. Out of adopters 92.11% were married, while 6.58% and 1.32% respondents were widowed and single, respectively. With regard to non-adopters about 86% were married, followed by 9.9% and 3.96 for divorced and widowed, respectively. The chi-square test indicated that marital condition was found to be statistically non-significant at 5% level and this

indicates that, there is no significant relationship between marital status of adopters and non-adopters in improved forage technology adoption

Table 11: Marital condition of adopters and non-adopters sample respondents

Variables	Character	Adopter=(76)		Non-adopter=(101)		All=(177)		χ^2 - value	p-value
		No.	%	No.	%	No.	%		
Marital status	Single	1	1.32	1	0.99	2	1.13	0.90	0.993 ^{ns}
	Married	69	90.79	92	91.09	161	90.96		
	Divorced	1	1.32	1	0.99	2	1.13		
	Widow	5	6.58	7	6.93	12	6.78		

Note: ns, show Not-significant at $p > 0.05$

Participation on demonstration

The survey result in (Table 12) indicated that out of the total sample household farmer's (48.59 %) of sample household have were attended on demonstration and the remaining 51.41% were not attended. It means that, around 62% of adopters group and 38.61% of non-adopters households responded that there were participated in demonstration activity during the 2024. And also 38.16% of adopter and 61.39% of non-adopter group were not participated demonstration activity at the same year. The Chi-square test shows that there is a statistically significant relationship between adoption decisions and attending on demonstration of the household heads at 5% level of significance.

Table 12: Participation of respondents on demonstration (χ^2 -test)

Variables	Character	Adopter=(76)		Non-adopter=(101)		All=(177)		χ^2 - value	p-value
		No.	%	No.	%	No.	%		
Demonstration	Yes	47	61.84	39	38.61	86	48.59	9.367	0.002**
	No	29	38.16	62	61.39	91	51.41		

Note: **, show significant at $p < 0.05$

Forage seed/planting material availability

The differences between adopters and non-adopters of improved forage technologies in access to seed/planting material are presented in Tables 13. The result of this study showed that more than half of the total sample respondents (51.97%) had access to improved forage seed/material in the study area, while 48.03% of sample households had no access to seed or forage planting materials. About 70% of the adopters and 37 % of the non-adopters noted that they had access to improved forage seeds/planting material from different sources. These sources can woreda animal production office, NGOs, and given by neighbours. The Chi-square test shows that there is a statistically significant relationship between adoption decisions and forage seed availability to household heads at 5% level of significance.

Table 13: Source of forage seed/planting for households

Variables	Character	Adopter=(76)		Non-adopter=(101)		All=(177)		χ^2 - value	p-value
		No.	%	No.	%	No.	%		
Access to seed	Yes	53	69.74	40	39.60	93	52.54	15.792	0.000**
	No	23	30.26	61	60.40	84	47.46		

Note: **, show significant at $p < 0.05$

Access to credit service

As shown in Table 14, out of the total sample respondents, about 25.4% got credit service from the ACSI to run their agricultural production accordingly. On the other hand, about 74.58% of the total sample households were not got credit service. Additionally, 35.52% of the adopter and 17.82% of non-adopter sample households had access to credit services, while the remaining 64.48% of adopters and 82.18% of non-adopters had not access to credit service. The Chi-square analysis disclosed that there is a significant association between farmers' adoption and access to credit at 5% level of significance. This shows farmers who have better access to credit to be more likely to adopt new agricultural technologies than farmers who have less access to credit. Ready access to credit would be greatly important in the adoption of improved forage technologies (Hycenth *et al.*, 2017).

Table 14: Respondents access to credit service

Variables	Character	Adopter=(76)		Non-adopter=(101)		All=(177)		χ^2 - value	p-value
		No.	%	No.	%	No.	%		
Access to credit	Yes	27	35.53	18	17.82	45	25.42	7.170	0.007**
	No	49	64.47	83	82.18	132	74.58		

Note: **, show significant at $p < 0.05$

Participation on training

Training can improve the knowledge of farmers on technology. The more farmers involve in training the more they make a decision to use a technology. As indicated Table 15, from the total training distribution of sample households, about 62.15% of the respondents recorded that they invited in training by agricultural office, NGOs, and by *kebele* extension agents. With regard to the adoption categories, 81.58% of the adopters and 47.52% of the non-adopters responded that there were obtained training in different agricultural enterprise, while 18.43% for adopters and 52.48 for non-adopters were never got training at all. The Chi-square test indicated that the association between attained training and improved forage adoption was significant at 5% level.

Table 15: Respondent's participation on training

Variables	Character	Adopter=(76)		Non-adopter=(101)		All=(177)		χ^2 - value	p-value
		No.	%	No.	%	No.	%		
Training	Yes	62	81.58	48	47.52	110	62.15	21.379	0.000**
	No	14	18.42	53	52.48	67	37.85		

Note: **, show significant at $p < 0.05$

Social-participation related factors

The survey result in Table 16 showed that 83.61% sample households were members to the local organizations, while 16.39% of sample respondents were not. About 82.89% of the adopter and 84.15% of the non-adopter sample households were participated to local organizations, like ikub and ider, gigi, and irrigation group. While, 17.11% of the adopter

and 15.85% of the non-adopter sample respondents were not participated in those local organizations. The chi-square test confirmed that participation to local organizations was not found to significant with 5% level. The study disagrees with study of (Solomon Estifanos *et al.*, 2021) who indicated that, membership in different social groups raise the probability of adopting.

Table 16: Membership to local organization of sample respondents

Variables	Character	Adopter=(76)		Non-adopter=(101)		All=(177)		χ^2 - value	p-value
		No.	%	No.	%	No.	%		
Membership	Yes	64	81.57	81	47.52	145	62.14	0.471	0.557 ^{ns}
	No	12	18.43	20	52.48	32	37.86		

Note: ns, show Not-significant at $p > 0.05$

Access to mobile telephone

Farmers need information about the presence of a technology, its benefits and how to use it effectively before adopting it. Ownership of mobile cell phones could improve access to market information and help farmers gain better insights about different aspects of the technologies. The result of this study showed that more than 90% of the total sample respondents had access to mobile telephone in the study area, while about 9% of sample households had no access to mobile telephone. About 93% of the adopters and 89% of the non-adopters noted that they had access to mobile telephone. Mobile ownership had positive relation with adoption, but not significant 5% level.

Table 17: Households ownership of mobile cell phones

Variables	Character	Adopter=(76)		Non-adopter=(101)		All=(177)		χ^2 - value	p-value
		No.	%	No.	%	No.	%		
Mobile ownership	Yes	71	93.42	85	84.16	156	88.14	3.558	0.059 ^{ns}
	No	5	6.58	16	15.84	21	11.86		

Note: ns, show Not-significant at $p > 0.05$

4.2. Improved Forage Technology Adoption Decision across Selected Districts

4.2.1. Major feed resources in the selected districts

The feed resources in study areas include grazing, cereal and legume crop residues, hay, agro-industrial by product (such as wheat bran and oil seed cakes), planted fodder, and non-conventional feed (such as crop thinning, leaf of banana, and atella). These feeds were either obtained from communal lands (grazing) and private lands (crop residues and weeds), produced (planted fodder and hay) or were purchased (crop residues, hay and green fodder).

Farmers depend on various sources of animal feed, most of which are obtained in their locality and from their own farms. About 74% of the farmers majorly depend on both from crop residues and natural pasture as source of animal feed. The types of residues fed to animals often depend on the types of crops grown in the selected districts. Among crop residues used, teff, wheat and barley straw, stalks of maize and sorghum, and maize Stover are mostly stacked and feed to livestock during the dry season. Hay (31.5%), crop aftermath (42%) and improved forage (10%) mainly lablab and cow pea are also major sources of feeds for animals in the study district. Green feed supply commonly elephant grasses are mostly practiced as cut and carries systems. Concentrate was also a common source of animal feed by 16.5% of the households. These concentrates mostly include wheat bran and *nuge* cake. Non-conventional feed resource (like *atela*, banana leaf) used by 4% of the households.

4.2.2. Adoption status of improved forage technologies

The figure 5 below shows the level of adoption of improved forage which is classified as adopter and non-adopter only in the study district. Adopters were farmers who after trying the technology had used it continuously for at least five years or more. Most of these farmers had slightly bigger pieces of land and therefore could afford to spare some land for the improved forage technology. They normally planted improved forage on a different portion of land each year. In the reverse, non-adopters were farmers who although had access to the improved forage technology over years and a few even having received seed and training, they tried the technology, but no longer had practise it or never planted

improved forage at all. However, Out of the total 177 respondents, 76 (42.94%) of them has been found to be adopters and the remaining higher proportion 101 (57.06%) of them were found to be non-adopters of improved forage in the selected districts. Most of the sample respondents are not practice improved forage technology in the area due to different factor. Mostly the farmers in the selected districts practice only cropping rather than applying improved forage practice that is the factor why the level of non-adopter were more than adopter of improved forage.

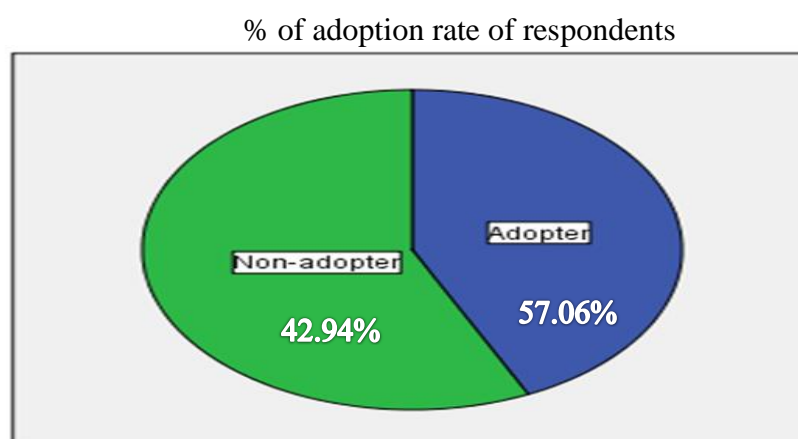


Figure 5 Improved forage adoption level in the selected districts

4.2.3. Adoption intensity of improved forage technologies for adopter farmers

The focus group discussion participants from the nine kebeles of the woreda indicated that, adoption rate of improved forage are increasing at lower rate. They indicated that, the low level of land allocation to improved forage is due to the lack of seed/planting material, training on livestock production and improved forage. Under the current study the extent of adoption of improved forage technology shows that only 8% of the farmland (0.06 ha on average) was used for production of forage crops. The land allocation for the improved forage species ranges from 0.01 to 0.1 hectare. There is also statistically significant difference ($P < 0.05$) amount cultivated improved forage among the adopters households in the study district. In the reverse, farmers tend to allocate more area of farmlands for the production of food crops than forage. Farm size and free grazing is also another factor that limits wider use of forage technologies.

Table 18: Adoption intensity of improved forage crops in selected districts

Mean land holding for adopter households			Average land size for cultivation (forage)			Std. Error Mean	t-value
No.	Ha.	%	No.	Ha.	%		
76	0.74	100	76	0.06	8.1	.00248	24.403**

Note: **, show significant at $p < 0.05$

4.2.4. Type of improved forage introduced and their adoption rate

In the study area the most adaptive type of forage crops introduced and cultivated by the respondents were elephant grass, Oat-Vetch, Rhodes grass, Lablab, Alfalfa, Cowpea, pigeon pea, tree lucerne, and Sesbania. The result had shown that from the total improved forage crop introducers 23.68%, 19.74%, 15.9%, 11.84%, 9.21%, 6.58%, 6.58%, 5.26%, and 1.32% respondents were cultivated for Elephant Grass, Oat-Vetch, Cowpea, Lucerne, Pigeon Pea, Lablab, Rhodes Grass, Sesbania, and Alfalfa respectively, through alley cropping, backyard, intercropping, and irrigation. The results of the study further showed that, the different varieties of forage crops have different levels of adoption rates. Out of these forage crops Alfalfa was the least adopted forage crops in the study district. The major reasons behind the less adoption rates of forage crops is associated with limited access to improved forage seeds ,shortage of farmlands and the consequent interest of the farmers to give priority for food than forage crops (Mamaru Tesfaye, 2021).

Table 19: Adoption rates of improved forage crops in the selected districts, 2024

improved forage	Improved forage adopter (n=76)	
	Freq.	Adoption rate (%)
Elephant grass	18	10.17
Oat-vetch	15	8.47
Cowpea	12	6.78
Lucerne	9	5.08
Pigeon pea	7	3.95
Lablab	5	2.82
Rhodes grass	5	2.82
Sesbania	4	2.26
Alfalfa	1	0.56

4.2.5. Improved forage crops production and strategies of their development in the selected districts

Improved forage practices have highly important in providing high quality feed, used as live fencing, source of fire wood, improving fertility of the soil, and reducing cost of production in the study area. It also have a vital role in improving the agricultural production by providing food, fodder and income for improved forage adopter farmers in the study area. Some of the most common improved forage practice that has practiced in the selected districts by improved forage technology adopters was the following:

Alley Cropping

Alley cropping is a forage production practice contains growing of food crop in the middle of hedge rows of planted fodder trees and shrubs. From a total of 76 improved forage adopter's group 29 (38.16%) respondents was practice alley cropping strategy in their arable land. Most farmers practice alley cropping that give high yields since their farm size were relatively small (on average 0.48ha).

Backyard

Backyard is one type of forage production strategy that includes cultivation of forages in and around the backyards and domestic animal around the homestead. A Backyard forage production is one of the forage production system practiced in the selected districts. Crops such as coffee and numerous kinds of vegetables are dominant components of the selected districts home gardens. Fruit trees like Avocado, Mango, and Papaya are also practiced in home garden agroforestry. Tree and shrub legumes such as Sesbania, Pigeon pea, and Lucerne species are among the species that practiced at home garden and also are used to produce large quantity of forage from their branches and leaves and produce green feed for much of the dry season, provide fuel wood, organic matter for soil fertility. Elephant grass was observed around the home compound used as live fence protection and source of quality feed for dairy cow. Backyard integrated mostly fruit trees combined with fodder crops, vegetable, and even maize on small gardens near to homestead. The main objectives of this practice are to produce feed, fuel materials and to gain income from the product. As

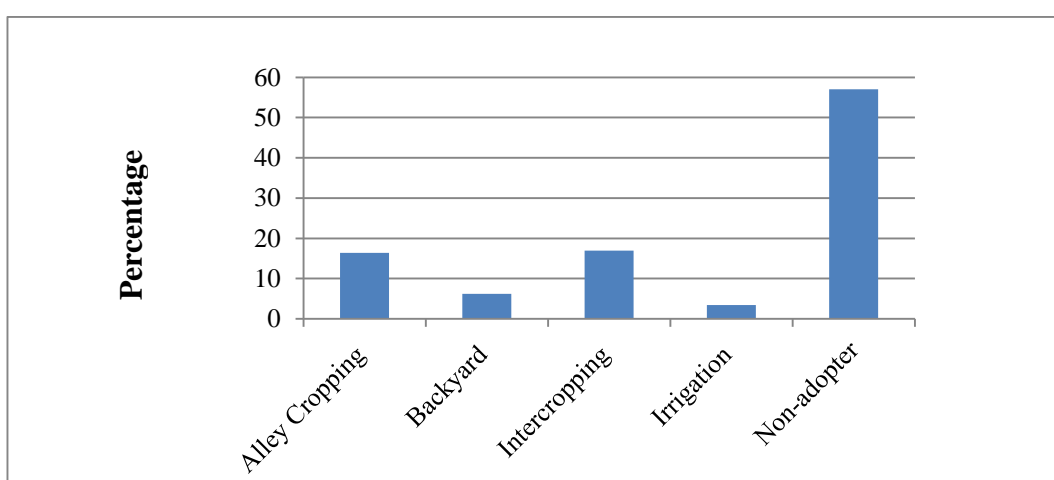
figure 6 shows that out of 76 improved forage adopters 11 (14.47%) are practicing backyard forage around their homestead.

Intercropping

Production of forage species with other food crops was adopted by farmers in the study district. The use of legumes in this system is contributed to the improved fertility and structure of cropping soils. Out of 76 improved forage adopters 30 (39.47 %) were growing tall cereals such as maize and sorghum under sowing with legumes like cow pea and lablab to produces high quality forage for utilization by cut and carry systems in the selected districts.

Irrigation

The practice of growing improved forage under irrigation land may be based on where such areas are protected from livestock grazing. Response from interviewed farmers indicated that, out of 76 improved forage adopters only 6 (7.89 %) of respondent are practicing forage under irrigation. A mixture of oat and vetch, Rhodes grass and Alfalfa were used in the selected districts in separate plots under irrigation for a long period of time.



Source: own survey data (2024)

Figure 6 Types of improved forage practice done in the selected districts

4.2.6. Farmer's perceptions about improved forage technology

The farmer's interest for adoption of improved forage technology depends on their perception about improved forage practice. Analysing farmers attitude towards improved forage are important to understand farmers knowledge. Farmer's perception towards improved forage includes awareness and knowledge of farmers about improved forage. As (Table 20) below indicates most of the respondents were aware of both economic and environmental benefits of improved forage. More particularly most of the respondent's perception towards improved forage technology is that it increased milk production, soil fertility, and a potential of solving their fuel wood needs. The farmers also believed that improved forage technology is profitable and less risky than other agricultural alternatives. Even if farmer's perceptions towards improved forage practice are positive most of the farmers still not adopted improved forage practice in the selected districts.

However, the main problems of the farmer's attitude towards improved forage are their negative thinking that improved forage production consumes land for crop production as a result they tried activities that generate income from crop production. The results in (table 20) shows that most of the respondents strongly agree that improved forage practice increase milk yield 76.27% of the respondents, 23.73% of the respondents are agree perception. The farmer's perceptions about improved forage practice increased growth/fattening are positive about 67.8% are strongly agree and 28.25% are agree and 3.95 are neutral the rest of the respondent are no disagree and strongly disagree about improved forage practice increased growth/fattening. Their perception towards improved forage practice increase soil fertility 51.41% are strongly agree, 45.20% agree, 1.13% neutral and the rest of the respondents are dis agree response. The fourth statement are about improved forage practice it is drought resistance and for this more respondents 35.03% are agree response, 28.25% strongly agree, 18.8% strongly agree, 4.52% neutral, 24.29% dis agree, 7.91% strongly disagrees. The other statements are improved forage practice improved reproductive and more respondents are 59.32% are strongly agree, 36.72% are agree, and the other are disagree and neutral response. The farmer's positive perception is shown as necessary steps in adoption of improved forage (Franzel et al., 2002). Negative attitude among the farmers may be the main reasons for less adoption of improved forage technology (Chauhan *et al.*, 2009).

Table 20: Farmers perception towards improved forage practice in the selected districts

Statement		Respondents response (perception)				
		1) S. agree	2) agree	3) neutral	4) disagree	5) S. disagree
IF practice	Increased milk yield	135 (76.27)	42 (23.73)	0	0	0
	Increased growth	120 (67.8)	50 (28.25)	7 (3.95)	0	0
	Increase soil fertility	91 (51.41)	80 (45.20)	2 (1.13)	4 (2.26)	0
	It is drought resistance	50 (28.25)	62 (35.03)	8 (4.52)	43 (24.29)	14 (7.91)
	Improved reproductive	105 (59.32)	65 (36.72)	5 (2.82)	1 (0.56)	1 (0.56)

IF = improved forage

4.2.7. Reasons why most of the farmers did not adopt improved forage technology

The study indicated that though limited proportions of households have already started using, large proportions of them have not yet started adopting improved forage technology. The six major reasons described by farmers included land shortage as reported by 24.68% of the households, shortage of seed/planting material (19.62%), lack of awareness about improved forage (32.68%), free grazing (29.11), irrigation problem (16.77), and drought (9.81) had been reported. Lack of awareness, free grazing and shortage of seed/planting material were found to be critical for the not adoption of for improved forage technology in the selected districts. The major reason was related with awareness and knowledge of improved forage technology. Therefore, intensive training should be given to bridge the gap.

Table 21: Farmers' reasons for non-adoption/discontinuation of the use of IF

Variables	Districts							
	Habru (n=33)		Kobo (n=30)		Gubalafto(n=38)		Overall (n=101)	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Awareness of IF in cow rations								
Yes	22	66.66	23	76.66	23	60.52	68	67.32
No	11	33.34	7	23.34	15	39.48	33	32.68
Land size	28	26.92	19	19.79	31	26.72	78	24.68
Lack of seed	17	16.35	20	20.83	25	21.55	62	19.62

Drought	11	10.58	7	7.29	13	11.21	31	9.81
Irrigation problem	15	14.42	20	20.83	18	15.52	53	16.77
Free grazing	33	31.73	30	31.25	29	25.00	92	29.11
Total		100		100		100		100

The non-adopting households listed different factors for not cultivating improved forage production were lack of awareness (32.68%) was the major impediment in the selected districts, followed by free grazing, land shortage, lack of planting material, lack of irrigation facilities, and drought are for 29.11, 24.68, 19.62, 16.77, and 9.81%, respectively (Table 21).

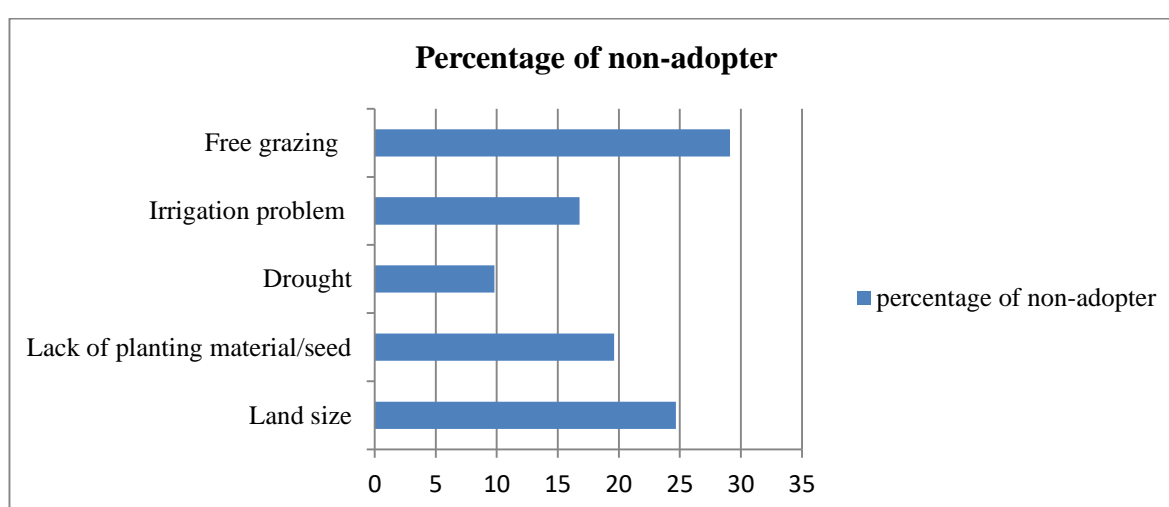


Figure 7 Reason for not adopting improved forage technology, 2021

4.3. Determinants of Adoption of Improved Forage Technologies in the Selected Districts

Determinants of decision to adopt: Fourteen variables were hypothesized to determine farmers' decision to adopt improved forage technologies in selected district. Out of these 14 variables hypothesized, only 10 were found to be significantly affecting farmer's decision to adopt improved forage technologies.

Analysis of the sampled farmers at the household level indicated that age of the farm household head was negatively related to the probability of adoption of improved forage technology at 5% probability level. As age farmers increases probability of adoption goes to decrease indicating that old farmers were more unwilling to adopt the improved forage

technology than younger farmers. This implies young farmers are fast enough to respond to improved forage technology too. This finding is in line with the study by (Mamaru and Paulos, 2022), who suggests that young people tend to be more adopters of new technologies than the old aged people. Older farmers may not have the physical strength to implement labour intensive farm operations that would increase productivity (Kebebe, 2015).

Total land size had a significant positive effect on the farmer's decision to adopt improved forage technology. As the farm holdings of the household increased the probability of forage adoption increased tending to expand the farm land under the improved technology. This might be due to the availability of space. The result is consistent with finding of (Mamaru and Paulos, 2022) who reported that farmers with large land size can adopt new agricultural technologies than smallholders and land size would initiate to adopt improved forage technologies. Larger land holdings are associated with greater wealth and increased availability of capital to invest on the technology (Kebebe, 2015). Therefore, farmers with larger farm size might be allocated part of their land for improved forage production.

The number of contacts with extension agent increased the likelihood of adopting forage increased significantly at less than 5% probability level. A frequent contact with development agent increased the probability of adopting improved forage. This shows that forage adopter group had more access to information than that non-adopter group. Frequent meetings with extension agents promote knowledge flows about new technologies and services (Kebebe, 2015).

Number of livestock significant positive effect on the farmer's decision to adopt improved forage technology at 5%. Households with larger number of animals are more likely to get improved forage knowledge, adopt improved forage and use it sustainably. The positive effect of number of livestock might be due to that a more animals are required to more feed, so farmers with more animals should be more interested to use improved forage than those having fewer animals. Similar results reported by (Mamaru and Paulos, 2022), the adopter household has more livestock owners than non-adopters.

Education is found statistically significant in affecting the adoption of small-scale irrigation at 5% level of significance. The likelihood of households increase in adopting

improved forage with an increase in years of education. The possible reason for this may be due to the capability of education in raising the awareness and information processing of farmers about new agricultural technologies. Farmers having more years of schooling do not face difficulty in getting and processing information beside their ability in making thoughtful evaluation about new agricultural technologies than farmers with less years of schooling.

Sex of the farm household head being male was positively associated to the probability of forage adoption technology, but not significant at 5% probability levels. This means the decision to adopt a technology may not differ between households headed by men and women and male farmers use more improved forage as compared to their female opposite sexes. However, gender by itself may not influence the decisions to adopt. Control of critical resources may influence adoption decisions as well. This is partly due to inequity in access and ownership of resources between males and females where men tend to have greater control hence a comparative advantage in adoption (Gebregziabher *et al.*, 2013); Male farmers might have more access to information, extension and credit services than their female counterparts (Hassen Beshir, 2014).

Access to credit service had greatly positive and significant effect on the probability of forage adoption at 5% probability level. Agricultural credit services are the major sources of finance to those farmers who adopt improved agricultural technologies (Hassen Beshir, 2014). Providing access to credit can raise the likelihood of adopting agricultural technologies for households falling short of finance to purchase and possess new agricultural technologies.

Once acquired the knowledge about improved forage, skill training in improved forage use may increase the possibility of adoption and continuous use greatly. Some adopters may not actually initially acquire the improved forage; they may ask from adopter neighbour. The Chi-square test indicated that the association between attained training and improved forage adoption was significant at 5% level. The result of the study in agreement with the findings of (Alemayehu *et al.*, 2018) who reported that those farmers with access to trainings have better chance to adopt improved forage technology.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

This study addressed analysis of the perception and adoption of small-scale dairy farmers towards improved forage and production in selected district. From the results of the current study, the researchers conclude that inadequate quality and quantity of animal feed is a highly significant factor that affects production and productivity of livestock. The empirical results show that education of household head, age; family size; livestock holding; land size; rate extension contact and training; participation on demonstration; availability of seed/planting material; and access to credit were found to affecting the adoption of improved forage technology significantly at 5% of probability level. In the same result, the rest variables like sex of households; marital status; mobile ownership; and social related participation were do not significantly affect famers' willingness to adopt improved forage crop production.

Factors for not cultivating improved forage for those non-adopter households were lack of awareness (32.68%) was the major impediment in the selected districts, followed by free grazing, land shortage, lack of planting material, lack of irrigation facilities, and drought are for 29.11, 24.68, 19.62, 16.77, and 9.81%, respectively. Generally speaking, adoption, production and utilization of improved forage to animal feed in selected district were relatively low. The types of improved forage crops introduced in study districts were Elephant Grass, Oat-Vetch, Cowpea, Lucerne, Pigeon Pea, Lablab, Rhodes Grass, Sesbania, and Alfalfa. The improved forage technologies that were practice in the study district are limited to four types; such as alley cropping, backyard, intercropping, and forage development in irrigation.

5.2. Recommendations

Based on the findings of the current study, the following recommendations are suggested:

Future development intervention and the collective efforts of stakeholders should give attention to these significant variables in order to enhance the probability of adoption and

strengthening intensity of use of improved forage technologies to improve the livelihoods of farming households.

Development agents and agricultural experts should provide intensive extension services and continuous follow-up on improved forage production so that farmers' willingness to adopt forage production can be enhanced.

Improved forage development strategies that are practice in the study district are only limited to four it should be diversified. There is also a lack of education; most dairy farmers lack formal education and have a little training in improved forage technology. There should be institutions which provide training courses targeted to smallholder dairy farmers.

There should be institutional and policy support for intervention in introduction of improved forage varieties and promotion of the production of forage at household level.

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APPINDIX



Figure 1: During collection of data using questioner



Figure 2: During group discussion



Figure 3: During interview with key informants



Figure 4: During survey with adopter farmers

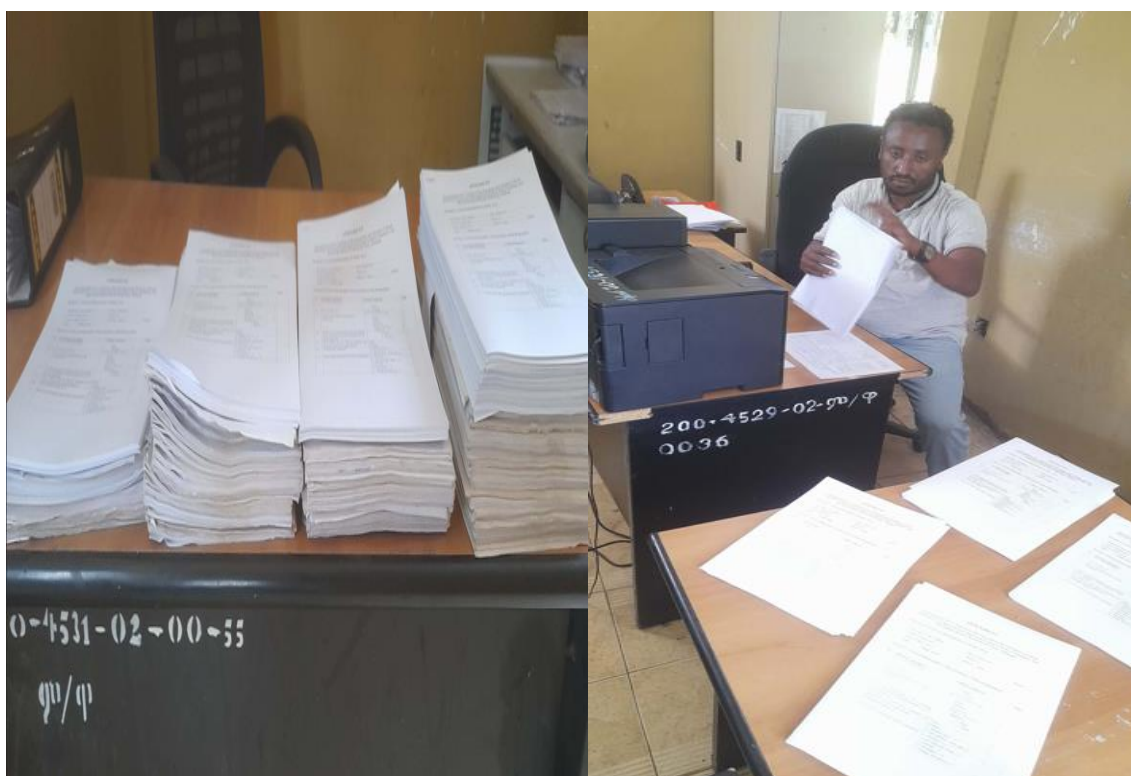


Figure 5: During duplication of questioner

Table 1: Group Statistics for independent variables

	Farmers category	N	Mean	Std. Deviation	Std. Error Mean
age	Adopter	76	41.2500	11.33034	1.29968
	Non-adopter	101	48.2277	12.22283	1.21622
Family size	Adopter	76	5.6447	1.86693	.21415
	Non-adopter	101	4.9010	1.95195	.19423
Numbers of education years	Adopter	76	4.3158	4.56716	.52389
	Non-adopter	101	3.0198	3.65234	.36342
TLU	Adopter	76	2.6030	.44429	.05096
	Non-adopter	101	1.9903	.36767	.03658
Land size	Adopter	76	.7389	.19969	.02291
	Non-adopter	101	.5907	.17090	.01701
Number of extension contact	Adopter	76	7.2895	1.53897	.17653
	Non-adopter	101	4.6337	1.62310	.16150

Table 2: Independent samples test for independent variable

		Levene's Test for Equality of <u>Variances</u>		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2- tailed)	Mean Differenc e	Std. Error Differenc e	95% Confidence Interval of the Difference	
									Lower	Upper
Age	Equal variances assumed	1.403	.238	-3.878	175	.000	-6.97772	1.79922	-	-3.42675
	Equal variances not assumed			-3.920	167.521	.000	-6.97772	1.77999	-	-3.46363
Family size	Equal variances assumed	.655	.420	2.556	175	.011	.74375	.29094	.16954	1.31796
	Equal variances not assumed			2.573	165.265	.011	.74375	.28911	.17292	1.31457
Numbers of education years	Equal variances assumed	20.505	.000	2.097	175	.037	1.29599	.61798	.07632	2.51565
	Equal variances not assumed			2.033	140.201	.044	1.29599	.63760	.03543	2.55654
TLU	Equal variances assumed	7.434	.007	10.030	175	.000	.61271	.06109	.49214	.73328
	Equal variances not assumed			9.767	143.612	.000	.61271	.06274	.48871	.73671
Land size	Equal variances assumed	3.053	.082	5.310	175	.000	.14820	.02791	.09312	.20328
	Equal variances not assumed			5.195	146.975	.000	.14820	.02853	.09182	.20458
Number of extension contact	Equal variances assumed	.283	.595	11.016	175	.000	2.65581	.24108	2.18002	3.13160
	Equal variances not assumed			11.100	165.916	.000	2.65581	.23926	2.18342	3.12820

Table 3: Social-Participation * Farmer Catagory Crosstabulation

			Farmer Catagory		Total
			Adopter	Non-adop	
Social-Participation	No	Count	12	20	32
		Expected Count	13.7	18.3	32.0
	Yes	Count	64	81	145
		Expected Count	62.3	82.7	145.0
Total	Count		76	101	177
	Expected Count		76.0	101.0	177.0

Chi-Square Tests of respondents for social related participation

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2- sided)	Exact Sig. (1- sided)
Pearson Chi-Square	.471 ^a	1	.492		
Continuity Correction ^b	.239	1	.625		
Likelihood Ratio	.476	1	.490		
Fisher's Exact Test				.557	.314
N of Valid Cases	177				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 13.74.

b. Computed only for a 2x2 table

Table 4: Mobile ownership * Farmer Catagory Crosstabulation

			Farmer Catagory		Total
			Adopter	Non-adopter	
Mobile ownership	No	Count	5	16	21
		Expected Count	9.0	12.0	21.0
	Yes	Count	71	85	156
		Expected Count	67.0	89.0	156.0
Total	Count		76	101	177
	Expected Count		76.0	101.0	177.0

Chi-Square Tests of respondents for mobile ownership

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2- sided)	Exact Sig. (1- sided)
Pearson Chi-Square	3.558 ^a	1	.059		
Continuity Correction ^b	2.728	1	.099		
Likelihood Ratio	3.775	1	.052		
Fisher's Exact Test				.065	.047
N of Valid Cases	177				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.02.

b. Computed only for a 2x2 table

Table 5: Marital Status * Farmer Category Crosstabulation

			Farmer Category		Total
			Adopter	Non-adop	
Marital Status	Divorced	Count	1	1	2
		Expected Count	.9	1.1	2.0
	Married	Count	69	92	161
		Expected Count	69.1	91.9	161.0
	Single	Count	1	1	2
		Expected Count	.9	1.1	2.0
	Widow	Count	5	7	12
		Expected Count	5.2	6.8	12.0
Total		Count	76	101	177
		Expected Count	76.0	101.0	177.0

Chi-Square Tests of respondents for marital status

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.090 ^a	3	.993
Likelihood Ratio	.089	3	.993
N of Valid Cases	177		

a. 4 cells (50.0%) have expected count less than 5. The minimum expected count is .86.

Table 6: Sex of Farmers * Farmer Catagory Crosstabulation

			Farmer Catagory		Total
			Adopter	Non-adop	
Sex of Farmers	Female	Count	11	24	35
		Expected Count	15.0	20.0	35.0
	Male	Count	65	77	142
		Expected Count	61.0	81.0	142.0
Total	Count		76	101	177
	Expected Count		76.0	101.0	177.0

Chi-Square Tests of respondents for sex

	Value	df	Asymp. (2-sided)	Sig. (2-sided)	Exact Sig. (2- sided)	Exact Sig. (1- sided)
Pearson Chi-Square	2.359 ^a	1	.125			
Continuity Correction ^b	1.809	1	.179			
Likelihood Ratio	2.419	1	.120			
Fisher's Exact Test					.133	.088
N of Valid Cases	177					

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 15.03.

b. Computed only for a 2x2 table

Table 7: Participation on Demonstration * Farmer Catagory Crosstabulation

			Farmer Catagory		Total
			Adopter	Non-adop	
Demonstration	No	Count	29	62	91
		Expected Count	39.1	51.9	91.0
	Yes	Count	47	39	86
		Expected Count	36.9	49.1	86.0
Total	Count		76	101	177
	Expected Count		76.0	101.0	177.0

Table 8: Participation on training * Farmer Category Crosstabulation

			Farmer Category		Total
			Adopter	Non-adop	
Training	No	Count	14	53	67
		Expected Count	28.8	38.2	67.0
	Yes	Count	62	48	110
		Expected Count	47.2	62.8	110.0
Total	Count		76	101	177
	Expected Count		76.0	101.0	177.0

Chi-Square Tests of respondents for training

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2- sided)	Exact Sig. (1-sided)
Pearson Chi-Square	21.379 ^a	1	.000		
Continuity Correction ^b	19.956	1	.000		
Likelihood Ratio	22.441	1	.000		
Fisher's Exact Test				.000	.000
N of Valid Cases	177				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 28.77.

b. Computed only for a 2x2 table

Table 9: Access to Seed or Planting material * Farmer Category Crosstabulation

			Farmer Category		Total
			Adopter	Non-adop	
Access to Seed	No	Count	23	61	84
		Expected Count	36.1	47.9	84.0
	Yes	Count	53	40	93
		Expected Count	39.9	53.1	93.0
Total	Count		76	101	177
	Expected Count		76.0	101.0	177.0

Chi-Square Tests of respondents for access to seed

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2- sided)	Exact Sig. (1- sided)
Pearson Chi-Square	15.792 ^a	1	.000		
Continuity Correction ^b	14.606	1	.000		
Likelihood Ratio	16.111	1	.000		
Fisher's Exact Test				.000	.000
N of Valid Cases	177				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 36.07.

b. Computed only for a 2x2 table

Table 10: Access to credit Service * Farmer Catagory Crosstabulation

		Farmer Catagory		Total
		Adopter	Non-adop	
Access to credit Service	Count	49	83	132
	No Expected	56.7	75.3	132.0
	Count			
	Count	27	18	45
	Yes Expected	19.3	25.7	45.0
	Count			
	Count	76	101	177
	Total Expected	76.0	101.0	177.0
Total		Count		

Chi-Square Tests of respondents for access to credit

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2- sided)	Exact Sig. (1- sided)
Pearson Chi-Square	7.170 ^a	1	.007		
Continuity Correction ^b	6.266	1	.012		
Likelihood Ratio	7.126	1	.008		

Fisher's Exact Test		.009	.006
N of Valid Cases	177		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 19.32.

b. Computed only for a 2x2 table