# DETERMINANTS OF IMPROVED FORAGE LEGUME ADOPTION: THE CASE OF KEDIDA GAMELA DISTRICT, KEMBATA TEMBARO ZONE, SNNPR, ETHIOPIA

**MSC THESIS**

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# Determinants of Improved Forage Legume Adoption: the Case of Kedida Gamela District, Kembata Tembaro Zone, SNNPR, Ethiopia

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The author, Mulatu Sendabo, was born in Kembata Tembaro Zone, Kedida Gamela woreda, Bezena Benara kebele, 280 km from Addis Ababa in 1972. He completed his primary education in Mishgida MekaneYesus primary school. He attended his high school education at Durame senior Secondary school. He then joined Ambo College of Agriculture (today's Ambo University) in September 1990 and graduated with Diploma in General Agricultural in July 1991.

After his graduation, he worked in Hadiya Zone, Konteb woreda (today's Misha) Agriculture and Rural Development office as a Development agent for three years. He then transferred to Kembata Tembaro Zone, Kedida Gamela woreda Agriculture and Rural Development office and worked as a Development agent, Supervisor, training expert for two solid years. He then joined Alemaya University (today's Haramaya University) for his B.Sc. study in 1997. He then worked at Kedida Gamela woreda, Kembata Tembaro zone as Extension communication and training expert, Crop production and protection desk head. He then transferred to Kembata Tembaro Zone Department of Agriculture and Rural Development Land Administration and Natural Resource Development desk head, Land Administration and Natural Resource Development office head for 13 solid years until he joined Jimma University for his post graduate study.

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## ACRONYMS

| | |
|---|---|
| ADPTIFL | Adoption of Improved Forage Legume |
| AE | Adult Equivalent |
| ARDU | Arsi Rural Development Unit |
| ACCTRN | Access to Training |
| ACCTCS | Access to Credit Service |
| CIMMIYT | International Maize and wheat improvement center |
| CADU | Chilalo Agricultural Development Unit |
| CC | Contingency Coefficient |
| CSA | Central Statistics Authority |
| CDMD | Crop Diversification Market Development |
| DM | Dry Matter |
| DSTAEOF | Distance to Extension Agent Office |
| DSTFMC | Distance from Market Center |
| ESAP | Ethiopian Society of Animal Production |
| EDUC | Education status of the household |
| EAC | Extension Agent contact |
| FTC | Farmers Training Center |
| FAMSZ | Family Size |
| FARMSZ | Farm size |
| FARMINC | Farm Income |
| FAO | Food and Agriculture Organization |
| FLDP | Fourth Livestock Development Project |
| FL | Fourage Legume |
| FEED | Feed Enhancement for Ethiopian Development |
| GDP | Gross National Product |
| HH | Household Head |
| HHLOBR | Household Labour |
| ILRI | International Livestock Research Institute |
| IFL | Improved Forage Legume |
| IFLA | Improved Forage Legume Adoption |
| KDFEDO | Kedida Gamela District Finance and Economy Development office |

| | |
|---|---|
| KDLFDO | Kedida Gamela District Livestock and Fishery Development office |
| KDANRDO | Kedida Gamela District Agriculture and Natural Resource Development office |
| LOWND | Livestock Owned |
| LPM | Linear Probability Model |
| ML | Maximum Likelihood |
| MoA | Ministry of Agriculture |
| NGO | Non Government Organization |
| OLS | Ordinary Least Square |
| PPS | Probability Proportional to Sample size |
| PES | Payment for Ecosystem |
| R&D | Research & Development |
| SNNPR | South Nation Nationalities and Peoples Region |
| SSA | Sub Saharan Africa |
| SEX | Sex of the household head |
| TLU | Tropical Livestock Unit |
| VIF | Variance Inflation Factor |

# ABSTRACT

*In Ethiopia the livestock sub-sector has significant contributions to the national income and the livelihoods of households. As the sector is facing many challenges, adoption of improved forage technologies is one of the most promising ways to reduce feed shortage in Ethiopia. The aim of this study was to analyze the determinants of improved forage legume adoption in Kedida Gamela District, Kembata Tembaro Zone of SNNPR. A two stage sampling procedure were employed to select 186 sample households. Primary and secondary data were collected from the district and three purposively selected kebeles Data were collected using structured interview schedule, focus group discussion and personal observation. Both descriptive and inferential data analysis methods were applied using SPSS v20. The result of the study indicated that 27.4% and 72.6% were found to be adopters and Non- adopters respectively. The results of land coverage reveals that the proportion of land for improved forage legume to total forage land was only 12.7%. The results of descriptive statistics also indicate as sex, education, grazing land size, livestock owned, participation in off-farm activities, distance from nearest market center, access to credit servise and extension agent contact were found to have significant influence on household adoption of improved forage legume at the different probability level. The results of binary logistic regression indicated as extension agent contact, access to credit service, participation in off-farm activities, distance from nearest market center, livestock owned, sex, grazing land size were found to have significantly determining household adoption of improved forage legume production. Shortage of land, lack of inputs, lack of extension service were major constraints affected adoption of improved forage legume. In general adopter households own more livestock units, have a relatively large grazing land size, have better access to credit, have contact with extension agents, most of them involved in off-farm activities and have more access to market to purchase inputs & sale their produce than Non-adopter households. Therefore government development interventions should give emphasis to improvement of such institutional support systems to increase adoption and productivity of improved forage legume.*


**Key Words:** Adoption, Improved Forage Legume, Kedida Gamela district

# 1. INTRODUCTION

## 1.1Background

Ethiopia is mainly an agricultural economy and known for its huge number of cattle population. The agricultural sector accounts for about 46 percent of national gross domestic product (GDP), 90 percent of exports, and 80 percent of employment (AfDB, 2012). In Ethiopia, 90 percent of the poor rely for their livelihood on crop and livestock production (Yu *et al.*, 2011). The livestock sub-sector has significant contributions to the national income and the livelihoods of households (Alemayehu 2012). Its contribution is about 27% of the agricultural GDP. A large proportion of livestock feed resources in Ethiopia are natural pastures, crop residues and aftermath grazing (Adugna 2008; Getnet 2012).

In addition, the existing natural pastures and crop residues, as the two most important feed resources, are unable to meet the nutrient requirements for milk production and reproduction. According to CSA (2015) the use of improved feed is limited (0.3%) in rural areas of Ethiopia. The native pasture grass (56.23%) is the major feed resource followed by crop residue 30.06%, hay and by-products are also used as animal feeds that comprise about 7.44% and 1.21% of the total feeds, respectively (CSA, 2015).

Although, in the tropics adoption of legume-based technologies has, in general, been disappointing in spite of many success stories with tropical forage legumes worldwide. The reasons were analyzed by Shelton *et al.*, (2005) and include a number of issues that should be taken into account when planning R&D programs promoting the use of tropical forage legumes.

In Ethiopia during 1987-1993 the Fourth Livestock Development Project (FLDP), different strategies and species for pasture and forage development were selected (Tegegne *et al.*, 2013). For this strategy to be successful, improved forages, which have comparative advantages over indigenous forage species in terms of dry matter yields and quality, need to be widely adopted. In addition, improved forages, e.g. tree legumes, provide benefits like improving soil fertility, serving as fence material and providing shade for crop farming. Eventhough, research has identified high yielding and better quality forages adaptable to various agro-ecologies and production systems, improved forages are not yet adopted and developed by the farming community due to inadequate knowledge, poor extension service, and shortage of land and policy issues (Jimma *et al.*, 2016).

In Kedida Gamela district, where this study was conducted, crop production is integrated with livestock farming is the basis of the smallholder farmers. The improved forage legumes, including vetch, alfalfa, dismodium, Leucaena, pigeon pea and Sesbania, have been introduced in an effort to increase the amount and quality of available forage and have been promoted in the region by MoA. However, the major livestock feed sources in the area are grazing pasture, straw of maize, wheat and teff (KDLFRDO, 2016/2017). Moreover, research has not been conducted to determine the factors that influenced the adoption or lack of adoption of improved forage legume by farmers in the area (KDLFRDO, 2016/2017). Thus, identifying problems that hinder farmers' adoption of improved forage legume is one of preliminary step to plan appropriate strategies. Therefore the purpose of this study was to analyze determinants of improved forage legume adoption: the case of Kedida Gamela District, Kembata Tembaro Zone, SNNPR, Ethiopia.

## 1.2 Problem Statement

Adoption of improved forage legume is believed to solve some of the critical feed shortages and quality problems in the study area. Essentially, the observed failure of farmers to recognize and fully adopt the improved forage legume could be ascribed to various factors which appeared to have some bearing on the farmers' decision to adopt improved forage legume. Beshir (2014) observed that since the adoption of improved technologies is dynamic having information with regards to the current technologies being adopted by farmers is very important.

However, in rural Ethiopia the shortage of land is likely to become escalating as the population continues to grow (Teshome 2014). Simultaneously livestock numbers are being greater than before to meet the increased demand for draft power for crop production (CSA (2015). This leads to decline in area of land available for natural grazing and feed production. As a result, the major livestock feed resources in the country are becoming crop residues, which are nutritionally characterized as deficient in energy, protein and micronutrients.

According to the study by ESAP (2003) and Zekarias (2015), the major challenges those made the livestock productivity and production in the country were identified as low adoption of improved forages and utilization system, awareness problem on improved forage production and husbandry practices, inadequate market infrastructure, absence of market oriented cattle production system, prevalence of various diseases. As the study of Alemayehu (2012) showed various feed-related constraints include: reduced grazing and pasture-lands, overstocking, seasonal variation in availability of roughage feeds, poor nutritional quality of forage, use of crop residues for other purposes, limited availability and unaffordability of concentrate feeds, low adoption of improved forages, low adoption of silage and hay making, and low adoption of urea treatment of crop residues at smallholder farmer level.

To alleviate such constraints, national, regional and international research institutions have developed several feed production and utilization technologies (Alemayehu *et al.*, 2017). However, based on 2014/15 livestock survey report only 0.3% of livestock holders practiced using improved feed technologies for their livestock (CSA, 2015).

Production of herbaceous and tree forage legumes can contribute improved nutritive value and sustainability to warm season, subtropical and tropical pastures and rangelands substantially (Muir, *et al.*, 2014). Moreover, the use of improved forages reduces the pressure on natural pastures, improve soil fertility and erosion on marginal lands, improve carbon sequestration to mitigate climate change, support system sustainability, and enhance natural assets and system resilience (ILRI, 2009).

The main intention of such initiations is to increase the adoption of improved forage legume that eventually improves the shortage livestock feed and quality. Despite the fact that, crop and livestock production are the major sources of income for farmers in Kedida Gamela district, there is a serious shortage of livestock feed. As the report of KDANRDO (2016/17) shows, the district is densely populated and because of this the mean of farm land holding is below 0.5 hectare. This indicates that there is shortage of farm land in the district. As a consequence of this, the livestock production is poor and cannot convene the production demand of farmers in the area. The major feed resources available in the district were natural pasture and crop residues with high fiber content and low digestibility which could decrease livestock productivity and disease resistance (Lemma *et al.,* 2016). The report of KDLFRDO, (2016/2017) also confirms that grazing pasture, straw of maize, wheat and teff are the major livestock feed sources in the area. The improved forage legumes, including vetch, alfalfa, dismodium, Leucaena, pigeon pea and Sesbania, have been introduced in an effort to increase the amount and quality of available forage and have been promoted in the region by MoA. However, empirical information about the adoption status and determinants of improved forage legume adoption is scarce in the study area KDLFRDO, (2016/2017).

Hence, the issue needs to be studied with supportive empirical evidences. Therefore, knowing the adoption status and understanding the demographic, socio-economic and institutional factors that affect adoption of improved forage legume can help to get consistent information that could be useful to plan appropriate strategy that promote adoption of improved forage legume to cope up with the current feed shortage problem of farmers of the area. The study was undertaken based on the following objectives.

## 1.3 Objectives

### 1.3.1. General objective

To analyze determinants of improved forage legume adoption, in Kedida Gamela district, Kembata Tembaro Zone, Southern Ethiopia.

### 1.3.2 Specific objectives of the study are

- To assess adoption status of improved forage legumes in the study area
- To analyze factors affecting smallholder farmers decision of improved forage legumes adoption in the study area
- To explore the constraints and opportunities of improved forage legumes production in the area

## 1.4 Research questions:

- What is the current status of adoption of improved forage legumes in the study area?
- What are the factors of smallholder farmers’ decision of improved forage legumes adoption?

- What are the constraints and opportunities of improved forage legumes production in the area?

## 1.5 Significance of the study

Adoption studies can afford research and extension staff, rural development institutions, and policy makers with valuable information that improve the efficiency of communication among them in promoting available technologies. Apart from this, acquired information from such studies could enhance the efficiency of agricultural research, technology transfer, input provision, and agricultural policy formulation. All development partners including extension educators, technical assistants, NGOs and other development agents involved in agricultural development must be aware and understand the factors affecting adoption of improved forage legume information in order to target and priorate appropriate technologies to farmers. The present study attempted to reveal those underlying factors which may account for the observed variations in the adoption status of improved forage legume among the farmers in Kedida Gamela district.

To this end, the findings of this study will have paramount importance as it was conducted to analyze adoption of improved forage legume and after the study those who are concerned with these issues was taken the study results and recommendations as source of information contribution on improved forage legume technologies. In addition, the results of this study will also be documented at district level and it will serve as source material for further research development plan.

## 1.6 Scope and limitations of the study

**Scope of the study**

This study was undertaken in three Kebeles of Kedida Gamela district, in Kembata Tembaro Zone of SNNPR. Due to limitation of resources, the study was restricted to limited number of farmers who were sampled from the district. The adoption of new technology is influenced by many factors. Even if, the determinants which affecting adoption of improved forage legume are wide, this study emphasized only on thirteen potential determinants influencing adoption of improved forage legume production such as age, sex, education status, family size, grazing land size, livestock ownd, labour availability in adult equivalent, distance from nearest market, livestock income, farm income, participating in off-farm activities, access to credit service, and extension agent contact.

**Limitations of the study**

The scope of this study was limited by unavailability of accurate secondary data from line offices and also limited in terms of its coverage. Additionaly it is constrained by time, budget and other resources. However, much effort was made to acquaint the respondents with the purpose of the study and obtain some essential data. Even if the study is restricted in terms of its coverage, its findings can be used as a springboard for more detailed and area specific studies.

## 1.7 Organization of the Thesis

This thesis is organized into five chapters. Chapter one introduces and sets out the background information, statement of the problem, research objectives, research questions, significance, scope and limitation and organizationof the study; chapter two is dedicated to review of the literature that includes conceptual explanation of forage legume practice and adoption of improved forage legume. Different empirical studies are also reviewed in this chapter. Next, brief descriptions of the study area and research methodology are presented. Survey results are discussed in chapter four. At last, chapter five presents the summary, conclusions and recommendations of the study.

# 2. LITERATURE REVIEW

## 2.1 Definitions and Concepts of basic terminilogies

### 2.1.1. Forage

Forage is defined as edible parts of plants, other than separated grain, that can provide feed for animals, or that can be harvested for feeding (Leep *et al.,* 2002). Generally the term refers to such material as pasturage, hay, silage, and green chop, in contrast to less digestible material known as roughage (Leep *et al.,* 2002). In practice, however, the concept is often extended to woody plants producing succulent growth and indeed in the tropics some shrubs and trees are of considerable importance in this respect. Forage crops may be used in pastures or may be cut and carried to the animals that are expected to eat them. Forages have always been an extremely important source of nutrients in livestock rations. While the term forage has a broad definition, the term forage crop is used to define crops, annual or biennial, which are grown to be utilized by grazing or harvesting as a whole crop.

### 2.1.2 Forage Legume

Forage legumes are of two broad types. Some, like alfalfa, clover, vetch (*Vicia*), stylo (*Stylosanthes*), or *Arachis*, are sown in pasture and grazed by livestock. Other forage legumes such as *Leucaena* or *Albizia* are woody shrub or tree species that are either broken down by livestock or regularly cut by humans to provide livestock feed (Graham and Vance, 2003).

### 2.1.3 Agricultural technology

Different intellects has been defined technology in diverse ways. For example, Rogers (2003) often use “innovation” and “technology” synonymously. Added also “is a design for instrumental action that reduces the uncertainty in the cause–effect relationships involved in achieving a desired outcome.” Agricultural technologies include all kinds of improved techniques and practices which affect the growth of agricultural output (Jain *et al.*, 2009). Agricultural new technologies are the factors of production which have undergone some form of amendment from their original state with the intent of enhancing their performance.

### 2.1.4 Adoption: definition and concepts

The decision of whether or not to adopt a new hinges upon a careful evaluation of a large number of technical, economical and social factors. Feder *et al.,* (1985), define adoption as the integration of an innovation into farmers' normal farming activities over an extended period of time. It is also distinguished that, adoption is not a permanent behavior. This means that an individual may make a decision to discontinue the use of an innovation for a variety of personal, institutional and social reasons one of which may be the accessibility of another practice that is better in farmers' fields.

Adoption is an essential factor in economic development especially in developing countries. Successful beginning of technologies in developing countries requires an understanding of the main concerns of smallholder farmers at the grassroots. It is viewed as a variable representing behavioral changes that farmers undergo in accepting new ideas and innovations in agriculture (Nordin *et al.*, 2014). The term 'behavioral change' refers to desirable change in knowledge, understanding and ability to apply technological information, changes in feeling behavior such as changes in interests, attitudes, aspirations, values and the like; and changes in overt abilities and skills.

## 2.2. Adoption and Decision Making

Various guidelines, perhaps more useful from extension approach or strategy point of view, evolved from plan regarding the adoption process. Based on available insight and research findings: The 5-stage or classical adoption process (Rogers, 1962)  includes:

**Awareness.** The individual gets to know about the existence of the innovation (new idea or practice) but has no information about it.

**Interest.** The individual becomes interested in the idea and seeks more information about it.

**Evaluation.** The individual mentally applies the innovation to his present and anticipated future situation, and then decided whether or not to try it.

**Trial.** The individual uses the information on a small scale in order to determine its utility in his own situations. He may seek specific information about the method of using the innovation at the trial stage.

**Adoption.** At this stage the individual decides to continue the full use of the innovation. Over the years more and more criticism has been voiced against this concept by different writer. In view of this criticism several new fashions have been developed and proposed.

Later on Rogers (1983) developed a new model: a model of the innovation decision process. The innovation decision process, according to him, it is the process through which an individual (or other decision making unit) passes from first knowledge of an innovation, to forming an attitude towards the innovation, to a decision to adopt or reject, to implementation of the new ideas, and to confirmation of this decision. According to him an individual decision about an innovation is not an instantaneous act rather, it is a process that occurs over time and consists of a serious of action. The model consists of five stages:

**Knowledge**: occurs when an individual (or other decision making unit) is exposed to the innovations existence and gains some understanding of how it functions.

**Persuasion**: occurs when an individual (other decision making unit) forms a favorable or unfavorable attitude towards the innovation.

**Decision**: occurs when an individual (other decision making unit) engages in activities that lead to a chose to adopt or reject the innovation.

**Implementation**: occurs when an individual (other decision making unit) puts an innovation in to use.

**Confirmation**: occurs when an individual (the decision making unit) seeks reinforcement of an innovation decision already made, but he or she may reverse this previous decision if exposed to conflicting messages about the innovation. Adoption of any agricultural technology can be measured in terms of both timing and extent of utilization by individuals (Sunding and Zilberman, 2001).

‘‘**Attributes of innovation’’**

Relating to the relationship of technological attributes with farmers’ adoption decision, (Rogers 2003) identified five characteristics of agricultural innovations, which are important in adoption studies. These include 1) Relative advantage 2) Compatibility 3) Complexity 4) Trialability and 5) Observability. Rogers (2003) defines these characteristics as follows:

**Relative advantage**: Is the degree to which an innovation is perceived as better than the idea it supersedes.

**Compatibility:** The degree to which the farmer perceive an innovation to be consistent with his/her cultural values and beliefs, traditional management objectives, the existing level of and stages of development.

**Complexity:** The degree to which an innovation is understood and is used by farmers.

**Trialability:** The degree to which the innovation could easily be tried by farmer on his farm

**Observability**: The degree to which results of innovation are visible to farmers.

Thus the importance of adoption study is to quantify the number of users over time and to assess impacts or determine extension requirements that would help us in monitoring and feedback in generation. It also provides further insights into the effectiveness of transfer.

## 2.3. Adoption of Forage Legume Technologies

Farmers' criteria differ greatly between households, depending on the productive resources controlled by the household. However, the criteria also vary within a household (Harris, and Lyon, 2006). The partition of responsibilities and tasks is socially defined according to gender and age. Thus farmers identify and select the type of crops most likely to do well in their areas and selection is normally preceded by extensive discussions both within the farm family and with neighbors (Harris, and Lyon, 2006). Any family member may make observations of crop performance, looking at the crop on field and other criteria after harvest and good crop stand is noticed by neighbors and becomes a subject of conversation within the community (Ratnakar, 2016).

The choice of one /practice over others is greatly influenced by the balance between its positive and negative characteristics (Waters-Bayer and Bayer., 2005). Depending on the preferences, resources, and constraints that individual farmers face, a beneficial characteristic for one farmer may be a negative one for another, or the balance between positive and negative traits may be acceptable for one farmer but not for another (Ratnakar, 2016). Every new presented to farmers will either improve or substitute for the technological options they presently have. It is fundamental to identify these options and understand perceptions about the advantages and disadvantages of each one then will researchers be able to assess the appropriateness of potential new technologies or practices, evaluate the likelihood that they will be adopted, and if necessary modify them to suit farmers' needs better (Harris, and Lyon, 2006).

Though, research has identified high yielding and better quality forages adaptable to various agro-ecologies and production systems, improved forages are not yet adopted and developed by the farming community due to inadequate knowledge, poor extension service, and shortage of land and policy issues (Jimma *et al.*, 2016).

## 2.4 Promotion of Forage Legume Technologies

In the tropics adoption of legume-based technologies has, in general, been disappointing in spite of many success stories with tropical forage legumes worldwide. As Shelton *et al.*, (2005) analyzed the causes and include a number of issues that should be taken into account when planning R&D programs promoting the use of tropical forage legumes. A mostly important issue is the organization of efficient seed production systems. The lack of seed availability is often cited as a key reason for adoption failure and the resulting vicious circle (lack of robust demand, lack of interest of the private seed production sector, lack of seed production and availability, lack of adoption) needs to be broken.

Although promotional and educational activities, along with results from further research involving farmer participation, might be helpful, we expected that constraints imposed by the need for management skills and investments will remain, unless attractive economic incentives are offered to farmers (White *et al*., 2013). Such incentives should not be limited to legume-based technologies but should extend to all tropical forage technologies which provide environmental services. We suggest that schemes of payment for ecosystem services (PES) (Van Noordwijk and Leimona, 2010; Schultze-Kraft, 2018) applicable to both smallholders and large livestock producers, be explored, developed and implemented.

## 2.5 Categories of Forage Legume Technologies

There are three categories of forages: legumes, grasses, and multipurpose browses (fodder trees). These are grown in different amount and locations in the country. Forage legumes contribute to sustainable agricultural production by enhancing soil fertility, which in turn leads to increased crop production, and by improving the quality of animal feed, which appears to be one of the major constraints to livestock production in sub-Saharan Africa (Nnadi and Haque, 1986). The feed shortages and poor quality feed are the major constraints to increased livestock productivity in sub-Saharan Africa (SSA). This highly prevailed also in Ethiopia that holds the largest livestock population in Africa with livestock ownership currently supporting and sustaining the livelihoods of an estimated 80 percent of the rural poor (FAO, 2004). Therefore, adoption of high yielding and better quality forage varieties, and development of improved forage legume production systems are seriously important for improving livestock productivity. In addition, the use of improved forages would also reduce the pressure on natural pastures, improve soil fertility and erosion on marginal lands, improve carbon sequestration to mitigate climate change, support system sustainability, and enhance natural assets and system resilience (ILRI, 2009).

## 2.6 The Benefits of Forage Legume Technologies

The term improved forage legume technologies in this study refers to improved exotic forage crops. Inadequate quantity and poor quality of feed, therefore, is one of the major constraints to increase livestock productivity in mixed crop livestock systems (Ayele *et al.,* 2012). Natural pastures and crop residues, as the two most important feed resources, are unable to meet the nutrient requirements for milk production and reproduction. This has necessitated the growing and feeding of improved forages (Lenné and Wood, 2004).

Adoption of improved Forage legumes have the possibility to supply high quality and quantity of feed, to increase soil nitrogen, to accumulate an extra income to farmers, and to reduce soil erosion when they are intercropped with cereals; therefore intercropping legumes offer a ray of hope for small-scale, resource-poor farmers in developing countries.

Legumes are well-known to do numerous functions. Grain legumes provide food and feed and facilitate soil nutrient management. Herbaceous and tree legumes can restore soil fertility and prevent land degradation while improving crop and livestock productivity on a more sustainable basis. Thus the adoption of such dual-purpose legumes, which enhance agricultural productivity while conserving the natural resource base, may be helpful for achieving income and food security, and for reversing land degradation.

Tropical grasses were of lower quality than their temperate counterparts and introduction of adapted legumes into tropical grazing systems would simultaneously address the problem of low N status of leached tropical soils and low dietary protein intake by grazing ruminants. There is an emerging and significant role for legumes as a protein supplement to reduce reliance on expensive concentrates (Wambugu *et al.,* 2011) which often account for a high proportion of direct costs. The future of the tropical ruminant livestock sector seems assured with predictions of continuing strong demand for livestock products due to population increase (Kristjanson *et al.,* 2004), and to an increasingly prosperous middle class in developing countries. However, production systems will necessitate intensifying to meet demand for high quality products while remaining environmentally sustainable.

As production systems intensify, the lack of ability of farmers to adequately feed their livestock year round will be even more important. The outstanding value of legumes in general is needed to meet the dry season feed gap, with the additional benefit of increased intake of associated poor quality roughage (Shelton, 2004b). Tree legumes are multipurpose, and their superior rooting depth delivers excellent water use efficiency and drought tolerance (Shelton, 2004a).

Forages can have both direct and indirect effects in increasing resource and land use efficiency (Humphreys, 1994). Direct effects on crop production include weed suppression, pest and disease reduction (when used in rotation), whereas indirect effects include their use as green manures, improved fallows, cover crops and live fences. Production costs are decreased due to the reduced need for external inputs such as fertilizers and pesticides and there are environmental benefits from less contamination of crops and water with pesticide residues, conservation of fossil energy as well as soil improvement through nitrogen fixation.

## 2.7 Attempts on Forage Technologies in Ethiopia

Forage development for livestock has a long history in Ethiopia similar to other developing countries, due to inadequate feed availability and malnutrition in the country, animals' performance measured by birth weight, growth rate, milk yield, mortality rate, and reproductive performance are below the expected range and different animals in the country are not able to produce at their genetic potential (Shapiro *et al.*, 2015). To address this constraint and improve the production and productivity of animals, in so far as surplus research and development efforts have been exerted by national and international research institutes to generate and disseminate improved livestock feed and feeding system in the country. For example, in the 1950's at Jimma and moving on through activities at Haramaya University; the Swedish funded Chilalo Agricultural Development Unit (CADU) starting in the late 1960's (Duncan *et al.*, 2011). The forage and pasture seed production began in 1970 in Ethiopia by Arsi Rural Development Unit (ARDU/ CADU) (Alemu, 2012, Mengistu and Assefa, 2012).

It introduced annual forage legumes and perennial grass species, as well as pastures. Key species under production were oats, vetch, Rhodes grass, Phalaris, Panicum, Buffel grass, Elephant grass, Desmodium green leaf and Fodder beet. Production sites included Kulumsa, Dera, Bekoji and Assela livestock farms. ARDU's forage seed production efforts were sustained and were well received among farmers where they multiplied starter seeds of oats, vetch and fodder beet offered by the unit. Then through various projects such as Fourth Livestock Development Project (FLDP); Crop Diversification and Marketing Development (CDMD); and Feed Enhancement for Ethiopian Development (FEED); improved forage seeds were disseminated to smallholder farmers in different parts of the country (Tekalign, 2014). Moreover, the role of agricultural research institutes such as International Livestock Research Institute (ILRI), Kulumsa and Melkassa Agricultural Research Centers and others in testing the adapt-ability and nutritional contents of various exotic and indigenous forages crops for different agro-ecological zones was very significant. As a result different improved forages and fodder crops have been released for different ecological zones and considerable efforts have been made to disseminate this pasture and forage technologies to smallholder farmers.

## 2.8 Feed Traditions and Practices

Lacking supply of quality feed and the low productivity of the indigenous cattle breeds are the major factors limiting livestock productivity in Ethiopia. Feed, regularly based on fodder and grass, are either not accessible in adequate quantities due to variable weather conditions or when available are of poor nutritional quality. These constraints result in low milk and meat yields, high mortality of young stock, longer parturition intervals, and low animal weights (McIntire *et al*., 1992). Native pasture is the major source of feed for ruminants both in the area of mixed farming system and pastoralism, although it is neither quantitatively nor qualitatively adequate to support profitable animal production (Seyoum *et al.,* (2001). Improved nutrition through adoption of cultivated 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.

## 2.9 Pasture Improvement Strategies

Forages are the inexpensive source of livestock feed. Ruminant animals have the ability to convert forages into milk, meat, hides and skins and draught power needed by man for food and drawing income (Sandra, 2002). Grazing lands which were mainly important source of natural pasture are being declined due to diverse reasons such as high population pressure, land degradation and change of grazing lands into arable lands. As a result, crop residues have shown as the main components of livestock diet as their production is increased due to cropping intensification. But their nutritive value and digestibility is too low to support animals' additional productivity. Therefore, production of improved fodder using different strategies is mandatory to satisfy feed and nutrient demand of animals if better production and productivity is needed (Shimelis and Temesgen, 2016). The study of Alemayeu (2005) also indicated that in the past two decades, considerable efforts have been made to test the adaptability of pasture and forage crops to different agro ecological zones and several useful forages have been selected for different zones.

As pointed out by Shimelis and Temesgen (2016) different forage development strategies like backyard forage development, under sowing of cereal crop with forage legumes, forage development on stock exclusion area, forage development on conservation structures, and over sowing on existing grazing/pasture land are practicing in Ethiopia. The key forage production strategies are conservation based and promote the use of legumes as improved forage (Robertson, 1990; Alemayehu, 2013). The key strategies are divided into two categories:

1. On farm strategies

   Backyard forage production, under-sowing and inter-planting, contour forage strips, agro-forestry.

2. Common land strategies

   Over-sowing common grazing areas, stock exclusion areas/forage banks, permanent pastures.

Table 1. Key species for backyard forage establishment in different agro-ecologies of Ethiopia

| Altitude | Browse legumes | Forage legumes | Grasses |
| --- | --- | --- | --- |
| <2000m | Leucaena<br>Sesbania<br>Pigeon pea | Green leaf<br>Silver leaf<br>Alfalfa | Rhodes grass Elephant grass Panicum grass |
| 2000-2400m | Sesbania<br>Pigeon pea<br>Tree Lucerne | Alfalfa<br>Vetch<br>Veranostylo | Phalaris grass<br>Elephant grass |
| >2400m | Tree Lucerne | Alfalfa<br>Vetch | Phalaris grass<br>Oats |

Source: (Alemayehu *et al* 2017)

## 2.10 Feed production system of Kedida Gamela

As a result of land scarcity and crop-dominated farming there has been limited spontaneous beginning of improved pasture and forages. During the Fourth Livestock Development Project (FLDP), different strategies and species for pasture and forage development were selected (Tegegne *et al.*, 2013). Over the past four decades several forages have been tested in different agro-ecological zones, and considerable efforts have been made to test the adaptability of different species of pasture and forage crops under varying agro-ecological conditions.

However animal feeding systems in this country are mostly based on grazed native pastures, which are deteriorating in quantity and quality, which fluctuate seasonally resulting in poor animal performance. Inadequate livestock nutrition is a common problem in the developing world, and a major factor affecting the development of viable livestock industries in low income countries (Sere *et al.*, 2008). The study of Lemma *et al.*, (2016) show that the major feed resources available in Kedida Gamela district were natural pasture and crop residues with high fiber content and low digestibility which could decrease livestock productivity and disease resistance. The same author investigated that the annual feed dry matter production in the district could only satisfy 31.4 % of the DM requirement of livestock kept in the area; with very low crude protein and very high lignin contents, indicating the critical shortage of quality feed supply. Therefore this study was focued to analyze the factors affect adoption of improved forage legume technologies (vetch, alfalfa, dismodium, sesbania, Leucaena and pigeon pea). The general objective of the study was to identify factors affecting adoption of improved forage in mixed crop and livestock farming systems in the district.

## 2.11 Empirical Studies on factors affecting adoption of forage legume

Institutions and researchers both outside and inside Ethiopia have conducted empirical studies on the adoption and diffusion of agricultural innovations. Studies conducted in forage legume are very limited. Insufficient feed and nutrition are major constraints to livestock production in sub-Saharan Africa. National and international research agencies, including the International Livestock Research Institute (ILRI), have developed several feed production and utilization technologies. However, adoption of these technologies has so far been low. Detection of the major socioeconomic and policy factors influencing the adoption of improved forage technologies is required to help design policy and institutional interventions to improve adoption.

In general, the variables so far identified as having relationship with adoption are categorized as household, personal and demographic variables, household resource ownership and economic as well as institutional variables.

### Household Demographic characteristics

In this study the household demographic characteristics includes (sex, age, family size and education status of the household head). Thus the age of the sample household head had a positive and significant effect on probability of adoption of improved forages, as study of (Beshir, 2014) investigated. Though, knowledge gained through experience enables older farmers to adopt improved agricultural technologies. The study by Zekarias (2016) access to formal education, training and number of dairy cattle owned affected positively the household choice to take part in adoption of improved forages in the district; while access to communal land, access to market point and farmers training center negatively affected the probability.

The study results of Alemayehu *et al.,* (2018) show that family size of household head: this is a continuous variable which positively and significantly affects probability of adoption of improved forage technologies at 5% significant level. According to study results of Ayalew (2011) male farmers have better access to information on improved technologies and are more likely to adopt new technologies than female.

### Household Resource Ownership and economic variables

**Household Resource Ownership:** the household resource ownership in this study includes (grazing land size owned, labour and livestock owned (TLU). The study of Beshir (2013) reveals that the intensity of use of improved forage was influenced by labour available, size of livestock ownership and farm size. Study of Alemayehu (2018) also pointed out that the availability of adult family labor also had a significant influence on forage adoption.

Hence using a panel data set from the crop–livestock mixed systems of the Ethiopian highlands (Beshir2013) found that the resource endowment of households like farm size, livestock ownership and labour available had a positive and significant effect on the adoption of forage technologies, implying that improving the resource endowment of farmers would boost agricultural production. The study results of the same author comparison of adopters and Non- adopters of improved forage technologies revealed that adopters were slightly old, educated and slightly better off in terms of resource endowment (labour, land and livestock) than the Non-adopters. The study of Beshir (2014) also revealed that the resource endowment of households like farm size, livestock ownership and labour available had a positive and significant effect on the adoption of forage technologies, implying that improving the resource endowment of farmers would boost agricultural production. However in the highland and midland agro-ecologies land shortage was the major constraint to improved forages cultivation (Gebreegziabher and Tsegay, 2016).

According to the study of Menbere (2014) in the livestock production sub-system of the area and only about 34.1% (n=46) of the farmers possess private grazing land with a very small an average holding of 0.073±0.014 ha which are mostly located at backyard and farm land boundaries. In addition, the study of (Muluken *et al.*; 2018) reveal that there was the higher utilization of grazing land as the source of animal feed in the average usage of grazing in the studied sites were (73.5%).

The study of Salo *et al.,* (2017) identified major constraints for improved forage adoption in their study was a shortage of land (28.8%), shortage of forage seed (13.5%), lack of awareness and poor extension services. As study result of Alemayehu *et al.,* (2018), indicated that the probability of improved forage adoption was higher for farmers with small land size than that of large farm sizes. This implies that having larger land size provokes the farmers to use the locally available grasses and browses than the farmers that have smaller land size. As study of Wambugu *et al.;* (2011) shown that size of household, total land size and number of dairy cattle significantly affected adoption of forage/browse legume technologies. As a result, adoption of improved forage legume technologies is estimated to be negatively associated with large size of livestock ownership.

**Economic Variables:** the farm income is taken as economic variable in this study. Consequently the study results of Alemayehu (2018) show that farmers with higher cash income were more likely to adopt improved forages. Feed, usually based on fodder and grass, are either not available in sufficient quantities due to fluctuating weather conditions or when available are of poor nutritional quality. Thus these constraints result in low milk and meat yields, high mortality of young stock, longer parturition intervals, and low animal weights (McIntire *et al.*, 1992). Study of Lemma *et al.,* (2016) concluded that the major feed resources available in Kedida Gamela district were natural pasture and crop residues with high fiber content and low digestibility which could decrease livestock productivity and disease resistance.

Livestock is an integral part of the agricultural systems serving as the source of draught power for land preparation, of meat and milk, of income and savings (Muluken *et al.*; 2018). Thus it was observed by the study of (Hintsa, 2016) that supplementation of improved fodder crops particularly oat-vetch increase average daily Weight gain and milk production. Therefore as concluded by the same author, to improve the productivity of livestock and reduce feed shortage problems smallholder farmers should be encouraged to adopt cultivation of improved fodder crops at a wider scale.

In market-oriented dairy farming in Ethiopia and Kenya, feed costs determine the majority of the cost price of milk production (Negash, 2018.). Inadequate quantity and poor quality of feed, therefore, is one of the major constraints to increase livestock productivity in mixed crop–livestock systems (Ayele *et al.,* 2012). Though natural pastures and crop residues, as the two most important feed resources, are unable to meet the nutrient necessities for milk production and reproduction. This has necessitated the growing and feeding of improved forages (Thomas and Sumberg, 1995; Lenné and Wood, 2004). Using cultivated fodder such as forage legumes, multipurpose trees and dasho grass, by the small householders is considered as an indicator of adoption of feed technologies/interventions in this study. Being involved in off-farm activities will have better opportunity to generate income, and hence might have better financial capacity to grow improved forage legume. Techane *et al.,* (2006) has found that participation in off farm activities positively influences farmers' adoption decision. The studies of Etalemahu (2015) found that the major factors found influencing the adoption of the grass and forage technologies by studied households were mainly related to: economic conditions, size and availability of active labor, agro-ecology and farming experience of the household.

**Institutional Related factors**

The study includes institutional factors as (development agent's contact, access to credit service, distance to the nearest market). The study of Alemayehu *et al.,* (2018) investigated the positive influence of access to extension services on adoption by farmers indicates that policies which enhance the availability of extension services in rural areas will promote adoption of new technologies. The study of Elias *et al.,* (2016) put that farmers who make contact with development agents have better access to information on and have better possibility to change their intent into action.

The coefficient of distance between Farmers Training Center (FTC) and home of the household had the negative sign and significant effect on the probability of adoption of improved forages. Thus study result of Beshir (2013) investigated that characteristics like distance from farmers' home to all weather roads, markets and input supply played a critical role in the adoption of improved forage technologies. As well Fikre (2018) investigated that forage seed production still faced with many problems in the country. Those are lack of adequate forage seed research, reliable forage seed production, processing and distribution schemes, less involvement of privet seed producers, lack of information on the national demand for forage seeds, poorly developed seed marketing systems, and lack of financial incentives for seed prices.

Main constraints include policies of government seed centers, plant health regulatory agencies, and non-governmental organizations that distribute free seed (Wambugu *et al.;* 2011). Decentralized, commercial models provide greater potential than government or NGO-led models (Lillesø *et al.*, 2018). As fodder trees require relatively little land, labor or capital, they are a knowledge-intensive practice as farmers need to acquire new skills such as nursery establishment, tree pruning and seed collection. Promoting innovative approaches such as farmer to farmer extension, civil society campaigns and facilitative policies can help promote widespread adoption (Wambugu *et al.,* 2011). Studies by Beshir (2013) show that Physical characteristics like distance from farmers' home to all weather roads, markets and input supply institutions played a critical role in the adoption of improved forage technologies as proximity to information, sources of input supply and credit and markets save time and reduce transportation costs. These results imply that public interventions that are aimed at developing markets can contribute to the widespread adoption of forage technologies.

## 2.12. Conceptual Framework of the Study

Agricultural adoption and diffusion patterns often vary from location to location. In general, the variations in adoption patterns proceed from the presence of disparity in agro ecology, institutional and social factors (CIMMIYT, 1993). Moreover, farmers' adoption behavior, especially in low-income countries, is influenced by a complex set of socio-economic, demographic, technical, institutional and biophysical factors (Legesse, 2001).

Adoption rates were also noted to vary between different group of farmers due to differences in access to resources (land, labor, and capital), credit, and information as well as differences in farmers' perceptions of risks and profits associated with new technology (Tesfaye *et al*., 2001). The direction and degree of impact of adoption determinants are not uniform; the impact varies depending on type of and the conditions of areas where is to be introduced (Legesse, 2004). Practical experiences and observations of the reality have shown that, one factor may enhance adoption of one in one specific area for certain period of time while it may create hindrance for other locations Tesfaye *et al*., (2001). Because of these reasons, it is difficult to develop a one and unified adoption model in adoption process for all specific locations. Hence, the conceptual framework presented in Figure-1 shows the most important variables expected to influence the adoption of improved forage legume in the study area.

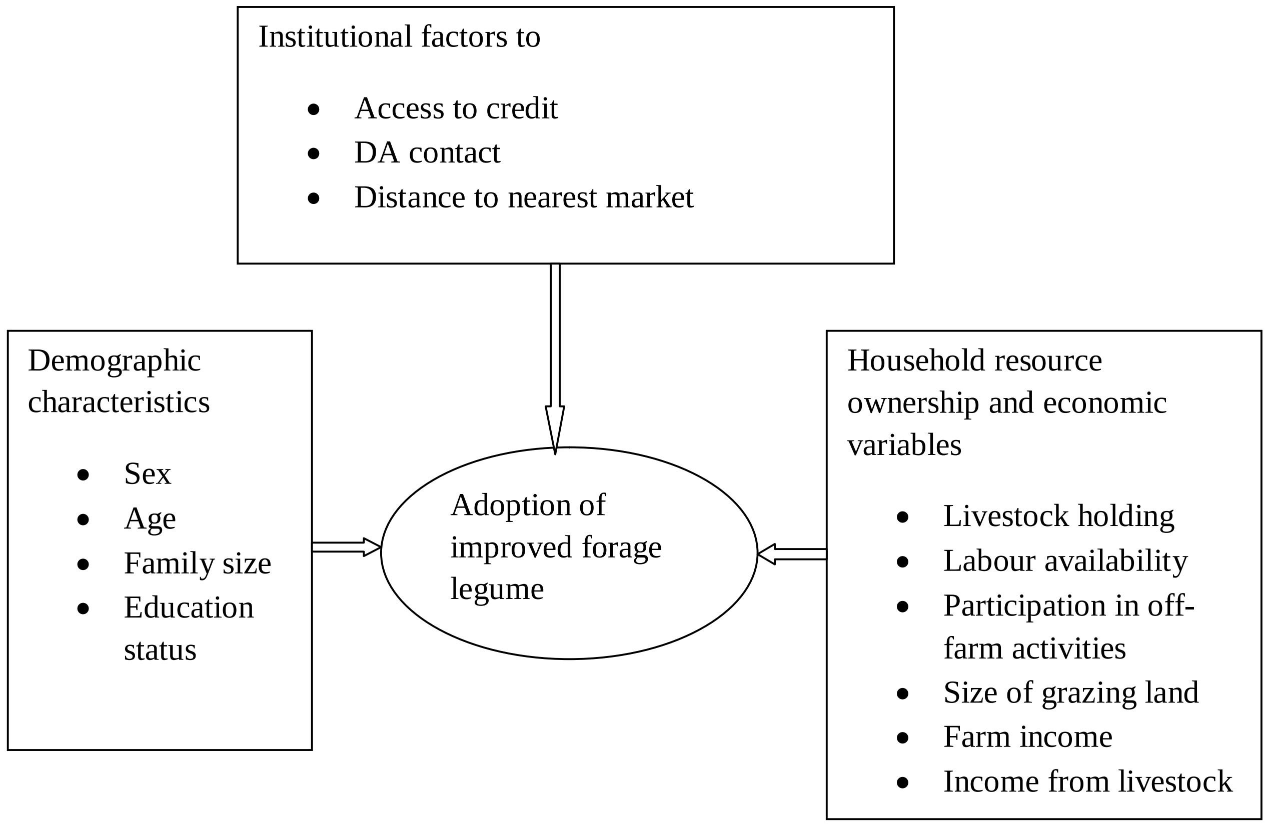


Figure 1 The conceptual framework for the study of determinants of improved forage legume adoption

Source: own, based on literature review.

# 3. RESEARCH METHODOLOGY

## 3.1. Description of the Study Area

### 3.1.1. Geographical location of the area

The study was conducted in Kedida Gamela district of Kambata Tembaro Administrative Zone (Figure 2), located from Addis Ababa 350 kms and 125 km from the regional capital Hawassa. Durame is the town of Kedida Gamela district and Kambata Tambaro Zone. Kedida Gamela is one of seven districts of Kambata Tembaro Administrative Zone in the SNNPR, and consists a total of 18 kebeles (17 farmers' administration and 1 developing municipality town).

The district is bordered on the east and south by an exclave of the Hadiya Zone, on the west by KachaBira, on the northwest by Angacha, on the north by Damboya, and on the northeast by the Bilate River which separates it from Alaba.

Kedida Gamela has 45 kilometers of all-weather roads and 17 kilometers of dry-weather roads, for an average road density of 199 kilometers per 1000 square kilometers. Kedida Gamelais located in southern and south western part of Ethiopia with latitude of 7' 12 " 0'' N to 7º 18'45"N / 37º51'0"E to 5'30"E occupying about 18,343.94 ha of land. The total human population of the district is estimated to be 70,762 from this, male and female accounts 35,081 and 35,681 respectively and the total number of households is estimated to be 14,554 from this, male and female accounts 12,914 and 1,644 respectively, the average family size is 5.8 as reported by (KDFEDO, 2016/17). The general elevation of the district ranges from 1700-3058 meter above sea level and its annual rain fall ranges from 1300-1800mm. The annual temperature of the district ranges from 21$^0$C- 23 $^0$C. The district consists of different types of land forms, including plains, plateaus, escarpments and lands with sharp slopes and deep valleys as well as mountains with long chains. The elevation of 93% of the district ranges from 1,801 to the highest peak of Hambaricho mountain, which is about 3,058 meters above sea level. The remaining 7% of the district is between 1,400 to 1,800 masl (KDFEDO, 2016/17).

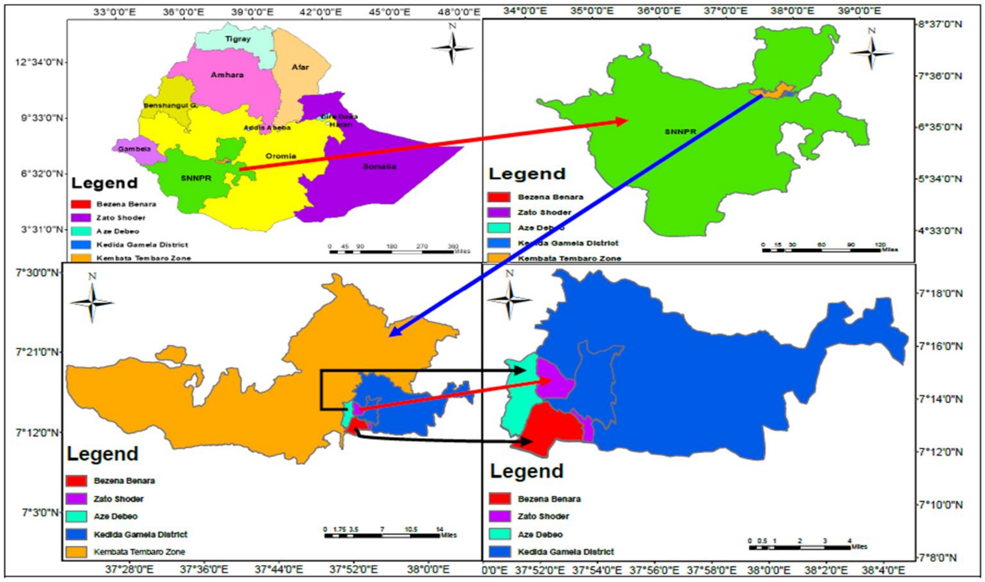


Figure 2 Map of the Study area (Source Kembata Tembaro Zone admnstrative office).

### 3.1.2 The agro-ecology of the area

According to Kedida Gamela District of Agriculture and Natural Resource Development Office report (KDANRDO, 2016/2017) the climatic condition of the district is characterized by three agro-climatic zones: Dega (wet highlands), Woinedega (moderately warm midlands), and Kolla (semi dry and relatively hot lowlands), that account for 21.82%, 72.73%, and 5.54% of the area respectively. The common agricultural practice of the district is mixed crop-Livestock production system. The major crops grown in the district are maize, sorghum, teff, wheat, barley; bean, potato, enset, coffee, root crops fruits and vegetables are common (KDANRDO, 2016/2017).

The vegetation cover other than crop varieties is scarce and includes natural forest remnants and human planted tree species such as Eucalyptus, Juniperus procera (yeabesha tid), Juniniperus spp (yeferenj tid), Grevillia robusta, Ficussur (Shola) Ficus Vasta (Worka), Acacia spp, Milletia ferruginea, Sesbania spp, Aningeria baphia, Podocarpus gracilus, Hyperthenia flipendula (in grassland), Papyrus typha (in swampy areas), and the endangered Ethiopian tree species of Cordia Africana, Olearabica (weyra) and Crotaonma crostachys (Bisana) to a lesser extent (KDANRDO, 2016/2017).

### 3.1.3. Livestock production system of the area

The farming systems of the district is mixed crop-livestock production system which is classified based on the crop commodities they produce and species of livestock they rear. According to KDLFRDO (2016/2017) the major livestock feed sources in the area are grazing pasture, straw of maize wheat and teff. Thus livestock production systems are generally characterized by low management in terms of nutrition, management, disease control, feeding system and the production system. The total livestock population in the district is estimated to be 67,163 cattle (25,959 and 41,204), 14207 Goat, 24,716 Sheep, 3742 Donkey, 610 Horse, 458 Mule, 87,153 Poultry and 4,624 bee hives are exists in the district (KDLFRDO, 2016/2017).

### 3.1.4. The crop production situation of the area

According to the information of KDFEDO (2016/17) it is estimated that 60% of the district is under the major cropping season, whereas 40% also has a minor cropping season. The district is mainly bimodal receiving relatively adequate amount of rainfall. The rainy months of the bimodal pattern extend from first week of March to last week of May, and the main rainfall months range from mid-June to the end of September, and sometimes extend to mid of October. The average annual minimum and maximum precipitation in the district ranges between 900 and 1400 mm, while the average daily temperature ranges from 7 to 25 degree centigrade. The mean annual temperature and rainfall of the district are 22 centigrade and 1100mm respectively KDFEDO (2016/17).

According to Agriculture and Natural Resource Development Office information, farmers are using extension services, and their livelihood is based on the cultivation of Enset, cereals, perennials like coffee, fruits and vegetables supplemented by varieties of legumes, root crops as well as livestock rearing on a small scale. The major crops grown in the district include (Table 2).

Table 2. Major crops (in the order of importance) and productivity estimates in the district.

| No | Types of crop | Productivity (Qt/ha) |
|---|---|---|
| 1 | Enset's yield (kocho, etc) | 134.93 |
| 2 | Maize (*Zea mays*) | 38 |
| 3 | Teff (*Eragrostis teff*) | 12 |
| 4 | Wheat (*Triticum aestivum*) | 43 |
| 5 | Barley ( *Horddeum vulgare* ) | 23 |
| 6 | Ginger (*Zingibereo fficinaleRosc*) | 144 |
| 7 | Faba bean (*vicia feba*) | 13.33 |
| 8 | Coffee (*Coffee arabica*) | 8 |
| 11 | Taro (*Colocasiae sculenta*) | 123 |
| 10 | Sorghum (*Sorghum bicolor*) | 16.06 |
| 11 | Haricot bean (*Phaseolus vulgaris*) | 10 |
| 12 | Potato (*Solanum tuberosum*) | 154 |
| 13 | Sweet potato (*Ipomoea batatas (L. Lam*) | 117 |
| 14 | Field pea (*pisum sativum L*) | 10.22 |
| 15 | Yam ( Dioscorea spp) | 148.42 |
| 16 | Kale | 175.50 |
| 17 | Pepper | 8.04 |
| 18 | Finger millet ( *Eleusine coracana*) | 16.88 |
| 19 | Onion /Shallot | 97.93 |
| 20 | Garlic (*Allium sativum*) | 77.40 |
| 21 | Linseed (*Linumu statissimum*) | 7.25 |
| 22 | Cabbage | 200.86 |
| 23 | Beetroot | 192.53 |
| 24 | Carrot | 151.19 |
| 25 | Tomato | 244 |
| 26 | Oats | 16.92 |
| 27 | Cassava | 101.50 |

Keys: Qt= quintal (1Qt=100kg or 0.1 tones) and ha = Hectares

Source: Kembata Tembaro Zone Agriculture and Natural Resource Development Office (Unpublished)

According to the Kedida Gamela district Agriculture and Natural Resource Development Office report (KDANRDO; 2016/2017), the total area of land in the district is 18,303.94 hectares and its land use pattern is as follows: crop land hectares (12032 annuals and 2,639.80 perennials), grazing land 967.5 hectares, land covered by forest and bushes 1398.5 hectares (natural 150, associations 300, private 948.5), degraded land that is not recommended for cultivation 750.14 hectares, and land that may cultivated in the future 515 hectares. As reports of (KDLFRDO, 2016/2017) show that grazing pasture, straw of maize, wheat and teff are the major livestock feed sources in Kedida Gamela. In the district, crop production is integrated with livestock farming and is the basis of the population. Improved forage legumes, including annual legumes such as Vetch; Perennial legumes such as Desmodium, alfafa (Lucern), Browse trees and shrubs such as Sesbania sesban, Leucaena (Leucaena leucocephala) and Pigeon pea (Cajanus cajan)., have been introduced in an effort to increase the amount and quality of available forage and have been promoted in the region by MoA (Table 3).

Table 3. Land use in the district

| | |
|---|---|
| Crop land | 14,671.8 |
| Annuals | 12,032.0 |
| Perennials | 2,639.8 |
| Grazing land | 967.5 |
| Forest & bushes | 1,398.5 |
| Natural | 150.0 |
| Associations | 300.0 |
| Private | 948.5 |
| Degraded land | 751.14 |
| Land potentially cultivable | 515.0 |
| Total | 18,303.94 |

KDANRDO (2016/2017)

According to the zone and district Administration Offices (2016/2017), Kedida Gamela is the second most densely populated district in the zone without including the city administration of Durame town.

### 3.2 Research design

A cross sectional survey design was used in this study. According to (Kothari, 2012), cross sectional design is considered as favorable because of its time effectiveness, minimizes biases and maximize reliability. Based on the specific objectives and the nature of the research questions of the study required, quantitative data were collected and appropriate analytic techniques were employed. The quantitative data were substantially supplemented by qualitative data in order to make the results sound. Quantitative data were collected, using interview schedule, with the aim of analyzing the substantial data and was made generalizations from the result.

## 3.3. Sampling methods

### 3.3.1. Sampling procedure

In this study two stage sampling procedure were employed to select representative sample size (Fig. 3). The first stage was purposive selection of improved forage legume producing Kebele*s* due to production potential in the district, followed by selection of sample households. The Kebele identification was made through reviewing secondary data on their production potential of the improved forage legume. Three potential improved forage legume growing Kebeles were purposively selected as a sample out of 17 kebeles of the district. Before selecting household heads to be included in the sample, the sampling frame of smallholder farmers household heads of each rural kebele were identified through reviewing secondary data in collaboration with kebele leaders and development agents of the respective rural kebele.

In the second stage, 186 household heads were selected from identified smallholder farmer households using systematic random sampling technique taking into account proportional to size (number) of smallholder farmer households in each of three selected rural kebeles. Selection of starting point from the farmers' list was made by using systematic random sampling technique. Then, respondents were selected by a fixed interval until the desired sample size was obtained. Thus, the survey was administered and data were collected and analyzed on 186 respondents.

Total household heads of sample kebele's

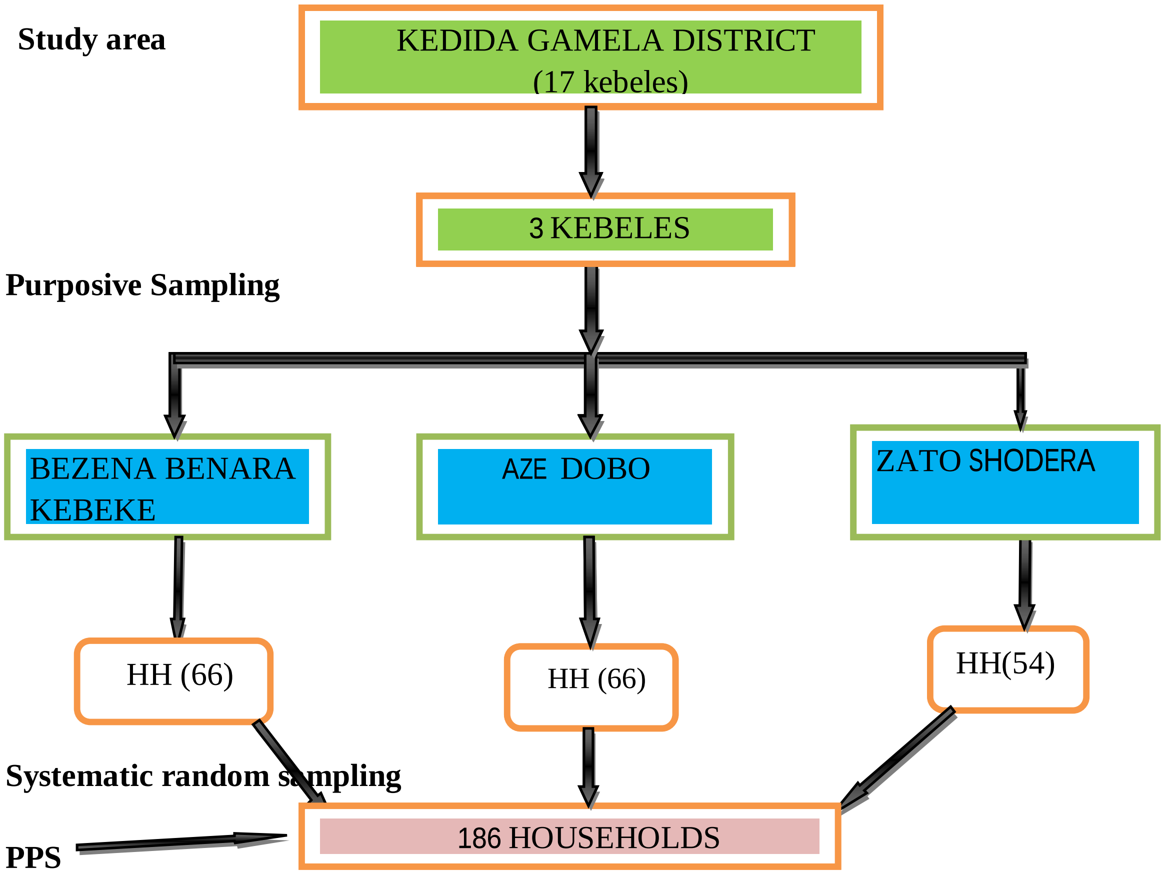


Figure 3 Sampling frame of the study (source own conceptualization)

### 3.3.2. Sample size determination

The sample size determination was computed by using Yamane (1967) sampling formula at 95% confidence interval, 0.07 level of precision. The level of precision was decided based on related studies approach. Hence, the formula is stated below.

$$n = \frac{N}{1+N(e)^2}$$ -----------------------------Yemane (1967) ----------------- (1)

$$n = \frac{2108}{1+2108(.07)^2} = 186$$

Where: n is the sample size, N is the population size (total household heads size), and $e$ is the level of precision. In general, total number of household heads size, the sample size from the kebeles and the proportion of sample size summarized in table 4.

Table 4. Sample size determination from selected kebeles

| Kebeles | Population (HH heads) | | | Sample size | | |
|---|---|---|---|---|---|---|
| | Male | Female | Total | Male | Female | Total |
| Bezena benara | 542 | 210 | 752 | 48 | 18 | 66 |
| Aze dobo | 543 | 204 | 747 | 48 | 18 | 66 |
| Zato shodera | 421 | 188 | 609 | 37 | 17 | 54 |
| Total | 1506 | 602 | 2108 | 133 | 53 | 186 |

(Source: own computation using kebele documents, 2019)

## 3.4. Data types and sources

Both quantitative and qualitative types of data were collected from primary and secondary sources.

### 3.4.1 Primary data sources

The primary data sources were 186 household heads were asked about adoption status of improved forage legumes; constraints and opportunities of improved forage legume production and factors affecting smallholder farmer's decision of improved forage legumes adoption and related issues. The qualitative primary data sources were elders and knowledgeable people about the area were asked on different issues relevant to the study.

### 3.4.2 Secondary data sources

Before thesis proposal planning secondary data were obtained from District's Agriculture and Natural Resource, Livestock and Fishery development, Finance and economy, Cooperative development office's relevant published and unpublished reports. The quantitative secondary data collected were number of kebeles in the district, total number of population, total number of household heads, total number of livestock, geographic location, agroecology, altitude, annual rain fall, annual temperature, land use, types of crops grown.

## 3.5 Methods of Data Collection

**Interview schedule of household survey:** based on the objectives of the study, the data were collected using questinnare with interview schedule (Appendices) through the household survey. Before data collection, the questinnare was translated in to Kembatissaa language, and pre-tested on 12 farmers but that are not included to the final sample households. Thus, appropriate modifications and corrections were made on the questionnaire and data with collecting under continuous supervisions of researcher. Primary data were collected by the researcher using household survey. The interview schedule include major variables assumed to have association with adoption of improved forage legume at household level such as household demographic characteristics; resource ownership and economic characteristics institutional factors.

**The focus group discussion:** to support the findings of survey data (mainly for the third specific objective); the focus group discussions was held one group in each kebeles **(**including ten members in each Bezena benara, Zato shodera and Aze dobo group**).** The composition of groups were farmers such as (lematbuden) developments group leaders, model and non-model farmers as well as respective kebeles' leaders were selected purposively in search of suitable information based on their specific characteristics such as age, farm experience and position. The discussions were formed on focus group in each kebele through taking notes. Key topics covered during the discussions include constraints and opportunities of improved forage legume adoption, input provision, the provision of agricultural extension service. Focus group discussions mainly employed to generate qualitative data that support the findings of survey based on predetermined checklists.

**Personal observation:** researcher's observation was made by taking notes through out the kebeles during the household survey to check what existed on the ground concerning improved forage legume production.

The data were collected by visiting each one of the sample households. Personal observation and focus group discussions were used as means of verifying the data collected from sample households. Besides, relevant secondary data were collected from concerned sectors in the district such as Agriculture and Natural Resource, Livestock and Fishery development, Finance and economy, Cooperative development office's relevant published and unpublished reports.

### 3.6. Methods of Data Analysis

Data collected through questionnaire was systematically coded. After accomplishing compiling, screening and cleaning the data in the questionnaire of 186 respondents were analyzed. Both descriptive and econometric methods were employed to analyze relationship between dependent and explanatory variables by using Statistical package for social Sciences (SPSS, version 20).

### 3.6.1. Descriptive analysis

The descriptive analysis statistics mainly used to describe distribution of variables and provides brief profiles. Descriptive statistics such as frequency, mean, standard deviation, and range were used and inferential statistics used to examine data for differences, associations and relationships to answer hypothesis. Inferential statistics such as chi- square $(\chi 2)$ and t-tests were used. Also Qualitative analysis was used to compare socio-economic, demographic and characteristics of respondents.

### 3.6.2. Econometric analysis

The econometric model was applied to analyze determinants of improved forage legume adoption. In the case of logit and probit, the estimated probabilities lay between logical limit 0 and 1 and they are the most frequently used models when the dependent variable happens to be dichotomous as well as the choice between these two models revolves around practical concerns such as the availability and flexibility of computer program, personal preference, experience and other facilities. In fact, it represents a close approximation to the cumulative normal distribution (Gujarati, 2015).

Crowder (2017) pointed out that a logistic distribution has got advantageous than others in the analyzes of dichotomous outcome variable. There are two primary reasons for choosing the logistic distribution. These are: (a) from a mathematical point of view, it is an extremely flexible and easily used function, and (b) it tends itself to a logically meaningful interpretation also state that, the logit model is simpler in estimation than the probit model. After reviewing the strength, drawbacks and assumptions of different models, the binary logistic regression model was employed to address the core objective of the study i.e. to analyze determinants of improved forage legume adoption.

The dependent variable in this case is a dichotomous variable, which takes a value of 1 if household adopt, otherwise 0. Demographic, household resource ownership and economic characteristics; as well as institutional factors that are assumed to be correlated with adoption of improved forage legume are come into along these classifications.

Model, which contain a ‘’yes’’ or ‘’no’’ type dependent variable, are called dichotomous or dummy variable regression model. Such models approximate the mathematical relationship between explanatory variables and the dependent variable that is always assigned qualitative response variables (Gujarati, 2015; Crowder, 2017). The four most commonly used approaches to estimate dummy dependent variable regression models are (a) the linear probability model (LPM), (b) the logit, (c) the probit and (d) the Tobit model. They are applicable in a wide variety of fields (Gujarati, 2015).

The most important point that distinguishes these functions from the linear regression model is that the outcome variable in these functions is binary or dichotomous. Besides, the difference between logistic and linear regression is reflected both in the choice of a parametric model and in the assumptions.

The probability model, which expresses the dichotomous dependent variable ($Y_i$) as a linear function of the explanatory variables ($X_i$), is called linear probability model (LPM). Due to econometric shortcomings like non normality of the disturbances($U_i$), heteroscedastic variances of the disturbances, non-fulfillment of $0 < E(Y_i/X_i) < 1$ and lower value of $R^2$, as a measure of goodness of fit, linear probability model (LPM) failed to test the statistical significance of estimated coefficients.

P(x) =E(Y=f/x) =------------------------------------------------------------------------------ 1

$P(x) = E(y = 1/x) = \frac{1}{1+e-(B0+BiXi)}$ ------------------------------------------------------------ (1)

For ease of explanation, we write (1) as:-

$P(x) = \frac{1}{1+e^{-zi}}$ ------------------------------------------------------------------------------------ (2)

Where P(x) = is a probability of being adopter ranges from 0 to 1

$Z_i$ = is a function of n-explanatory variables (x) which is also expressed as:

$Z_i = B_o + B_1X_1 + B_2X_2 +$ ------------------------------------------------------------------ $+ B_nX_n$

$ADPTIFL = \beta 0 + \beta_1 AGE + \beta_2 SEX + \beta_3 FAMSZ + \beta_4 EDUC + \beta_5 HHLOBR + \beta_6 GLANDSZ + \beta_7 LOWND + \beta_8 FARMINC + \beta_9 LVSTKINC + \beta_{10} PARTOFFA + \beta_{11} ACCCRS + \beta_{12} EAC + \beta_{13} DSNMC$

Where,

$X_1$=Age of household head

$X_2$ = Sex of household head

$X_3$ = Family size

$X_4$ = Education status of household head

$X_5$ =Household labour size in ME

$X_6$ = Grazing land of HH in ha

$X_7$ = Livestock owned (TLU)

$X_8$= Farm income

$X_9$ = Livestock income

$X_{10}$ Participation in off-farm activities

$X_{11}$= Access to credit services,

$X_{12}$= Contact with development agents

$X_{13}$= Distance from near market center

$B_o$ = intercept

$B_1$, $B_2$......................................... $B_n$ = are slopes of the equation in the model

The probability that a given household adopter is expressed by (2) while, the probability of not adopt is:-

$$1- P(x) = \frac{1}{1 + e^{zi}} \quad \text{-----} (3)$$

Therefore we can write:-

$$\frac{P(x)}{1-P(x)} = \frac{1+ e^{zi}}{1+ e^{-zi}} = e^{zi} \quad \text{-----} (4)$$

Now P(x) / (1- P(x)) is simply the odds ratio in favor of adoption. It is the ratio of the probability that a household adopt to the probability that do not adopt. Finally, taking the natural log of equation (4) we obtain-

$$L_i = \ln \left[\frac{P(x)}{1-P(x)}\right] = Z_i \quad \text{-----} (5)$$

$Z_i = B_o + B_1X_1 + B_2X_2 + \text{--------------------------------------------------------------------} + B_nX_n$

If the disturbance term, ($U_i$) is introduced the logit model becomes

$Z_i = B_o + B_1 X_1 + B_2 X_2 + ........ + B_nX_n + U_i$---------------------------------------------------------------------- (6)

$L_i$ = log of the odds ratio, which is not only linear in $X_i$ but also linear in the parameters.

$X_i$ = Vector of relevant explanatory variables

Changing an independent variable in this case, is expected to alter the probability that a given individual becomes adopter, and this helps to predict the probability of adoption.

#### 3.6.2.1. The estimation procedure

The model selected for analysis is the binary logit model; the dependent variable is assigned by value of 1 or 0, representing adopter or Non-adopter, respectively. Estimated the values of $B_0$ and $B_i$'s, a set of data was fitted into equation 6. Since the method of OLS does not make any assumption about the probabilistic nature of the disturbance term ($U_i$), the parameters of the model are estimated using the maximum likelihood (ML) method (Gujarati, 2015). Before estimating the logit model, existence of multicollinearity among the continuous variables is checked and the association among discrete variables is also verified by checking covariance. Existence of multicollinearity seriously affects the parameter estimates. In short, the coefficients of the interaction of the variables indicate whether one of the two associated variables should be eliminated from model analysis (Kothari, 2012).

Accordingly, Variance Inflation Factors (VIF) technique was employed to distinguish the problem of multicollinearity for continuous explanatory variables (Gujarati, 2015). Each selected continuous variable is regressed on the other continuous explanatory variables and an evaluation was made on the coefficient of determination ($R^2_j$). If an approximate linear relationship exists among the explanatory variables, then this results in a 'large' value for $R^2_j$ in at least one of the test regressions. A popular measure of multicollinearity is VIF defined as:

$$VIF(X_j) = \frac{1}{1-Rj^2} \quad \text{...........................................................} \quad (7)$$

A rise in the value of $R^2_j$ that is an increase in the degree of collinearity does indeed lead to an increase in the variances and standard errors. A VIF value greater than or equal to 10 is used as a signal for the strong collinearity. In the same way it is necessary to test whether there is or not interaction between discrete variables that can lead to problem of association among each other using coefficients of contingency. If the value of CC greater than or equal to 0.75 it is used as signal for the existence of strong association among the discrete variables (Gujarati, 2015).

$$CC = \sqrt{\frac{\chi^2}{n+\chi^2}} \qquad (8)$$

Where CC is coefficient of contingence, $\chi^2$ is the chi-square test and n is total sample size.

## 3.7. Definition of Variables and working hypothesis

### 3.7.1. The dependent variable of the model

In this study, adoption of Improved forage legume by smallholder farmers' is treated as a dichotomous dependent variable which is thought to be affected by explanatory variables include household's demographic variables, household's resource ownership and economic as well as institutional variables. Adoption"(**ADPTIFL**)**"**which is dependent variable for the binary logit analysis as dichotomous variable and represented by 1 for adopter and 0 for non-adopter household heads. Improved forage legume Adoption (referring to the dependent variable) is defined as a binary variable with a value of 1 for those farmers who have adopted at least one improved forage legume (vetch, alfalfa. dismodium, sesbania sesban, pigeon pea and leucaena). Non-adopters are farmers who did not developed and use either of this technology.

### 3.7.2.The independent variables of the model

Following the logical procedure clearly delineated, the potential explanatory variables are identified that affect smallholder farmers adoption of improved forage legume. The independent variables of the study are variables that expected to affect farmers' adoption of improved forage legume and can be many types. An explanation of the thirteen potential hypothesized explanatory variables is presented & summarized in as following. Consequently, review of literature, past research findings, and expert's opinions are used to identify the potential affecting factors of adoption of improved forage legume in the study area. Thus, taking adoption as dependent variable, the following explanatory variables are identified and their influence in adoption of smallholder farmers was examined.

**Age of the rural farm household head (AGE):** It is a continuous variable, defined as the farm household heads age and measured as the number of years from the date of birth up to the day of the survey interview. When farmers' age increases they will be ready to apply new technologies. The age of the sample household head had a positive and significant effect on probability of adoption of improved forages, as study of (Beshir, 2014) investigated. In contrast study of Elias *et al*., (2013) indicated that, older farmers are often viewed as less flexible, and less willing to engage in a new or innovative activity due to fear of risk whereas young farmers may be more risk averse to implement new technologies on their farm. Though, knowledge gained through experience enables older farmers to adopt or less flexible and less willing to improve agricultural technologies. Hence, in this study it is hypothesized that when household head's age increases it affects adoption of improved forage legume positively and negatively.

**Sex of the household head (SEX):** This is a dummy variable that assumes a value of “1” if the head of the household is male and “0” otherwise. Sex is biological difference of being male or female of respondents. With this background male headed households have better probability of mobility, participate in different meetings and have more exposure to information about better adoption; According to study of Ayalew (2011) male farmers have better access to information on improved technologies and are more likely to adopt new technologies than female. Then, it is hypothesized that male headed households have more chance to adopt improved forage legume and it influence positively and significantly.

**Family size (Famsz):** Family size is a continuous variable and it refers to the total number of household members who lived with household head at least for six months. Family size is the major source of labour for farm activities. The study results of Alemayehu *et al.,* (2018) shows that family size of household head is a continuous variable which positively and significantly affects probability of adoption of improved forage technologies at 5% significant level. Therefore, it is expected that a larger active work force positively affect the decision of adopting forage legume technologies.

**Education status of house hold head (EDUC):** it is a categorical variable and refers to education status of household attended or none (not attended) formal education. It is often assumed that educated farmers are better able to process information and search for appropriate technologies to alleviate their production constraints. As studied by Zekarias (2016) access to formal education affected positively the household choice to take part in adoption of improved forages in the district. In this study, this variable is expected to have positive relationship with improved forage legume adoption.

**Household lobour availability in AE (HHLOBR):** It is a continuous variable and measured by number of members under control of one HH head in adult equivalent ratio. Production of improved forage legume is laborious so, that availability of labour can ease the production activities in house hold. According to Alemayehu (2018) study as pointed out that the availability of adult family labor also had a significant influence on forage adoption. Hence, in this study availability of labour is hypothesized that affect the adoption of small holder farmers' in improved forage legume positively and significantly.

**Grazing land size in hectares (GLANDSZ):** It is a continuous variable measured in number of hectares by the household and which are mostly located at backyard and farm land boundaries. Grazing Land is a portion of total land of household and is one of the key productive resources for the smallholder farmers for supply of livestock feed. Owning larger area of grazing land can be a means of accumulating wealth and source of animal feed. Households who have better grazing land size have better capacity to adopt improved forage legume. According to the study of Menbere (2014) in the livestock production sub-system of the area and only about 34.1% (n=46) of the farmers possess private grazing land with a very small an average holding of 0.073±0.014 ha which are mostly located at backyard and farm land boundaries. The result of Mapiye *et al.* (2006a) recorded full adoption of forages in households with large pieces of land (≥100 ha) and partial adoption by households with smaller pieces of land (≤5.93 ha) in Zimbabwe.

**Livestock owned (TLU):** It is a continuous variable and refers to the total TLU that the household owns. Livestock are good sources of cash to be used for purchasing agricultural inputs and hence it is expected to positively affect adoption of improved technologies. As study of Wambugu (2011) shown that the number of dairy cattle significantly affected adoption of forage/browse legume technologies. Thus, it is hypothesized that adoption of improved forage legume technologies is expected to be positively associated with large size of livestock ownership.

**Farm income (**FARMINC**):** It is continuous variable measured in amount of money the household earns annually from sale of crop produce in ET Br. When increase in farm income enable to get money and enhancing other production input purchasing power. According to Alemayehu (2018) studies farmers with higher cash income were more likely to adopt improved forages. In this study it is hypothesized better farm income influence smallholder farmers' adoption of improved forage legume positively and significantly.

**Livestock income (LVSTKINC):** It is continuous variable measured in amount of money the household earns annually from sale of livestock in ET Br. When increase in productivity of livestock enable to get money and enhancing improved purchasing power. According to Alemayehu (2018) studies farmers with higher cash income were more likely to adopt improved forages. Thus livestock is an integral part of the agricultural systems serving as the source of draught power for land preparation, of meat and milk, of income and savings (Muluken *et al.*; 2018). In this study it is hypothesized better income from livestock influence smallholder farmers' adoption of improved forage legume positively and significantly.

**Participation in off-farm activities (**PARTOFFA)**:** It is a dummy variable that takes a value of 1 if the farm household members participate in off-farm activities and 0 otherwise. Farmers who are involved in off-farm activities will have better opportunity to generate income, and hence might have better financial capacity to grow improved forage legume. Techane *et al.*, (2006) has found that participation in off farm activities positively influences farmers' adoption decision. Therefore, it is hypothesized that this variable affects adoption of improved forage legume positively.

**Access to credit services (ACCCRS):** It is a dummy variable taking a value of one when the household has access to credit and zero otherwise. Credit is an important instrument to solve liquidity problem that farm households are facing. Households who are involved in credit; they can purchase agricultural inputs. New agricultural technologies require a significant capital investment. Smallholder farmers may not have adequate financial capital to invest in agricultural technologies. As shown by the study results of Hailemariam *et al.,* (2012) the importance of the value of assets and the availability of credit in influencing the purchase of inputs (improved seed and fertilizer) calls for improving credit delivery systems. In Ethiopia less than 14% of the rural population has access to credit (Agrifin, 2012). Therefore, it is expected that farmers who have better access to credit to be more likely to adopt forage legume technologies.

**Extension agent contact** (**FRQEAC):** It is a categorical variable which assumes a value of one when the household has contact with extension agent and zero otherwise. Contact is one type of sharing knowledge and experience with development agents. According to Elias *et al.,* (2016), farmers who make contact with development agents have better access to information on and have better possibility to change their intent into action. In this study it is hypothesized contact with development agents have positive and significant influence on smallholder farmers' adoption of improved forage legume.

**Distance to a nearest market center (DSNMC):** It is continuous variable which can be measured in walking distance (kilometers) takes from their home to reach near market (time spent to arrive nerarest market center is converted to kilometer per hour). The closer they are to the nearest market, the more likely to have update market information and enabled to adopt improved and intensive farming activities. Studies of Beshir (2013) Physical characteristics like distance from farmers' home to all weather roads, markets and input supply institutions played a critical role in the adoption of improved forage technologies as proximity to information, sources of input supply and credit and markets save time and reduce transportation costs. These results imply that public interventions that are aimed at developing markets can contribute to the widespread adoption of forage technologies. So, in this study it is hypothesized that distance from near market to their home is expected to influence adoption of improved forage legume negatively and significantly.

Table 5. Definitions and measurements of variables used in the logistic regression model

| Definition of variables | Nature and units of measurement of variables | Expected Sign |
|---|---|---|
| Dependent variables | | |
| Adoption of improved forage legume | Dummy (yes/no) | 1 or 0 |
| Independent variables | | |
| Sex of the household head | Male/female | + or - |
| Age of the household head | Years | + |
| Family size | Number of families in the HH | + |
| Education status of the household head | Attended/None | + |
| Household labour availability | Number (productive in AE) | + |
| Grazing land size | In ha | + |
| Livestock ownership | TLU | + |
| Farm income | ET Birr | + |
| Livestock income | ET Birr | + |
| Participation in off-farm activities | Yes/no | + |
| Access to credit service | Yes/no | + |
| Contact with development agents | Yes/no | + |
| Distance from near market center | In Kilometers | - |

# 4. RESULTS AND DISCUSSIONS

This chapter is dedicated to result and discussion part of the study. Descriptive and econometric analysis were summarized and discussed under different subheadings to understand the existing relation of farm household's characteristics with respect to the determinants of improved forage legume adoption. In this section descriptive statistics for characteristics of respondents and three specific objectives were included. In doing so, the influence of different demographic, economic, and institutional factors on adoption of improved forage legume was discussed consecutively.

The description was made using mean, minimum as well as maximum values, percentage and standard deviations. Binary Logit model was used to determine the relative influence of various explanatory variables on the dependent variable. In addition, mean difference for continuous and discrete variables were tested using t-test and chi-square test respectively.

## 4.1. Characteristics of the respondents

Out of 186 respondents, 69.3% were male and the rest 30.7% were female. Out of the total sampled household 70.4% are married, 3.8% divorced , 25.3% widowed and (0.5% is single. Age range of respondents varies between 26 and 95. Majority of the farmers 90.3% were found in the age category of 18 - 60 years. 9.7 % were over 60 years old. From the total of respondents 27.4% of farmers have grown improved forage legumes such as sesbania, dismodium, alfalfa, vetch, leuceana and pigeon pea on their plot of land. Others have grown grass types.

### 4.1.1 Demographic variables of sampled households

#### 4.1.1.1 Age

Age is one of the demographic factors that is useful to describe households and provide clue about the age structure of the sample and the population. The role of age in explaining technology adoption is somewhat controversial. It is usually considered in adoption studies with the assumption that older people have more farming experience that helps them to adopt new technologies. On other side, because of risk averting nature older age farmers are more conservative than the youngest one to adopt new technology for example, (Elias *et al*., 2013).

The mean age of the sample farmers was 45.95 with standard deviation of 11.14 and the range varies between 26 and 95.The mean age of adopters and Non-adopters were found to be 46.19 and 45.80 years respectively (Table 6). The mean age difference of adopters and Non-adopters sample household head was 0.396. Though, the mean age of adopters in this study reveals that knowledge gained through experience enables older farmers to adopt or less flexible and less willing to improved agricultural technologies.

Table 6. Age distribution by adoption of improved forage legume, Kedida Gamela District, Kembata Tembaro Zone, Ethiopia.

| Age of the Household head | Household heads | | Total | t- value |
|---|---|---|---|---|
| | Adopter N=51 | Non-Adopter N=135 | N=186 | |
| Minimum | 30.00 | 26.00 | 26 | |
| Maximum | 75.00 | 95.00 | 95 | |
| Mean | 46.1961 | 45.8000 | 45.95 | -0.215 |
| Std.Deviation | 10.82039 | 11.36031 | 11.14 | |

(Source: own survey data)

#### 4.1.1.2 Sex

Out of 186 respondents, 69.3% were male and the rest 30.7% were female (Table 7). Out of all adopters, 40 (78.4 %) of sample households were found to be male adopters of improved forage legume and 11(21.6%) were female Adopter of improved forage legume. While 89 (65.9%) of sample households were found to be male Non-adopters and 46 (34.1%) were female Non- adopter of improved forage legume. The majority of female were found in Non-adopters which indicates that they lack information in adopting improved forage legume as compared to their male household counterparts. It implies that males are movable than females and have high chance to get information to adopt improved forage legume. This clearly shows the existing gap among male headed and female headed households in terms of participation on improved forage legume adoption. Regarding its association with adoption of improved forage legume, correlation test using Pearson chi-square indicated that sex of the household head had significant relationship ($\chi^2$=2.724) with adoption of improved forage legume ($p<0.1$) significance level. In addition, during focus group discussions with Zato shodera group participants it was found that only one female has grown sesbania and explained its importace for milk production. But in the rest two groups (Bezena benara and

Aze dobo) females have not involved in growing improved forage legume due to lack of information.

Table 7. Distribution of sampled household heads by sex; Kedida Gamela District, Kembata Tembaro Zone, Ethiopia.

| Sex | HH Interviewed | | | $\chi^2$ value |
|---|---|---|---|---|
| | Adopter | Non-Adopter | Total | |
| Male | 40 (78.4%) | 89 (65.9%) | 129 (69.3%) | |
| Female | 11 (21.6%) | 46 (34.1%) | 57(30.7%) | |
| Total | 51 (100%) | 135 (100%) | 186 (100%) | 2.724* |

**Significant at less than 10%, own survey2018/19)*

This is in line with the study of Ayalew (2011) which indicated that male farmers have better access to information on improved technologies and are more likely to adopt new technologies than female and extension services which contribute for lower adoption of technologies in general.

**4.1.1.3 Family size**

The mean family size of the sampled farmers, in this study was found to be 5.54 persons, which is higher than the national average of 4.8 persons (CSA, 2016/17). The mean of family size for adopters and Non-adopters of improved forage legume was 5.96 and 5.38 with standard deviation of 1.85 and 1.90 respectively. The family size of households ranged between 1 and 10 persons with standard deviation of 1.9 adopter households have high labor force to grow improved forage legume than Non-adopter household . This result is allied with the results of Alemayehu *et al*., (2018) which shows that family size of household head is positively and significantly affected probability of adoption of improved forage technologies at p< 0.1 significant level.

Table 8. Distribution of sample households by family size

| Family size | Adopters (N= 51) | Non adopters (N= 135) | Total=(186 ) | t-value |
|---|---|---|---|---|
| Mean | 5. 96 | 5.38 | 5.53 | |
| SD | 1.85 | 1.90 | 1.9 | |
| Minimum | | 1 | 0.00 | -1.855 |
| Maximum | | 10 | 10 | |

#### 4.1.1.4 Educational status of sample households

Adoption of a given technology is a behavioral change process, which is the result of a decision to apply that particular innovation. Farmers need enough information about the technology to make the right decision. Education enhances the capacity of individuals to obtain, process, and utilize information disseminated by different sources.

Table 9. Distribution of households by education status

| Education status | Sampled household heads | | | | | | $\chi^2$ value |
|---|---|---|---|---|---|---|---|
| | Adopter | % | Non adopter | % | Total | % | |
| None | 15 | 29.4 | 57 | 42.2 | 72 | 38.7 | |
| Attended formal education | 36 | 70.6 | 78 | 57.8 | 114 | 61.3 | |
| Total | 51 | 100 | 135 | 100 | 186 | 100 | 3.422* |

** Significant at less than 10% Significant level.*

The result showed that from total adopters 70.6% were attended formal education, 29.4% were none (not attended formal education) while from total Non-adopters 57.8% were attended formal education, 42.2% none (not attended formal education). This illustrates its role in adoption of improved forage legume. The chi square test showed that the education status of the household is significantly affected adoption of improved forage legume. The implication is that adopters of improved forage legume are influenced by their education status, implying that those who have attended formal education can get information easily than none (not attended formal education). This result is in line with Zekarias (2016) as assumed access to formal education positively affected the household choice to take part in adoption of improved forages in Sodo Zuria District.

### 4.1.2 Household economic factors

#### 4.1.2.1 Grazing land size

The study results showed that livestock forage is the feed produced by sampled households in the study area. Of the total sampled households, 99.96% possess a piece of land for grazing while only 0.04% have not possess land for grazing. The analysis showed that the mean area of grazing is 0.2584 & 0.2053 for adopters and Non-adopters with a standard deviation of 0.2403 & 0.1563 respectively (Table 10**).** This result showed that the grazing land size of adopters of improved forage legume is higher than that of Non-adopters implying that it provides chance to grow improved forage legume, it is in line with study results of Menbere (2014) in the livestock production sub-system of the area and only about 34.1% (n=46) of the farmers possess private grazing land with a very small an average holding of 0.073±0.014 ha which are mostly located at backyard and farm land boundaries and the result of Mapiye *et al.* (2006a) recorded full adoption of forages in households with large pieces of land (≥100 ha) and partial adoption by households with smaller pieces of land (≤5.93 ha) in Zimbabwe. The three focus group participants also confirmed that those who possess relatively more land have got opportunity to grow improved forage legume in their land. As shown on Table 10, the result of the t-test revealed that the mean difference is significant at less than 10% significant level (t= -1.765, p=0.075).

Table 10. Area for Grazing land in hectare; Kedida Gamela District, Kembata Tembaro Zone, Ethiopia.

| Grazing land size in hectare | Adopter =(51) | Non Adopter=(135) | Total=186 ) | t- value |
|---|---|---|---|---|
| Minimum | 0.01 | 0.00 | 0.00 | |
| Maximum | 1.21 | 0.63 | 1.21 | -1.765* |
| Mean | 0.258 | 0.2053 | 0.219 | |
| Std.deviation | 0.2403 | 0.1563 | 0.184 | |

** Significant at less than 10% Significant level.*

**4.1.2.2 Total livestock holding**

In rural situation, livestock holding is an important indicator of household's wealth position. Livestock is an important source of income. In the study area, farmers undertake mixed farming where livestock rearing is one of the important activities. As it confirmed in many studies farmers who have better livestock ownership status are likely to adopt improved agricultural technologies like improved forage legume; because, livestock can provide cash through sales of products which enables farmers to purchase different agricultural inputs. To indicate the livestock holding of each household in terms of total livestock unit (TLU), the TLU per household was calculated.

The result of the survey indicated that livestock holding of the sample ranges from 0.04 to 6.2

TLU implying the existence of variation among the households in livestock ownership. The mean livestock holding of the sample population was 2.09 TLU with standard deviation of 1.14 (Table 11). Accordingly, the mean livestock size owned by adopters and Non-adopters of improved forage legume which is measured using TLU was 2.52 and 1.92 respectively indicating that improved forage legume adopters have relatively large livestock size than Non-adopters. This may be due to the fact that as farmers own large livestock population, they need to have feed available at their vicinity to provide their livestock population with feeding. The result showed that the mean difference of the total livestock owned (TLU) of adopters and Non-adopters was 0.614. This is found significant at (at t= -3.345, P<0.01). This clearly showed the significant role of livestock holding in adoption of improved forage legume. Similarly, the three focus group participants pointed out that among the group participants those who have relatively large number of livestock grown improved forages on their piece of land.

Regarding relationship of livestock holding with adoption of agricultural technology in general and improved forage legume in particular, many studies reported similar results. It is similar with the result of Wambugu (2011) which shown that the number of dairy cattle significantly affected adoption of forage/browse legume technologies.

Table 11. Total tropical livestock holding (TLU) in adoption of improved forage legume

| Adoption category | No | Total livestock holding (TLU) | | | | t-value |
|---|---|---|---|---|---|---|
| | | Min. | Max. | Mean | Std. Deviation | |
| Adopters | 51 | 0.75 | 5.76 | 2.5326 | 1.16503 | |
| Non adopters | 135 | 0.04 | 6.20 | 1.9187 | 1.09785 | |
| Mean | 186 | 0.04 | 6.20 | 2.09 | 1.1468 | -3.345*** |

**** Significant at less than 1% Significant level.*

**4.1.2.3 Labor availability among sampled households**

The relative importance of high labor required for the production practices of livestock feed, land preparation, planting, weeding shows its essential importance in improved forage legume. The mean available labor in adult equivalent was 3.50 the maximum and minimum being 8.6 and 0.8 respectively (Table 15**)**. The result indicate that improved forage legume adopter farmers have relatively larger labor units in adult equivalent (3.78) when compared with non-adopter sample households (3.39) signifying its central component for adoption of improved forage legume. This leads to the conclusion that to undertake improved forage legume practice households need to have sufficient labor availability. However the result of the t - test revealed that the mean difference is not at significant level. As revealed by participants of focus group discussion from each group, the higher the labour force occur in their home the more they grow forage on their piece of land.

#### 4.1.2.4 Income from livestock

The livestock resource possession was found to be vital in adoption of improved forage legume. The mean annual income from livestock of the sample households was 3421.82 Ethiopian birr. Adopters had higher mean annual livestock income (about 4284.90 Ethiopian birr) as compared to Non-adopters who had only 3095.77 Ethiopian birr (Table 12**)**. Concerning this variable, the majority of empirical study shows that the effect of livestock income on household's adoption decision is positive and significant. This is in line with Alemayehu (2018) studies shows that farmers with higher cash income were more likely to adopt improved forages.

#### 4.1.2.5 Participation in off-farm activities

Participation in off-farm activities is believed to have an impact on the income of households. Additional income earned through participation in these activities improves farmers' financial capacity and increases the ability to adopt new technology. Of the total sampled households, 59.14% don't involve in off-farm activities, while only 40.86% were involved in off-farm activities. The categorical analysis showed, 84.31% of adopters were involved in off-farm activities while only 49.63 % of Non-adopters were involved in these activities. Whereas 15.69% adopters and 50.37 Non-adopters were not participated, involved in off-farm activities. Cross tabulation also showed significant association between adopting improved forage legume and involving in off-farm activities ($\chi^{2.}$= 18.428) at less than 1% probability level (Table 12). This is in line with results of Techane *et al.*, (2006) has found that participation in off farm activities positively influences farmers' adoption decision. The result of the analysis leads to the conclusion that farmers who earn more money from off-farm activities have better chance to adopt improved forage legume.

Table 12 Respondents' participation in off-farm activities; Kedida Gamela District, Kembata Tembaro Zone, Ethiopia.

| | | Adopter | | Non-Adopter | | total | | $\chi^2$ value |
|---|---|---|---|---|---|---|---|---|
| | Response | № | % | № | % | № | % | |
| Participation in off-farm activities | Yes | 43 | 84.31 | 67 | 49.53 | 110 | 59.14 | 18.428*** |
| | No | 8 | 15.69 | 68 | 50.47 | 76 | 40.86 | |
| | Total | 51 | 100 | 135 | 100 | 186 | 100 | |

*** *Significant at less than 1% Significant level.*

#### 4.1.2.6 Farm income

Household's farm income position and resource ownership was found to be important in adoption of improved forage legume. Adopters had mean annual farm income (about 7356.02 Ethiopian birr) as compared to Non-adopters who had 9408.08 Ethiopian birr (Table 13**)**. Analysis of mean annual farm income between adopters and Non-adopters had indicated that there was no significant mean difference. But in this study as described it may be due to the proportion of adopters which was found to be only 27.4% of the total respondents. Concerning this variable, most empirical study showed that the effect of farm income on household's adoption decision is positive and significant. To mention some, for example, Alemayehu (2018) studies farmers with higher cash income were more likely to adopt improved forages.

### 4.1.3 Institutional variables

Farmers make decisions within a broader environment or context (Tesfaye, 2003). Institutional factors are part of such broader environment, which affects farmers' adoption decision of agricultural technologies. Farmers' institutional environment has important bearing on the farmers' decision with respect to adoption of improved forage legume. In this study, concerns of Institutional factors include support provided by various institutions and organizations to enhance the use of improved forage legume.

#### 4.1.3.1 Distance from nearest market center

Market is the most important place where rural households exchange not only their output but also share whatever information they have. If farmers are closer and have access to market services, they can easily purchase improved agricultural inputs and sell their agricultural outputs without moving long distances. Reasonable price for outputs motivate farmers to adopt technologies. The distance market center was measured by time spent to arrive and converted to kilometer per hour. This particular study revealed that the minimum and maximum distance to reach at the nearest local market center is 3 & 11.5 km respectively. The mean distance sample households were expected to walk 7.37 km to arrive at the nearest local market center (Table 14**)**. Adopters and Non-adopters farmers walk mean distance for 6.08 and 7.85 km, respectively. The t-test was carried out to see the association of market distance with adoption of improved forage legume. The result conclude negative association at $p<0.01$ level ($t = 6.186$). This indicates that market distance from dwelling may matter on improved forage legume adoption. This result was also supported by Beshir (2013).

**4.1.3.2. Access to credit service**

Access to credit service can lighten up farmers financial constraints & expected to make farm households willing to participate in improved forage legume. This variable, therefore, may not have direct impact on improved forage legume practice but indirect one as farmers use the credit for agricultural activities giving the chance to invest their own capital on improved forage legume activities which would have been used for another agricultural undertaking.

During the last cropping season (2017/018), 45.17% of the respondents have got credit services for different purposes while 54.83 % do not. Independent treatment between adopter and Non adopter of the technology witnessed that 88.23% of adopters and 28.9% of Non-adopters were beneficiaries of the credit service. Whereas 11.77% adopters and 71.1% Non-adopters were not beneficiaries of credit service. Adopters were larger in proportion in credit utilization than Non-adopters. The $x^2$ test also shows significance relationship at $p<0.01$ with ($\chi^2$=52.641, p=0.000) signifying the impact of credit on adoption of improved forage legume (Table 13). Participants of each focus group discussion have also briefed that lack of access to planting materials, availability and unaffordable seed prices influenced them not to grow improved forage legume. As discussed, majorly the government credit opportunities are strictly focused on provision of fertilizer credit than forage seed/planting materials. In a similar development Hailemariam *et al.,* (2012) have reported the importance of the value of assets and the availability of credit in influencing the purchase of inputs (improved seed and fertilizer) calls for improving credit delivery systems.

Table 13 Respondents' response to the use of credit; District, Kembata Tembaro Zone, Ethiopia.

| Credit access | Adopter | | Non-adopter | | Total | | $\chi^2$ value |
|---|---|---|---|---|---|---|---|
| | No | % | No | % | No | % | |
| Yes | 45 | 88.23 | 39 | 28.9 | 76 | 45.17 | |
| No | 6 | 11.77 | 96 | 71.1 | 110 | 54.83 | |
| Total | 51 | 100 | 135 | 100 | 186 | 100 | 52.641*** |

*** *Significant at less than 1% Significant level.*

### 4.1.3.3 Extension agent contact

The study showed that from the total households 55.4% have got chance of contact with extension agents while 44.6% have not contact with extension agents. From the total number of adopters 82.4% have got chance to contact with extension agent while only 45.2% Non-adopters have got chance to contact with extension agent respectively. But 17.6% adopters and 54.8% Non-adopters have not contact with extension agents (Table 14). The chi-square test also shows that the significance value for test statistics ($\chi^2$= 20.694, p= 0.000) which is below level of significance ($p<0.01$). Therefore this showed that there is significant association between extension agent contact and adoption of improved forage legume. This means the chance of adopting forage legume increase as an extension agent contact increase. Lack of extension service on improved forage legume is also indicated by each group of focus group participants. As briefed, more attention is given to production of food crops than considering feed. The result is in line with the findings of Elias *et al.*, (2016).

Table 14 Respondents' response to contact with extension agent; Kedida Gamela District,

| Response | Frequency | | | | | |
|---|---|---|---|---|---|---|
| | Adopters | | Non adopters | | Total | |
| | No | % | No | % | No | % |
| No | 9 | 17.6 | 74 | 54.8 | 83 | 44.6 |
| yes | 42 | 82.4 | 61 | 45.2 | 103 | 55.4 |
| Total | 51 | 100 | 135 | 100 | 186 | 100 |

Before a switch to the descriptive analysis it seems appropriate to summarize the results of the survey as shown below.

Table 15 Summary of descriptive statistics of continuous explanatory variables.

| Variables | Mean | | | t-value | P -value |
|---|---|---|---|---|---|
| | Total HH(186) | Adopter | Non-adopter | | |
| AGE | 45.908 | 46.1961 | 45.8000 | -0.215 | 0.830 |
| FAMSZ | 5.543 | 5.9608 | 5.3852 | -1.855* | 0.065 |
| GLANDSZ | 0.219 | 0.258 | 0.2053 | -1.765* | 0.079 |
| LOWND(TLU) | 2.087 | 2.5326 | 1.9187 | -3.346*** | 0.001 |
| LVSTKINC | 3421.83 | 4284.90 | 3095.77 | -1.039 | 0.300 |
| FARMINC | 8845.63 | 7356.80 | 9408.09 | 1.010 | 0.314 |
| HHLOBR | 3.50 | 3.7882 | 3.3963 | -1.504 | 0.134 |
| DSNMC | 7.37 | 6.08 | 7.86 | 6.186*** | 0.000 |

*, and *** significant at less than 10% and 1% respectively.

(Source: own survey).

Table 16 Summary of descriptive statistics of dummy explanatory variables.

| Variables | Categories | % value of Adoption status | | $\chi^2$- value | p-value |
|---|---|---|---|---|---|
| | | Adopters % | Non adopters% | | |
| SEX | Male | 78.4 | 65.9 | 2.724* | 0.099 |
| | Female | 21.6 | 34.1 | | |
| EDUC | None | 29.4 | 42.2 | 3.422* | 0.064 |
| | Attended formal education | 70.6 | 57.8 | | |
| PARTOFFA | Yes | 84.3 | 49.6 | 18.428*** | 0.000 |
| | No | 15.7 | 50.4 | | |
| ACCCS | Yes | 88.2 | 28.9 | 52.641*** | 0.000 |
| | No | 11.8 | 71.4 | | |
| FRQAEC | Yes | 82.4 | 45.2 | 20.694*** | 0.000 |
| | No | 17.6 | 54.8 | | |

*, and *** significant at less than 10% and less than 1% respectively. (Source: own survey).

## 4.2 Adoption status of improved forage legume production

### 4.2.1 Improved forage legume adoption in the proportion of area coverage

The status of improved forage legume adoption is measured in the proportion of area coverage of improved forage legume to total forage land. The result of the study indicated that the proportion of land (improved forage legume land (ha)/ total forage land (ha) ) was only 0.127 (12.7%) (Table 17). As indicated, adopters posses land area for forage and improved forage legume production was 15.13 ha and 1.92 ha respectively. The mean area of land posses for forage and improved forage legume was 0.296 and 0.0736 respectively. From the total respondents 27.4% and 72.6% were found to be adopters and Non- adopters respectively. The national data of 2014/15 livestock survey report showed that only 0.3% of livestock holders practiced using improved feed technologies for their livestock.

Table 17 Adoption status of improved forage legume

| Adoption category | Frequency | % | Forage land (ha.) Total (mean) | Improved forage legumenland (ha) Total (mean) | Average proportion of land (improved forage legume land/ total forage land ) (ha) |
|---|---|---|---|---|---|
| Adopters | 51 | 27.4 | 15.13 (0.296) | 1.92(0.0376) | 0.1269 (12.7%) |
| Non-adopters | 135 | 72.6 | 28.01 | - | - |
| Total or mean | 186 | 100 | 43.14(0.232) | 1.92(0.0376) | 0.1269 (12.7%) |

(source own survey data)

### 4.2.2 Improved forage legume production practices of adopter households

In the study area from total adopters, 13.7% used mono-cropping method of production, 82.3% employed intercropping and 2 (4%) used mono-cropping as well as intercropping (Table 18). During group discussion the respondent mentioned that due to farm land shortage most of them employ intercropping improved forage legume in their plots of land and also plant around homestead, roadside and used as life fence.

Table 18 Type of improved forage legume production

| Do you grow Improved forage legume | Number respondents | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Frequency | Percent | | | | | | |
| Yes | 51 | 27.4 | | | | | | |
| No | 135 | 72.6 | | | | | | |
| Kebele | Type of production | | | | | | | |
| | Mono-cropping | | Intercropping | | Both | | Total | |
| | Adopters | % | Adopters | % | Adopters | % | Adopters | % |
| Bezena benara | 1 | 1.9 | 9 | 17.6 | - | - | 10 | 19.6 |
| Zato shodera | 2 | 3.9 | 15 | 29.4 | 1 | 1.9 | 18 | 35.3 |
| Aze dobo | 4 | 7.8 | 18 | 35.3 | 1 | 1.9 | 23 | 45.1 |
| total | 7 | 13.7 | 42 | 82.3 | 2 | 3.9 | 51 | 100 |

(source: own survey)

### 4.2.3 Types of improved forage legume grown by adopter households

As the data analysis showed that there are three major types of improved forage legume grown by the majority of adopters (51) 27.4% adopter households in the area. These cover 88.2% (sesbania, dismodim, and vetch), other types cover 11.8% (alfalfa, pigeon pea, leuceana) which is in a very small amount whereas Non-adopters 135 (72.6%) have grown grass types (Table 19). From the total respondents those who have grown improved forage legume were 10 (5.3%) in Bezena benara, 18 (9.7%) in Zato shodera and 23 (12.4%) in Aze dobo.

There are many reasons related to adoption. It was related to types of livestock owned (TLU), awareness, accessibility to market and credit, access to different infrastructures, access to grazing land. As the district office of agriculture and Natural resource development and livestock and fish resource development information very few types (sesbania, pigeon pea, dismodium, vetch were introduced but they focused only on the production of grass types. The kebele extension agents also mentioned that their focus was multiplying and distributing forage grass types than forage legume. The result of interviewed respondents and each focus group discussion participants also showed that few had adopted improved forage legume. The result of focus group discussion showed that from 10 focus group participants at each kebele (Zato shodera, Bezena benara and Aze dobo) only two, one and three participants respectively have grown sesbania and pigeon pea. As confirmed by participants, this was because improved forage legumes were not available in FTCs as compared to grass types.

As information of kebele FTCs, more attention and focus was given to demonstrate food crops and grasses than improved forage legume. The focus group discussion and the respondents response from each kebele was comparable, therefore this can give option to bring solution through integration at all levels to boost the adoption of improved forage legume. This is in line with the study of (Zekarias, 2015; ESAP, 2003).

Table 19 Types of improved forage legume grown

| Grow Improved forage legume | Respondents of each Kebele | | | | | | Total number of respondents | |
|---|---|---|---|---|---|---|---|---|
| | Bezena benara | | Zato shodera | | Aze dobo | | Frequency | % |
| | N | % | N | % | N | % | | |
| Yes | 10 | 5.3 | 18 | 9.7 | 23 | 12.4 | 51 | 27.4 |
| No | 56 | 30.1 | 36 | 19.3 | 43 | 23.1 | 135 | 72.4 |
| Types of improved forage legume grown | | | | | | | | |
| alfalfa | - | | 1 | 0.01 | 1 | 0.01 | 2 | 3.9 |
| dismodium | - | | 9 | 17.6 | 4 | 0.08 | 13 | 25.5 |
| leuceana | - | | - | | 1 | 0.01 | 1 | 0.02 |
| pigeon pea | 1 | 0.01 | 2 | 0.04 | - | - | 3 | 5.9 |
| sesbania | 6 | 11.6 | 4 | 0.08 | 13 | 25.5 | 23 | 45.1 |
| Vetch | 3 | 5.9 | 2 | 0.04 | 4 | 0.08 | 9 | 17.6 |
| Total | 10 | 19.6 | 18 | 35.3 | 23 | 12.4 | 51 | 100.0 |

(source: own survey)

**4.3. Determinants of adoption of improved forage legume in the study area**

For this study, Binary Logistic Regression Model was used to identify determinant variables in adoption of improved forage legume. In the section followed procedures to select independent variables (continuous and dummy) and results of logistic regression analysis conducted to identify determinants of adoption of improved forage legume in the district are presented.

**4.3.1 Econometric results for the binary logistic regression model**

The purpose of this section is to identify the most important hypothesized independent variables that influence the dependent one. Prior to running the Logit model, the presence or absence of multicoliniarity was checked. There are two measures that are often suggested to test the existence of multi-collinearity. These are: Variance Inflation Factor (VIF) for association among the continuous explanatory variables and contingency coefficients for categorical variables. A statistical package known as SPSS was employed to compute these values. Once VIF values were obtained the $R^2$ values can be computed using the formula. The larger the value of VIF, the more "troublesome" or collinear the variable $X_i$. As a general rule, if the VIF of a variable exceeds 10, there is multicolinearity. According to Gujarati 2003, to avoid serious problems of multicollinearity, it is quite essential to omit the variable with value 10 and more from the logit analysis. Thus, the variable inflation factor (VIF) was employed to test the degree of multicollinearity among the continuous variables.

Table 20 Multicolliniarity test among continuous variables.

| Continuous variables | Collinearity Statistics | |
|---|---|---|
| | Tolerance ($R^2_i$) | VIF |
| Age of the Household | 0.837 | 1.195 |
| Family Size of the Household | 0.440 | 2.273 |
| Grazing land size of the household in hectare | 0.939 | 1.065 |
| livestock ownd (TLU) | 0.876 | 1.141 |
| Livestock income of household in Birr | 0.446 | 2.243 |
| Farm income of household in Birr | 0.477 | 2.095 |
| Household labor availability | 0.431 | 2.319 |
| Distance from nearest market in kilometer | 0.810 | 1.235 |

As shown in table 20, the values of the VIF for 8 continuous variables were found to be small (i.e VIF values less than 10) indicating that the data have no serious problem of multicollinearity. Hence, all the 8 continuous explanatory variables were retained and entered into the binary logistics analysis (Table 22). In a similar vein, contingency coefficients were computed from survey data to check the existence of high degree of association problem among discrete independent variables. The decision rule for contingency coefficients states that when its value approaches 1, there is a problem of association between the discrete variables, i.e., the values of contingency coefficients ranges between 0 and 1, with zero indicating no association between the variables and the values close to 1, indicating a high degree of association.

Table 21 Contingency coefficient of categorical variables

| Categorical variables | Contingency coefficient | Chi square |
|---|---|---|
| SEX | 0.120 | 2.72 |
| EDUC | 0.134 | 3.422 |
| PARTOFFA | 0.300 | 18.428 |
| ACCCR | 0.470 | 52.541 |
| FRQEAC | 0.316 | 20.694 |

The result of the contingency coefficient reveals the absence of multicollinearity or high degree of association problem among independent variables. All the screened variables, therefore, were decided to be included in the model analyses (Table 22). In this study, a farmer who grow improved forage legume is considered to be “an adopter”. The dependent variable is either adopter or non-adopter of improved forage legume and logit model was employed to estimate the effects of the hypothesized independent variables on adoption of improved forage legume.

In doing so a total of thirteen independent variables were included in the model. These are Age, sex, education status, Family size, grazing land size, livestock owned (TLU), labour availability in adult equivalent, distance from nearest market, livestock income, farm income, participating in off-farm activities, access to credit service, and extension agent contact. These variables were selected in consultation of experts in the area, based on literatures, practical situations, observation and experience of the researcher and the relevance of the variables. Furthermore; they were selected by testing significant differences of the mean using t-test and $x^2$ test. 92.6% of households that were Non-adopter of improved forage legume predicted correctly with this model, on the other hand 76.5% of those households that adopt improved forage legume were predicted correctly. The model showed that the overall predicted percentage correct was 88.7%.

Table 22 The results of logit model

| Variables | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|
| AGE | 0.018 | 0.023 | 0.673 | 1 | 0.412 | 1.019 |
| SEX | 1.433 | 0.683 | 3.185 | 1 | 0.074* | 3.382 |
| EDUC | 0.804 | 0.562 | 2.044 | 1 | 0.153 | 2.235 |
| FAMSZ | -0.036 | 0.218 | 0.028 | 1 | 0.867 | 0.964 |
| GLANDSZ | 2.879 | 1.596 | 3.256 | 1 | 0.071* | 17.794 |
| TLU | 0.572 | 0.238 | 5.782 | 1 | 0.016** | 1.772 |
| LVSTKINC | 0.000 | 0.000 | 0.168 | 1 | 0.682 | 1.000 |
| PARTOFFA | 1.657 | 0.596 | 7.737 | 1 | 0.005*** | 5.242 |
| FARMINC | 0.000 | 0.000 | 0.347 | 1 | 0.556 | 1.000 |
| HHLOBR | -0.002 | 0.235 | 0.000 | 1 | 0.993 | 0.998 |
| DSNMC | -0.621 | 0.192 | 10.450 | 1 | 0.001*** | 0.537 |
| ACCCRS | 2.329 | 0.599 | 15.107 | 1 | 0.000*** | 10.267 |
| FRQEAC | 1.867 | 0.555 | 11.339 | 1 | 0.001*** | 6.471 |
| Constant | -4.418 | 1.990 | 4.931 | 1 | 0.026 | 0.012 |

Chi-square=110.221***, Sig= 0.000;
-2log likelihood=108.287, Cox & Snell R square= 0.447, Nagelkerke R square= 0.647
Percentage of correct prediction=88.7;
*, ** and *** are significant at less than 10%, 5%, and 1% probability level respectively.
(Source: Model out put)

### 4.3.2 Interpretation of empirical results and discussions

As indicated in the previous sections, a number of independent explanatory factors (demographic, economic and institutional) were postulated to influence the probability of adoption of improved forage legume. Out of thirteen explanatory variables hypothesized to affect farmers' decision to use improved forage legume, seven were found to be statistically significant. These factors include, sex, grazing land size, livestock owned (TLU), distance from nearest market, participating in off-farm activities, access to credit service, and extension agent contact.

Of the total significant variables, all were found to be statistically significant with expected signs. These are sex (SEX), grazing land size (GLANDSZ), livestock ownd (TLU), distance from nearest market (DSNM), participating in off-farm activities (PARTOFFA), access to credit (ACCCR), and extension agent contact (FRQEAC). The section ahead describes interpretation of findings of the model as a result of the simultaneous interaction of several variables.

**Sex of the household head (SEX)** was positively and significantly at ($p < 0.1$) related with adoption in favor of male headed households indicating that being female headed might mean having low resource ownership, relatively low physical labor and poor access to information It implies that males are movable than females and have high chance to get information to adopt improved forage legume. In line with this the odds ratio indicated that male headed households were 3.382 times more likely to adopt improved forage legume than female headed households (Table 22). The positive sign reveals that the comparison of the result with the hypothesis that being male-headed households were better in using improved forage legume than female HH head. This finding is in line with the result of Ayalew (2011). The results of focus group discussion showed that from Zato shodera focus group participants one female has grown sesbania and explained its importance for milk production. But the rest two groups (Bezena benara and Aze dobo) briefed that focus group participant females have not involved in growing improved forage legume due to lack of information. Therefore, males have higher opportunity to get information than females as revealed in the model results.

**Grazing land size (GLANDSZ)** with regard to this variable the result of the model analysis revealed a positive and significant ($p < 0.1$) association with adoption of improved forage legume, The odds ratio for this variable is 17.794. This implies that maintaining other determinants constant, additional hectare of grazing land size will enhance improved forage legume adoption of the household by factor of 17.794 (Table 22). This result confirms that the possession of large grazing land size can encourage farmers to adopt improved forage legume. it is in line with study results of Menbere (2014) in the livestock production sub-system of the area and only about 34.1% (n=46) of the farmers posses private grazing land with a very small an average holding of 0.073±0.014 ha which are mostly located at backyard and farm land boundaries and the result of Mapiye *et al.* (2006a) recorded full adoption of forages in households with large pieces of land (≥100 ha) and partial adoption by households with smaller pieces of land (≤5.93 ha) in Zimbabwe. The results of focus group discussion showed that focus group participants of Bezena benara, Aze dobo and Zato shodera kebeles confirmed that shortage of land is their serious problem to grow improved forage legume. This is related with the above model result.

**Livestock owned (TLU)** livestock ownership was found to have positive and significant at

P<0.05) relationship with improved forage legume adoption (Table 22). Most households accumulate their wealth in terms of livestock as they are major sources of wealth to farm households. Households with relatively large livestock size (larger TLU), the probability to be an adopter increases. In line with this, the odds ratio in favor of improved forage legume adoption increase by factor of 1.772 for each in TLU increment. The primary logic behind might be as farmers own more livestock, they need to have feed available at their vicinity to provide their livestock population. Similarly, the three focus group participants pointed out that among the group participants those who have relatively large number of livestock grown improved forages on their piece of land. This result is consistent with the finding of many other studies undertaken at different space and time to mention some Wambugu (2011) shown that the number of dairy cattle significantly affected adoption of forage/browse legume technologies.

**Participation in off-farm activities (**PARTOFFA) was hypothesized to have positive association with household adoption of improved forage legume. The model output illustrates that it was found to be positively and significant at (p< 0.01) level and has positive relationship with probability of improved forage legume adoption, such that households who participated in off-farm activities were 5.242 times more likely to adopt improved forage legume than households those did not (Table 22). In this particular study, smallholders who solely depend on farm activities have inadequate income to purchase farm inputs and fulfill family needs and thus, they are found to be Non-adopters. This shows that off-farm job opportunities play prominent role in managing household adoption of improved forage legume in Kedida Gamela district. Techane *et al.,* (2006) has found that participation in off farm activities positively influences farmers' adoption decision.

**Access to credit service** (ACCCRS)**:** It is one way of improving farmers' access to new production technology. The Logit model indicated that access to credit had positive and significant (p< 0.01) influence on the adoption of improved forage legume production, suggesting that households who had access to credit were 10.267 times more likely to adopt improved forage legume than households have not accessed to credit (Table 22). Thus Provision of credit can motivate resource poor farmers financial constraints to buy technologies. This is in line with the results of (Hailemariam *et al.,* 2012) access to credit increases the farmers' economy to purchase improved seed, fertilizer and other inputs. Participants of each focus group discussion have also briefed that lack of access to planting materials, availability and unaffordable seed prices influenced them not to grow improved forage legume. As discussed, majorly the government credit opportunities are strictly focused on provision of fertilizer credit than forage seed/planting materials. So, this was among factors which affected forage legume adoption.

**Distance from nearest market (DSNM)** it was hypothesized that distance from near market to their home is expected to influence adoption of improved forage legume negatively and significantly. The result of the model indicated that distance from nearest market influenced negatively and significantly at ($p < 0.01$) level, such that the odds ratio in favor of improved forage legume adoption decreases by factor of 0.537 for each in a Kilometer increment (Table 22). The implication of inverse relation of market centers and adoption of improved forage legume signify that farmers located nearer to market centers will have a higher probability to adopt improved forage legume. This result is in conformity with the findings of Beshir (2014) who found a negative relationship between distance to market centre and adoption of forage technologies in Ethiopia. It is possible that the long distance to market centre limited marketing of milk, the main product from livestock, and consequently farmers did not have incentives to plant forages to improve milk production.

**Extension agent contact (EAC):** This variable confirms with our positive and significant expectation of extension agent contact with adoption of improved forage legume at positive and significant ($p < 0.01$) level, suggesting that households who had contact with extension agent were 6.471 times more likely to adopt improved forage legume than households did not (Table 22). This showed farmers who have options to contact with development agents have enhanced access to information on the use of improved forage legume and have better possibility to change their plan into action. Lack of extension service on improved forage legume is also indicated by each group of focus group participants. As briefed, more attention is given to production of food crops than considering feed. The result is allied with the findings of Elias *et al.,* (2016), farmers who make contact with development agents have better access to information on and have better possibility to change their intent into action.

## 4.4 Constraints and opportunities of improved forage legume production

### 4.4.1 Constraints of improved forage legume production

In the highland and midland agro-ecologies land shortage was the major constraint to improved forages cultivation (Gebreegziabher and Tsegay, 2016).

As shown below on table 23 from the total of 186 household respondents mentioned land shortage 98 (52.7%), lack of inputs 44 (23.7%), lack of extension service 35 (18.8%), drought 5 (2.75), lack of soil fertility 4 (2.2%) were the main constraints in the area to adopt improved forage legume. From the total respondents the proportion of adopters and Non-adopters chose the constraints to adopt improved forage legume were land shortage (58.8%, 50.4%), lack of inputs (21.6%, 24.4%), lack of extension service (13.7%, 20.7%), drought (3.9%, 2.2%), lack of soil fertility (2%, 2.2%), respectively. This result indicated that majority of the respondents mentioned land shortage, lack of inputs and lack of extension service and few of them mentioned drought and lack of soil fertility were the constraints of improved forage legume adoption in the area.

**Shortage of land**

Land shortage was identified as one of the constraint of adoption of improved forage legumes in Kedida Gamela district. This can be attributed to the fact that improved forage legumes production competes with food crop production and farmers may not want to take land away from food production for other uses. Use of intercropping improved forage legumes would not affect the cereal crops. As observed, intensification of crop production, such as use of modern soil fertility management techniques, encourages adoption. This implies that the development and use by farmers of high yielding crop varieties and intensive crop management practices can significantly enhance adoption of improved forage legumes by releasing land for forage production (Gebremedhin *et al* 2003).

**Shortage of planting material**

The key inputs limiting adoption of improved forage was shortage of planting material. As district agriculture and natural resource development and livestock and fishery development office information, forage legume development and forage seed production is not considered as one of potential contributor to food security and it lacks emphasis. However development agents and development practitioners gave more attention to food crop development than forage production in general; insufficient forage seed production or availability and unaffordable seed prices for the users is another problem that discourages to get involved in the area of forage legume production. In agreement to results of this survey, Mapiye *et al* (2006) asserted that adoption of legumes in Zimbabwe is hampered by high cost and low availability of seed for the recommended varieties. Efforts should be made to overcome shortage of planting material by training farmers and farmer groups on seed collection and encouraging them to produce and use their own seeds.

**Lack of extension service**

The survey results obtained through focus group discussions (Bezena benara, Aze dobo and Zato shodera groups) identified several constraints of adoption of improved forage legume. Among these, lack of extension service is one of the constraints. Some focus group discussion participants emphasize poor extension services, lack of awareness, on improved forage legume and less attention to improved forage legume were constraints of improved forage legume adoption.

**Drought and lack of soil fertility:** Un-conducive environmental factors, for instance scarcity of rainfall is challenge; and Limited attention given by research establishments to conduct research in the area. The survey results obtained through focus group discussions (Bezena benara, Aze dobo and Zato shodera groups) identified drought (shortage of rain fall) and lack of soil fertility were constraints of adoption of improved forage legume.

Table 23 Constraints to improved forage legume production; Kedida Gamela District, Kembata Tembaro Zone, Ethiopia.

| List of constraints | Frequency | | | | | |
|---|---|---|---|---|---|---|
| | Adopter | % | Non adopter | % | total | % |
| Land shortage | 30 | 58.8 | 68 | 50.4 | 98 | 52.7 |
| lack of soil fertility | 1 | 2.0 | 3 | 2.2 | 4 | 2.2 |
| lack of inputs | 11 | 21.6 | 33 | 24.4 | 44 | 23.7 |
| drought | 2 | 3.9 | 3 | 2.2 | 5 | 2.7 |
| lack of extension service | 7 | 13.7 | 28 | 20.7 | 35 | 18.8 |
| Total | 51 | 100.0 | 135 | 100 | 186 | 100.0 |

### 4.4.2 Opportunities of improved forage legume production

In existing situation there was agriculture office structure at kebele level which comprises three DAs in three disciplines (crop production, natural resource development and livestock production). FTCs were constructed at each kebele having aim to demonstrate, multiply seed and provide planting materials for farmers in the area. As stated by focus group participants, the existence of development team (lemat buden) structure under kebele structure which is led by model farmers can be taken as an opportunity to promote improved forage legume. This can be taken as a golden opportunity to promote improved forage legume production.

Natural pastures and crop residues, as the two most important feed resources, are unable to meet the nutrient requirements for milk production and reproduction. This has necessitated the growing and feeding of improved forages (Lenné and Wood, 2004). Among the options, at smallholder level, greater attention needs to be given to improved forage production by using available forage technologies; for native pastures, over sowing with improved grass and legume species, and bush clearing from grazing fields is recommended. Use of improved forage varieties with their management techniques was also recommended.

To improve supply of forage seed by making land and credit services available to private seed producers. Regional and federal investment agencies can play a key role in facilitating investment initiatives for forage seed production, while research institutes at regional and federal levels and the MoA are the main actors in capacity building support to research centres and seed enterprises. Even though the strategic options set, the respondents and focus group discussion results showed that less attention was given to produce improved forage legume production. In addition, realities in the ground showed that few farmers were observed practicing improved forage legume production. This also confirmed that less attention was given to practice improved forage legume production in the study area.

Like other seed production, forage seed production can also be considered as a potential income sources; forage seed production can be a potential income sources for smallholder farmers and can be a source of income diversification; and the need for more forage seed production may create an opportunity for more practical attachment of youth and may create job opportunity. Livestock and fishery development office information confirmed that the existing livestock feed necessitate strong support by high yielder and quality improved forage legume demand is an opportunity for one to involve in forage seed production. Therefore this showed that the existence of these golden opportunities can be used as a bridge to promote adoption of improved forage legume to benefit smallholder farmers of the area.

Focus group participants indicated that those who have got training on forage production opportunity have benefitted and the need for training is not questionable, so based on the need of farmers government should equip DAs through trainers training support in collaboration with potential stakeholders at each levels. As discussed, majorly the government credit opportunities are strictly focused on provision of fertilizer credit than forage seed/planting materials. Therefore forage planting materials especially improved forage legume seeds/planting materials credit should be considered. This can benefit smallholders to reduce the feed shortage, improve livestock productivity and can encourage them to develop improved fodder plants. As mentioned by focus group participants, the increased demand for livestock products in the study area is another opportunity to grow improved forage legume. There is an emerging and significant role for legumes as a protein supplement to reduce reliance on expensive concentrates (Wambugu *et al.*, 2011) which often account for a high proportion of direct costs. Since the price of milk and meat become higher farmers in the area were encouraged to plant improved forage legume which is important to boost milk and meat production.

# 5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

## 5.1 Summary and Conclusion

In the face of rising rural population density, emerging climatic change, and ever intensifying land degradation problems of Ethiopia, the importance of improved forage legume production is not questionable. Potentially improved forage legume is the right intervention for attaining livestock feed in Ethiopia. However, only a fraction of the potential is released so far. In this regard, improved forage legume has scarcely benefited from scientific research outputs, and monitoring systems.

This study was conducted in Kedida Gamela district, Kembata Tembaro Zone of SNNP Regional State, Ethiopia. The main idea of this study was to assess the current status of adoption and identify factors (demographic, socio-economic and institutional) affecting adoption of improved forage legume. A total of 186 sample households (129 male and 57 female) selected from 3 kebele*s* of the district were interviewed using structured interview schedule. Qualitative data were collected using group discussion and personal observation among selected improved forage legume growers and extension development agents who were working in the respective kebeles.

The data were analyzed, and presented quantitatively using different statistical methods such as percentage, frequency, tabulation, Chi-square test (for dummy /discrete variables) and (t-test for continuous variables) used to test the variation of the sample group towards adoption of improved forage legume production. Logit model was employed using SPSS 20 software to estimate the effects of hypothesized independent variables on dependent variables.

According to the result of the descriptive statistics analysis sex of the household head was significantly related to adoption of improved forage legume indicating that being male headed household positively correlated with adoption of the same. It implies that males are movable than females and have high chance to get information to adopt improved forage legume. The majority of adopters have attended formal education and it might have importance on adoption of improved forage legume. This implies that those who have attended formal education can get information easily. In a similar move, adopters of improved forage legume own more livestock units implying that they need feed availability to their livestock, have a relatively large family size so they have high labor force to grow improved forage legume, have a relatively large grazing land size, implies that it provides chance to grow improved forage legume, have better access to credit which provokes them to buy inputs and Extension agent contact implying that adopters can get agricultural information and most of them involved in off-farm activities in the past cropping season implies that it enhances their financial capacity. The majority of adopters relatively have more access to market to purchase inputs & sale their produce.

Based on the study, the adoption status of sample households indicated that 27.4% of the respondents were adopters of improved forage legume and majority 72.6% of respondents were Non-adopters. The results of land coverage reveals that the proportion of land for improved forage legume to total forage land was only 12.7%. They too, feel that they use the land they currently have throughout their life time than Non-adopters. This implies that the status of improved forage legume adoption was not good. Indeed, most adopter farmers have exposures to external support from GOs and NGOs, contact with extension agents, field visits, training, and other improved forage legume related matters, which makes them proactive about the benefit of improved forage legume.

In the logistic regression model, thirteen hypothesized explanatory variables were used to identify factors affecting adoption of improved forage legume. At the end, the result of the binary logit analysis indicated that four variables at $p<0.01$ level, one variables at $p<0.05$ level and two variable at $p<0.1$ level were found to be significant to affect adoption of improved forage legume.

Sex of household head was positively and significantly related with adoption in favor of male headed households at $p<0.1$ significant level indicating that being female headed might mean having low resource ownership, relatively low physical labor and poor access to information. this implies that male headed households have chance to move and got information better than femel headed households. Grazing land size was found to have significant influence at $p<0.1$ level implies that it provides chance to grow improved forage legume. Livestock owned (TLU) significant at $p< 0.05$ level implying that they need feed availability to their livestock, participation on off-farm income activities implies that it enhances adopters financial capacity, access to credit and Extension agent contact affect adoption of improved forage legume at $p < 0.01$ significant level implying that it provokes adopters to buy inputs and can get agricultural information respectively.

The result of the model also revealed significant relation of distance from nearest market at $p<0.01$ significance level with adoption of improved forage legume pointing that farmers located nearer to market centers will have a higher probability of using improved forage legume implying that adopters can be benefited through selling their produce in near market .

According to the information obtained from focus group discussions, shortage of land, high price of improved forage legume seeds, lack of attention for growing improved forage legume, problem on distribution of different improved forage legume seedling, knowledge gap among farmers and DAs about the introduced improved forage legume were constraints affected adoption of improved forage legume. Shortage of planting material and grazing land coverage of the area were potential factors which influenced adoption of improved forage legume.

## 5.2. Recommendations

Improved forage legume contribution to households' livestock feed, income and food security is very high. Regardless of its contribution, however, the emphasis given nationally to the sector is relatively low compared to other food crops. As a result of this, institutional support provided to this sector, such as credit service, research and extension were not to the expected level. These factors together with several household personal, demographic and socio-economic factors affected the adoption of improved forage legume production and consequently production and productivity of the sector. Based on the findings of this study, the following points are recommended to improve farmers' adoption of improved forage legume production so as to enhance its production and productivity:

- Improve forage legume production extension service (for male and female headed household, women in male headed households) such as participating in training, farmer's field day, field visits, visits to other villages and other livestock feed related issues should be given prior agenda to improve farmers' outlook towards improved forage legume production. To accomplish this, government has to first equip the important experts who are working particularly at kebele and district levels with the necessary skills as they are basic under discussion.

- Adoption of improved forage legume among households was found to be influenced by different factors such as sex difference, resource ownership and institutional. As a result of these, female headed households could not adopt improved forage legume. Therefore, opportunities for equal access to informaton for women should be provided through extension agents.
- Farmers hesitate to adopt improved forage legume if roads and transport are inadequate and too poor for them to market their output. There is a clear need to put improved forage legume production by an integrated approach. The adoption process depends not only on farmers' willingness but also on an overall sustainable rural development process, hence the need to emphasize the importance of road networks and communication services are works should not be left to be done for tomorrow.
- Livestock ownd was another important factor which influenced adoption of improved forage legume in the study area. Therefore, depending on the needs and managerial ability of the farmers, the district Ministry of Agriculture and Natural Resource Development, Livestock and Fishery Resource Development and input delivery agencies provision of medium and long term credits to farmers with little or no livestock can enhance adoption of improved forage legume to feed their livestock in the study area.
- Availability of planting materials through improved forage legume seed multiplication is vital for effective utilization of improved forage legume. It is also important to strengthen the technical and material capacity of government agencies (regional and federal seed enterprises, and research centres) for forage seed production. This calls for coordinated effort of the district Ministry of Agriculture and Natural Resource Development, Livestock and Fishery Resource Development and input delivery agencies.
- Finally it is the felt need of the author, to see research studies on improved forage

production in general, improved forage legume in particular focusing the stage of adoption and the extent to which socio-economic (participation in off-farm activities, etc), institutional (such as credit service, extension agent contact, etc) and other factors affect the adoption decision of the same at a broader scope in the nation.

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# 7. APPENDICES

**Jimma university College of Agriculture and Veterinary Medicine Department of Rural Development and Agricultural Extension**

Interview Schedule for MSc thesis proposal entitled Determinants of Improved Forage Legume Adoption: The case of Kedida Gamela district, Kembata Tembaro Zone, SNNPR

Appendix 1. Questionnaire information

Date of interview ----------------

Number (code) -------------------

kebele ---------------

Name of enumerator ----------

**Part I/Household head characteristics**

1.1/ Respondent Number: ----------------------- .

1.2/ Age of the respondent -------------------------- .

1.3/ Sex 1= male 0= Female

1.4/ Education status ----------------0=None 1= attended formal education

1.5. Mariatl status: 1. Single 2. Married 3.Widowed 4. Divorced

1.6. HH type 1. Male headed 2. Female headed 3. Married woman (this is if the respondent is female who has husband

1.7/ Household family size/ demographic characteristics.

| SN | List of family members | Sex1=male 0=Female | Age | Education level |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| | | | | |

1.8/ Total mixed Farming experience of the household head in years ----------

1.9/ Improved forage legume Farming experience of the household head in years------

1.10/ Membership role of the household head in the kebele 1.Kebele executive member 2. Kebele development team leader 3. Religious leader 4.Edir and other social committee leader 5. Other, specify

1.11/ In which of the following institutions are you involving? 1=Equib 2= Bank 3=Micro-finance 4=Edir 5=cooperatives 6.Others,

**Part II: Socioeconomic characteristics**

**2.1. Land holding (ha) ----------------**

**2.2. Land use type (table) for crop, forage, grazing, forest, Homestead Land + others owned in 2011E.C**

| Land allocation | Land size (hectars.) |
|---|---|
| Coverage of land for grass | |
| Cultivated Land/ covered by food crops | |
| Unused /fallow land | |
| Forest and wood land | |
| Homestead Land + others | |
| Other (specify) | |
| Total | |

**2.3. Farm size for forage crops grown by HHin 2011 E.C. production season (ha)**

| Types crop grown | Area coverage (ha) |
|---|---|
| Improved forage legume | |
| Vetch | |
| Alfalfa | |
| Dismodium | |
| Sesbania | |
| Pigeon pea | |
| Luceanea | |
| Local forage grass | |
| Others | |

Type of production 1) Mono cropping 2) intercropping 3/ both

**2.4/ Grazing Land size in 2011E.C**

| Land allocation | size (hectars.) |
|---|---|
| Coverage of land for improved forage legume | |
| Coverage of land for local forage/ grass Grazing Land size | |
| Total | |

**Part III Livestock owned in 211EC (Tir 2011EC)**

3.1. Do you own livestock? 1=Yes 0=No

3.2. If yes, indicate the number of livestock owned

| Types of animal | No | Types of animal | No |
|---|---|---|---|
| Cows | | Sheep | |
| Oxen | | Donkey | |
| Heifers | | Poultry | |
| Bulls | | Horse | |
| Calves | | Others | |
| Goats | | Total | |

3.3. Do you have exotic animal breed? 1=Yes 0= No

3.4. Do you have enough feed for your animal? 1=Yes 0= No

3.5 Mention the types of feed used in the last three years?

3.6 Mention the types of legume feed used in the last three years?

**Part IV Sources of HH income**

**4.1/ Household's annual farm income from sale of crops /2011E.C in quintals**

| Types grown | Annual harvest | Consumed | Gift | sold | | Total price |
|---|---|---|---|---|---|---|
| | | | | Birr | Ce. | |
| Improved forage legume | | | | | | |
| Local grass | | | | | | |
| Maize | | | | | | |
| Coffee | | | | | | |
| Vegetables | | | | | | |
| Fruits | | | | | | |
| Enset | | | | | | |
| Others | | | | | | |
| Total | | | | | | |

**4.2/ Income from sale of livestock/2011 E.C /**

| Animal type | Number sold | Unit price | Total sale price | Purpose |
|---|---|---|---|---|
| Oxen | | | | |
| Cows | | | | |
| Heifers | | | | |
| Bull | | | | |
| Calves | | | | |
| Goats | | | | |
| Sheep | | | | |
| Donkey | | | | |
| Horse | | | | |
| Poultry | | | | |
| Hide | | | | |
| Others | | | | |
| Total | | | | |

**4.3/ Income from sale of livestock products 2011 E.C**

| Product type | Amount collected per year | Consumed | Sold | Unit price | Total revenue | Purpose of sale |
|---|---|---|---|---|---|---|
| Milk | | | | | | |
| Butter | | | | | | |
| Egg | | | | | | |

Purpose includes 1) For purchasing farm inputs 2) For settling debts 3) For buying clothes for family 4) To buy food grains 5) Others (Specify) ------------------------------

**4.3 Forage as source of income**

| No | Type of feeds sold | Season | Price per quintal in Birr | Remark |
|---|---|---|---|---|
| 1 | Hay | | | |
| 2 | Green feed | | | |
| 3 | Cereal crop residue | | | |
| 4 | Improved forage legume | | | |
| 5 | Other specify | | | |

4.4. Is there livestock feed shortage in your village? 1=Yes 0=No

4.5 Have faced/experienced feed shortage in the past three years? 1=Yes 0=No

4.6 If yes to Q4.4&4.5. above, What is the reason of animal feed shortage? 1. Shortage of water 2. shortage of land 3. shortage of improved fodder 4. Improper management

5.otherspecify

4.7. Is there a market for livestock feed in the area? 1= Yes 0= No

4.8. If yes, do you buy feed from the market for your livestock 1= Yes 0= No

4.9. If Yes to 4.7, how much money do you spend annually for feed? _______

4.10. If No to 4.7, do you sale feed to the market? 1= Yes 0= No

4.11. If yes to 4.7, complete the following

| No | Type of feeds available in the market | Season | price per quintal | Remark |
|---|---|---|---|---|
| 1 | Hay | | | |
| 2 | Green feed | | | |
| 3 | Cereal crop residue | | | |
| 4 | Improved forage legume | | | |
| 5 | Other specify | | | |

**4.12 Income from off-farm activities**

| Income from | Amount in Birr |
|---|---|
| Annual income from daily labor in farm activities | |
| Annual income from trading cattle | |
| Annual income from grain trading | |
| Annual income from hiring | |
| Other incomes | |

**4.13Income from non-farm activities (in Birr)**

| Income from | Amount in Birr |
|---|---|
| Petty trade | |
| Daily labor in towns | |
| Income from handcraft | |
| Income from remittance | |
| Others specify | |

**Part V Household labor availability**

**5.1 Household labor availability in 2011E.C**

| Age category | Male No | Female No | Activities participated in improved forage legume production |
|---|---|---|---|
| <18years | | | |
| 18-65 years | | | |
| >65 | | | |

Improved forage legume production activities includes: - 1) Land preparation 2) planting/ sowing 3) Weeding 4) cutting 5) transporting 6) feeding 7) Marketing 8) others (specify)

**Part VI Distance to the nearest market centers**

6.1 Do you sell agricultural produce? 1=Yes 0= No

6. 2 If Yes answer the following

| Name of the market | Distance (Km) | Time (Hr) | Mode of transport | Transport Cost (birr/Qt) | Commodities sold at market place |
|---|---|---|---|---|---|
| Durame | | | | | |
| Shinshico | | | | | |
| Adilo | | | | | |

Mode of transport; 1=feet 2= bus 3= other………………

Commodity; 1 = cereals 2= improved forage legume 3=coffee 4 = fruits & vegetables 5=livestock

6.3 Who are your buyers? 1=Local consumers 2=Cooperative 3=Middlemen 4=Other specify

6.4 Did you face any marketing problem to your farm outputs? 1=Yes 0= No

6.5 If yes, what are they?

| No | Market problem | For crop products | | For livestock products | |
|---|---|---|---|---|---|
| | | Yes | No | Yes | No |
| 1 | Low output price | | | | |
| 2 | Lack of storage facilities | | | | |
| 3 | High transportation cost | | | | |
| 4 | Others, specify | | | | |

6.6 Which type of agricultural inputs do you use for forage legume production in 2011E.C.? 1/ vetch seed 2/ alfalfa seed 3/ dismodium seed 4/ pigeon pea seed 5/ sesbania seed 6/ luecenea seed 7/ local forage seed

6.7 What type of fertilizer did you use? 1/NPS 2/ Urea 3/ Other specify

6.8 What are the sources for agricultural inputs? 1/ market 2/KDLFDO 3/ cooperative

4/ Other specify

**Part VII Credit accessibility**

7.1/ Is there any credit facility/institute or Access to Credit in this district? 1= Yes 0=No

7.2/ Have you obtained credit for improved forage legume production in the last three years? 1=Yes 0= No

7.3/ If yes, from where you get and how much did you get?

1=Equib 2= Bank 3=Micro-finance 4=Edir 5=cooperatives 6.Others, ----------------------

Amount (in Birr) --------------------------------

7.4/ for what purpose did you use the credit?

1) For purchasing fertilizer 2) For purchasing improved seeds/planting material 3) For purchasing chemicals 4) Other purpose (Specify) -----------------------

7.5/ Have you obtained credit of improved forage legume in kind? 1=Yes 0=No

7.6/ If yes, from where you get and how much did you get?

Source --------------------------------------------

Amount planting material (in K/gram, in number of seedlings or cuttings) ------------------

7.7 Quantity of inputs purchased /used for improved forage legume production and their price in 2011E.C

| Input type | Quantity purchased/ used | Unit price Birr /kg |
|---|---|---|
| Vetch | | |
| Alfalfa | | |
| Sesbania | | |
| Dismoodium | | |
| Pigeon pea | | |
| Luceanea | | |
| NPS | | |

7.8 Did you face problem on getting farm inputs? 1=Yes 0=No

7.9 If yes what are they?

| No | Input problem | For seed | | For Fertilizer | |
|---|---|---|---|---|---|
| | | Yes | No | Yes | No |
| 1 | High input price | | | | |
| 2 | High transportation cost | | | | |
| 3 | Too late delivery | | | | |
| 4 | Quality | | | | |
| 5 | Others, specify | | | | |

7.10 How much does the timeliness of availability of inputs affect your status of input adoption? Tick 1= high effect 0= not effect

7.11 Do you expect low price in forage legume? 1=Yes 0=No

7.12 When you expect low prices?.....................................................................

**Part XIII Access to Extension services**

8.1 Is there access to extension service in your area? 1=Yes 0=No

8.2. Do you know the extension agent in your area? 1=Yes 0=No

8.3 Do you know where you can get farm assistance/advice about livestock forage legume in your village/area? 1=Yes 0=No

8. 4 If the answer is yes, on question 8.3 above, please specify where you can get assistance about your livestock forage legume ________________________________

8.5 Does the government plays an important role in helping farmers through the extension service? 1=Yes 0=No

8.6 The extension agents are friendly and easily approachable regarding your farm problems? 1=Yes 0=No

8.7 Do you grow improved forage legumes? 1=Yes 0=No

8.8 When have you first heard of improved forage legume? _____________

8.9 From whom/which source? ___________________________

8.10 which improved forage legume have you first grown?

1) -----------------2) ------------3) -------------4) others (specify) ------------

8.11 How many improved forage legumes types you have? 1/ one 2/two 3/three

8.12. Why did you choose this particular forage legume first? ------------------------

8.13 Did you use it continuously? 1=Yes 0=No

8.14 Once the improved forage legume is grown for how long it serves

1/ one year 2/ one to two years 3/ three years 4/ other specify

8.15 Which improved forage legume you have grown so far? when you have grown them?

| Type of forage legume | First grown Year | Duration of use (Years) | Reason for stopping if not using now |
|---|---|---|---|
| Vetch | | | |
| Alfalfa | | | |
| Sesbania | | | |
| Dismoodium | | | |
| Pigeon pea | | | |
| Luceanea | | | |

Reason for stopping 1) Availability of better type purchase price 2) Unavailability of seeds/planting material 3) High seed/ planting material price 4) Low yield in my field 5) disease and pest problem 6) Others (Specify)

8.16 Have you participated in improved forage legume field day/ visit in the last three years? 1=Yes 0=No

If yes, how many times ----------------------------------------

Who arranged for you? 1) KDLFRDO 2) Research 3) NGO 4) Others (Specify)

8.17. Do you think the extension system (through extension agents) offers what you really need? 1=Yes 0=No

8. 18 Would you encourage one of your friends to attend an extension education program in your area? (Give a reason for your response) 1=Yes 0=No

Reason: -----------------------------

**Part IX Extension Agent's contact**

9.1. Do you have contact with extension agent? 1=Yes 0=No

9.2. How much contact you had with extension agent? 0=No 1= per week 2= per month 3= per year

9.3 Do you get advisory services from extension agents? 1=Yes 0=No

9.4 When does extension agent visit you? 1) During land preparation 2) During sowing 3) When disease/ pest occur 4) during harvesting 5) others (Specify)

9.5 Do you visit extension agent? 1=Yes 0=No

| Sources of information | How often you contact them | | | | | Means of Information exchange |
|---|---|---|---|---|---|---|
| | Never(0) | Once in a year( 1) | Monthly(2) | Weekly(3) | Daily(4) | |
| Researcher | | | | | | |
| Contact farmer | | | | | | |
| Fellow farmer | | | | | | |
| Kebele leader | | | | | | |
| NGO | | | | | | |
| Cooperative | | | | | | |
| Neighbors/ friends | | | | | | |
| Input dealers | | | | | | |
| Agricultural professional | | | | | | |

9.6 If yes, when do you visit? 1) During sowing for technical advice 2) During input provision to obtain inputs 3) It depends (any time when there is technical problem)

9.7 What are your other sources of information and how often you use/ have contact with them?

Means of information exchange: 1) Demonstration 2) Field day/visit 3) Training 4) Written materials (leaflets, manuals, and so on) 5) Others (specify)

9.8 Does the extension agent provide good ideas that help you in improving your livestock forage legume production? 1=Yes 0=No

9.9. Does the extension agent is readily available (can easily be reached) to help you? 1=Yes 0=No

9.10 How would you rate the quality of your extension agent in helping farmers in your area? 1=Excellent 0=Poor

9.11What are the major forage legume production problems?

1. Land shortage 2. Lack of soil fertility 3. Lack of inputs 4. Drought 5. lack of extension service 6. Other specify

**Appendix 2: Checklist used to conduct focused group discussion**.

Agriculture and Natural Resource and Livestock and Fishery Resource Development office is annoying to popularize improved forage legume, which is thought to improve livestock productivity of small holder farmer. In addition, development agents are supporting the farmers in different dimensions to increase adoption of improved forage legume. Though, the majority of the farmers are not adopting the improved forage legumes.

- Why?
- Why few farmers are adopting the improved forage legume?
- Can adopting the improved forage legume benefit farmers or not? If yes how? If no why?
- What are farmers experienced difficulties in adopting the improved forage legume?
- What are the general impressions /overall effect about adopting the improved forage legume?

- How can you get improved forage legume input in required quantity at the right time?
- Which type of forage legume did you use mostly in your locality and why?
- Which type of forage legume /local type or improved type/ you like better to produce and why?

Appendix 1. Conversion factor used to compute adult equivalent (Labour Force)

| Age group (years) | Male | Female |
|---|---|---|
| Less than 10 | 0.0 | 0.0 |
| 10-13 | 0.2 | 0.2 |
| 14-16 | 0.5 | 0.4 |
| 17-50 | 1.0 | 0.8 |
| Greater than 50 | 0.7 | 0.5 |

Source: Abebe Haile Gebriel, 2000

Appendix 2. Conversion factors that used to estimate tropical livestock unit

| Animal Category | TTLU | Animal Category | TLU |
|---|---|---|---|
| Calf | 0.25 | Donkey (young) | 0.35 |
| Weaned Calf | 0.34 | Camel | 1.25 |
| Heifer | 0.75 | Sheep & Goats (adult) | 0.13 |
| Cow and Ox | 1.00 | Sheep & Goats (young) | 0.06 |
| Horse | 1.10 | Chicken | 0.013 |
| Donkey (adult) | 0.70 | | |

Source: Stork, *et al.*, 1991. TLU= Total Livestock Unit.

Appendix 3.Sample size determination from selected kebeles

| Kebeles | Population (HH heads) | | | Sample size | | |
|---|---|---|---|---|---|---|
| | Male | Female | Total | Male | Female | Total |
| Bezena benara | 542 | 210 | 752 | 48 | 18 | 66 |
| Aze dobo | 543 | 204 | 747 | 48 | 18 | 66 |
| Zato shodera | 421 | 188 | 609 | 37 | 17 | 54 |
| Total | 1506 | 602 | 2108 | 133 | 53 | 186 |

(Source: own computation using kebele documents, 2019)

Appendix 4 Definitions and measurements of variables used in the logistic regression model

| Definition of variables | Nature and units of measurement of variables | Expected Sign |
|---|---|---|
| Dependent variables | | |
| Adoption of improved forage legume | Dummy (yes/no) | 1 or 0 |
| Independent variables | | |
| Sex of the household head | Male/female | + |
| Age of the household head | Years | + or - |
| Family size | Number of families in the HH | + |
| Education of the household head | Attended/None | + |
| Household labour availability | Number (productive in AE) | + |
| Grazing land size | In ha | + |
| Livestock owned | TLU | + |
| Farm income | ET Birr | + |
| Livestock income | ET Birr | + |
| Participation in off-farm activities | Yes/no | + |
| Access to credit service | Yes/no | + |
| Contact with development agents | Yes/no | + |
| Distance from near market center | In Kilometers | - |

Appendix 5 Age distribution by adoption of improved forage legume, Kedida Gamela District, Kembata Tembaro Zone, Ethiopia**.**

| Age of the Household head | Household heads | | Total | t- value |
|---|---|---|---|---|
| | Adopter N=51 | Non-Adopter N=135 | N=186 | |
| Minimum | 30.00 | 26.00 | 26 | |
| Maximum | 75.00 | 95.00 | 95 | -0.215 |
| Mean | 46.1961 | 45.8000 | 45.95 | |
| Std.Deviation | 10.82039 | 11.36031 | 11.14 | |

(Source: own survey data)

Appendix 6. Summary of descriptive statistics of continuous explanatory variables.

| Variables | Mean | | | t-value | P -value |
|---|---|---|---|---|---|
| | Total HH(186) | Adopter | Non-adopter | | |
| AGE | 45.908 | 46.1961 | 45.8000 | -0.215 | 0.830 |
| FAMSZ | 5.543 | 5.9608 | 5.3852 | -1.855* | 0.065 |
| GLANDSZ | 0.219 | 0.258 | 0.2053 | -1.765* | 0.079 |
| LOWND(TLU) | 2.087 | 2.5326 | 1.9187 | -3.346*** | 0.001 |
| LVSTKINC | 3421.83 | 4284.90 | 3095.77 | -1.039 | 0.300 |
| FARMINC | 12352.29 | 7356.80 | 9408.09 | 1.010 | 0.314 |
| HHLOBR | 3.50 | 3.7882 | 3.3963 | -1.504 | 0.134 |
| DSNMC | 7.37 | 6.08 | 7.86 | 6.186*** | 0.000 |

*, and *** significant at less than 10% and 1% respectively.

(Source: own survey).

Appendix 7. Summary of descriptive statistics of dummy explanatory variables.

| Variables | Categories | % value of Adoption status | | $\chi^2$ - value | p-value |
|---|---|---|---|---|---|
| | | Adopters % | Non adopters% | | |
| SEX | Male | 78.4 | 65.9 | 2.724* | 0.099 |
| | Female | 21.6 | 34.1 | | |
| EDUC | None | 29.4 | 42.2 | 3.422* | 0.064 |
| | Attended formal education | 70.6 | 57.8 | | |
| PARTOFFA | Yes | 84.3 | 49.6 | 18.428*** | 0.000 |
| | No | 15.7 | 50.4 | | |
| ACCCS | Yes | 88.2 | 28.9 | 52.641*** | 0.000 |
| | No | 11.8 | 71.4 | | |
| FRQAEC | Yes | 82.4 | 45.2 | 20.694*** | 0.000 |
| | No | 17.6 | 54.8 | | |

*, and *** significant at less than 10% and less than 1% respectively. (Source: own survey).

Appendix 8.Multicolliniarity test among continuous variables.

| Continuous variables | Collinearity Statistics | |
|---|---|---|
| | Tolerance ($R^2_i$ ) | VIF |
| Age of the Household | 0.837 | 1.195 |
| Family Size of the Household | 0.440 | 2.273 |
| Grazing land size of the household in hectare | 0.939 | 1.065 |
| livestock ownd (TLU) | 0.876 | 1.141 |
| Livestock income of household in Birr | 0.446 | 2.243 |
| Farm income of household in Birr | 0.477 | 2.095 |
| Household labor availability | 0.431 | 2.319 |
| Distance from nearest market in kilometer | 0.810 | 1.235 |

Appendix 9. Contingency coefficient of categorical variables

| Categorical variables | Contingency coefficient | Chi square |
|---|---|---|
| SEX | 0.120 | 2.72 |
| EDUC | 0.134 | 3.422 |
| PARTOFFA | 0.300 | 18.428 |
| ACCCR | 0.470 | 52.541 |
| EAC | 0.316 | 20.694 |

Appendix 10.The results of logit model.

| Variables | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|
| AGE | 0.018 | 0.023 | 0.673 | 1 | 0.412 | 1.019 |
| SEX | 1.433 | 0.683 | 3.185 | 1 | 0.074* | 3.382 |
| EDUC | 0.804 | 0.562 | 2.044 | 1 | 0.153 | 2.235 |
| FAMSZ | -0.036 | 0.218 | 0.028 | 1 | 0.867 | 0.964 |
| GLANDSZ | 2.879 | 1.596 | 3.256 | 1 | 0.071* | 17.794 |
| TLU | 0.572 | 0.238 | 5.782 | 1 | 0.016** | 1.772 |
| LVSTKINC | 0.000 | 0.000 | 0.168 | 1 | 0.682 | 1.000 |
| PARTOFFA | 1.657 | 0.596 | 7.737 | 1 | 0.005*** | 5.242 |
| FARMINC | 0.000 | 0.000 | 0.347 | 1 | 0.556 | 1.000 |
| HHLOBR | -0.002 | 0.235 | 0.000 | 1 | 0.993 | 0.998 |
| DSNMC | -0.621 | 0.192 | 10.450 | 1 | 0.001*** | 0.537 |
| ACCCRS | 2.329 | 0.599 | 15.107 | 1 | 0.000*** | 10.267 |
| FRQEAC | 1.867 | 0.555 | 11.339 | 1 | 0.001*** | 6.471 |
| Constant | -4.418 | 1.990 | 4.931 | 1 | 0.026 | 0.012 |

Chi-square=110.221***, Sig= 0.000;
-2log likelihood=108.287, Cox & Snell R square= 0.447, Nagelkerke R square= 0.647
Percentage of correct prediction=88.7;
*, ** and *** are significant at less than 10%, 5%, and 1% probability level respectively.
(Source: Model out put)