

**DETERMINANTS OF ADOPTION OF ARTIFICIAL INSEMINATION
TECHNOLOGY OF DAIRY CATTLE: THE CASE OF BEDELE
WOREDA OF BUNO BEDELE ZONE OF OROMIA REGION OF
ETHIOPIA**

MSc THESIS

TESFAYE SOLOMON

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HARAMAYA UNIVERSITY, HARAMAYA

**Determinants of Adoption of Artificial Insemination Technology of Dairy
Cattle: The Case of Bedele Woreda of Buno Bedele Zone of Oromia
National Regional State of Ethiopia**

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Agribusiness
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DEDICATION

This paper is dedicated to My Mother W/Ro Almaz Abdeta and my uncle Ato Getachew Gonfa.

STATEMENT OF THE AUTHOR

By my signature below, I declare that this thesis is my own work. I have followed all ethical and technical principles of scholarship in the preparation, data collection, data analysis and compilation of the Thesis. Any scholarly matter that is included in the Thesis has been recognized through citation.

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BIOGRAPHICAL SKETCH

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ABBREVIATIONS AND ACRONYMS

AI	Artificial Insemination
AIC	Akaike Information Criterion
AIT	Artificial Insemination Technology
BWAO	Bedele Woreda Agricultural Office
BWLF	Bedele Woreda Livestock and Fishery
CSA	Central Statistical Authority
DA	Development Agent
GDP	Gross Domestic Product
HH	Household
HU	Haramaya University
ILRI	International Livestock Research Institute
Km	Kilometer
TLU	Tropical Livestock Unit

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Determinants of Adoption of Artificial Insemination Technology of Dairy Cattle: The Case of Bedele Woreda of Buno Bedele Zone of Oromia National Regional State of Ethiopia

ABSTRACT

Artificial insemination technology of dairy cattle is a popular technology to improve the performance of new breeds. But, the adoption and utilization of the technology by dairy cattle owners in Ethiopia in general and study area in particular is very low. This study was conducted in Bedele Woreda of Buno Bedele zone of Oromia National Regional State with the aim of assessing determinants of adoption decision and intensity use of artificial insemination technology of dairy cattle. This study used cross sectional data which was collected from a total of 174 farm households which were randomly and proportionally selected from 4 kebeles of the Woreda using two stage sampling technique. The primary data were collected through individual interviews of respondents using semi-structure questionnaire. Secondary data was collected from different relevant literatures such as Woreda reports, publications, journals and other documents relevant for the study. Descriptive statistics and Econometric model were used to assess the collected data. The result of Descriptive statistics indicated that about 36.78% and 63.22% of respondents were adopters and non-adopters of artificial insemination of dairy cattle respectively. The results from probit regression of double hurdle model revealed that education level, non-farm income, landholding size, experience in utilizing artificial insemination technology, amount of credit obtained and extension contact positively and significantly affected the probability of adoption decision of artificial insemination technology of dairy cattle. Whereas sex, age, distance from extension center and dependency ratio are negatively and significantly affected the probability of adoption decision of artificial insemination technology of dairy cattle. The truncated regression result of double hurdle model asserts that Education level of household heads, landholding size, experience in utilizing artificial insemination technology; amount of credit obtained and extension contact affected the intensity of use of artificial insemination technology positively and significantly. While, age and distance from extension center were negatively and significantly affected the intensity of use of artificial insemination technology of dairy cattle. Therefore, attention should be given to major factors that affect adoption decision and intensity use of artificial insemination technology by Woreda livestock and fishery development office to increase production and productivity of dairy sector.

Keywords: Adoption, intensity of adoption, artificial insemination, double hurdle model

1. INTRODUCTION

1.1. Background of the Study

In Ethiopia, the agricultural sector is a corner stone of the economic and social life of the people. It is also the foundation of Ethiopian economy which supports about 85% of the population in terms of employment and livelihood which mainly depends on crop and livestock production. It contributes over 41% of the country's gross domestic product and generates about 90% of export earnings (Samuel *et al.*, 2017).

Livestock production is one of the fastest growing agricultural sectors in developing countries, where it accounts for more than one-third of agricultural Gross Domestic Product (Temesgen *et al.*, 2017). Ethiopia is the largest livestock producer in Africa with more than 59.5 million cattle, 30.70 million sheep, 30.20 million goats, 2.16 million horses, 8.44 million donkeys, and 0.41million mule, 1.21million camels and 56.53 million poultry. About 98.2% of the total population of cattle is local breeds. But, the population of hybrid and exotic breeds are estimated at about 1.62% and 0.18% respectively (CSA, 2017).

The livestock sector contributes much to the economy of the country in general and the improvement of people's livelihood in particular (Endalew and Ayalew, 2016). It supports the livelihoods of a large number of rural as well as urban and peri-urban households in Sub-Saharan Africa particularly Ethiopia (Assefa and Hailu, 2018). Its contribution to the total Gross Domestic Product (GDP) of the country is about 15 to 17% as well as 37 to 87% of the household incomes (ILRI, 2015). Rearing of livestock in Ethiopia is not only for economic development but also for getting by-products like meat, milk, butter, etc that provides a nutritional diet for the household (Endalew and Ayalew, 2016). It provides export commodities, such as live animals, hides and skins to earn foreign exchanges to the country due to surplus output and preferably of the breeds in the Middle East Countries (CSA, 2018).

Even though Ethiopia has the largest livestock population, the contribution of the country's livestock sector in general and the dairy sector, in particular, is below its potential at both the national and household level (Behnkle, 2010). Although there are a large number of diverse animal genetic resources in Ethiopia, the livestock productivity, especially on milk and meat,

remains very low (Wondossen and Tesfaye, 2017). According to Guadu and Abebaw (2016), the low production level of the livestock sector is attributed to the inefficient productivity of the livestock as a result of the traditional method of production, poor breeds, poor feeding, inferior health care and services and low capital investment in human and fixed assets.

The dairy production in Ethiopia plays a crucial role in the rural household's economy and livelihood. However, the level of dairy productivity in the country remains relatively low since the production activity is dominated by indigenous breeds which have poor genetic potential and low productivity capacity (Samuel *et al.*, 2017). The country is facing an increasing demand of dairy cattle products for food as human population keeps increasing rapidly. This is due to that the dairy industry in the country also facing a critical shortage of high producing dairy cows. In order to give responses for such highly demands, different livestock development projects and breeding strategies were made by introducing crossbred animals to improve milk productivity and milk market involvement of subsistence farmers (Kebede, *et al.*, 2018).

Crossbreeding and Artificial Insemination (AI) are the breeding strategies which are executed to increase the productivity of dairy cattle as well as the profitability of the dairy production. In addition, there is a need for the expansion of the national dairy production through efficient and cost effectiveness breeding technologies such as artificial insemination technology (Biru *et al.*, 2018).

Artificial Insemination (AI) is considered as a promising, cheaper and faster tool to improve genetic potential of dairy cattle. It was introduced into Ethiopia in 1938 as a means for genetic improvement of dairy cattle (Riyad, *et al.*, 2017). Its main advantage is for elimination of the costs incurred and dangers of maintaining a bull on the farm (Raey, 2014). The use of artificial insemination technology in developing country is intended to allow the rapid genetic improvement of dairy cattle in order to ensure high productivity and better livelihood status among small dairy owner households (Ingabire, 2018).

Even though the introduction of AIT into Ethiopia was a long period of time, its expansion and effectiveness at household level is still very low (Gebre Medhin *et al.*, 2007). According to the Woreda report of 2018, Bedele Woreda experiences the same condition concerning low

prevalence of service provision like readily availability of semen, liquid nitrogen and adequate number of artificial insemination inseminators. There is a limited land size and shortage of labour to keep a cow that have low genetic potential for milk production which is uneconomical. This implies that the welfare of the dairy owners is not guaranteed. Although the Woreda has high potential in the production of dairy cattle, the productivity of dairy cattle was very low (BWLF, 2018). For this matter, the development and widely adoption of improved dairy cattle that have higher genetic potential for milk production need to be implemented with the aim of achieving higher productivity and consequently alleviating poverty among the dairy owners in the Woreda. Besides, the low level of adoption of artificial insemination technology of dairy cattle contributed for low productivity of dairy cattle in the Woreda. But, information on status of artificial insemination technology of dairy cattle and factors that favor or limit the adoption decision and intensity of use of artificial insemination technology of dairy cattle is unknown. Therefore, this study was proposed to provide primary information on factors affecting adoption decision and intensity of use of artificial insemination technology of dairy cattle in Bedele Woreda.

1.2. Statement of the Problem

Ethiopia is the home of Africa's largest livestock population as well as the top livestock producer but the fewer exporters of live cattle on the continent (Endalew and Ayalew, 2016). The country is also endowed with the highest population of dairy cattle. But, the productivity of the dairy sector is very poor. Furthermore, dairy production systems in the country are traditional and the cattle breeds used in the system have a poor genetic potential that yields a low amount of milk per lactation (Tadesse *et al.*, 2017).

The increasing demand for milk products provides opportunities for dairy cattle owners to realize their better livelihoods. While the increasing demand for milk products in Ethiopia is widely known, the dairy sector has not been able to produce adequate milk to satisfy this demand, mainly due to low productivity of dairy animals. The researcher also stated that the preconditions for increasing livestock productivity and resource use efficiently in the smallholder dairy sector is based on availability of improved breeds of dairy cows and cultivation of improved forages (Gunte, 2015).

According to Mijena *et al.* (2017), the cattle breeding system in Ethiopia is mostly uncontrolled which makes genetic improvement difficult. Furthermore, an appropriate bull selection criterion has not yet been established, applied and controlled. In Ethiopia, the improvements in livestock production have generally been inadequate and one of the limiting factors has been the lack of genetically improved livestock (Aregawi, 2013).

The increasing demand for animal products and the very low productivity of the indigenous cattle in Ethiopia makes it essential for animal scientists and other stakeholders to find a way of improving the productivity performance of the indigenous cattle (Joseph *et al.*, 2014).

Crossbreeding and artificial insemination technology are the most commonly used techniques for improving the productivity performance of indigenous cattle (Ojango *et al.*, 2016). The genetic improvement of dairy cattle has been mainly focused on cross breeding in order to combine high milk yield potential of exotic breed with adaptive potential of local breeds (Katpatal, 1977). The main problems that could hinders the cross breeding system in Ethiopia are, lack of cross breeding policy, poor infrastructure, poor market system and lack of finance and trained man power(Tona, 2018).

Artificial insemination technology (AIT) is another important technique for breeding that has been extensively used in dairy farming in the Worldwide (Bagheri and Razeghi, 2011). It is an assisted reproduction technology (ART) used worldwide for the rapid genetic improvement of livestock. In addition, it is economically beneficial and ensures freedom from several diseases (Mazimpaka *et al.*, 2018). It is a fundamental instrument for the rapid improvement of livestock allowing for maximum use of best sires as well as enhances production and returns from livestock at a faster rate through crossbreeding program. The technology also speeds up genetic progress, reduces the risk of disease transmission and increases the number of animals that can be bred from superior parents (Temesgen *et al.*, 2017).

The success of artificial insemination technology depends on its reliability and its technical results, which is governed by the link between the health of animals, effectiveness of semen collection centers' inseminators and dairy producers (Getachew and Tadele, 2015).

The development of the livestock industry and its role in poverty mitigation in developing countries depends on how adaptive the production systems (Ojango *et al.*, 2016). Adoption of

artificial insemination technology of dairy cattle is an effective modernization in the dairy industry of the developing countries where most of the producers are smallholders. The high yielding capacity of dairy cattle has also a marked positive impact on smallholder's income and thus their standards of living (Nandadasa and Edirisinghe, 2013).

The low genetic potential of dairy cattle played high role for the low productivity of dairy cattle in bedele Woreda (BWLF, 2017/18). In spite of a number of advantages of artificial insemination technology over natural breeding, the adoption and the intensity use of the technology in study area existing at the lower level. In addition, the adoption of artificial insemination technologies has been low, despite numerous efforts have been made to disseminate the technologies in the past. Moreover, the number of AI adopter households in the Woreda is very small (BWLF, 2017/18). Furthermore; studies on the adoption of artificial insemination technology of dairy cattle haven't been done yet in the Woreda. Therefore, there was a need to distinguish factors affecting the adoption decision and intensity use of artificial insemination technology of dairy cattle by dairy owners and provide intervention strategies to the problem. Thus, this study was designed to generate detailed information on the factors affecting the adoption decision and intensity of use of artificial insemination technology of dairy cattle in Bedele Woreda of Oromia national regional state.

1.3. The Objectives of the Study

The general objective of the study is to assess determinants of adoption decision and intensity of use of artificial insemination technology of dairy cattle in Bedele Woreda of Buno Bedele zone.

The specific objectives of the study were:

1. To examine factors affecting the adoption decision of artificial insemination technology of dairy cattle in the study area, and
2. To identify factors affecting the intensity of use of artificial insemination technology of dairy cattle in the study area

1.4. Research Questions

In light of the above research gaps, this study was proposed to reply empirically to the following research questions.

1. What are the determinants of adoption decision of artificial insemination technology of dairy cattle in the study area?
2. What are the determinants of intensity of use of artificial insemination technology of dairy cattle in the study area?

1.5. Significance of the Study

Increasing the dairy products in the developing world in general and Ethiopia, in particular, had been a primary concern of the policy makers and development agencies for many years. But, the productivity of dairy cattle is not matched with the existing demands yet. Improved dairy technology which is the results of scientific research must be available to farmers, along with full information on how to use the new technologies. If researchers lack understanding of households' problems and the conditions under which they are operating, it may result in the development of inappropriate technologies and fail to accelerate the process. However, many households in Bedele Woreda prefer natural mating method for rearing dairy cattle rather than using artificial insemination technology.

Therefore, the result of this study would help the farmers, policy makers, researchers and other stakeholders to know the reasons why dairy owners prefer natural mating rather than using artificial insemination technology and provide information on driving factors of the extent of adoption of artificial insemination technology of dairy cattle. Furthermore, it would serve as a catalyst for others similar detailed and comprehensive studies in the country.

1.6. Scope and Limitations of the Study

This study was confined to Bedele Woreda of Oromia national regional state, focusing on the dairy cattle owners of households in the Woreda. The adoption of artificial insemination technology of dairy cattle in the Woreda was studied in four representative Kebeles using

sample size of 174 dairy cattle owners. Focusing on adoption of artificial insemination technology of dairy cattle rather than other dairy technologies such as feeding, housing, and veterinary service practices was one of the limitations of the study. The other possible limitation of the study was the types of data. This study used cross sectional data collected in 2017/18 production year to analyze factors affecting adoption decision and intensity use of artificial insemination technology of dairy cattle which may not show the dynamic nature of variation in adoption of the technology by dairy cattle owners in the study area. However, the result of this study would help mainly to the areas having the same features and can be utilized as a reference for other similar studies.

1.7. Organization of the thesis

This thesis is organized into seven chapters. In the first chapter, introductory parts of the research are displayed. Chapter two presents reviews of literatures that provides broader views on the methodological framework, conceptual, theoretical and empirical studies of adoption and intensity use of artificial insemination technology. In chapter three, methodology of the study was dealt and chapter four covers discussion of the major findings of the study. Chapter five summarizes and concludes the findings of the study with certain policy recommendations. The last two chapters present reference and appendixes

2. LITERATURE REVIEW

2.1. Definition of Basic Terms

Adoption: According to Feder *et al.* (1985), adoption may be defined as the incorporation of innovation into farmers' normal farming activities over an unlimited period of time. As stated by Ban and Hawkins (1996), the term adoption is defined as the act or process of commencement to utilize something new or different within a reasonable period of time. Adoption of technology is not a one-step process; it takes time for adoption to complete (Rundquist, 1984). As stated by Ghosh *et al.* (2005), adoption of any advanced technology includes a process in which attentiveness is created, outlooks are changed and favorable conditions for adoption are provided. On the other hand, adoption is the use or not to use new technology by a farmer at a given period of time. Amuge (2017) stated that adoption is a conscious decision to use and implement a technology by farmers after access to information, careful evaluation of knowledge learnt through observation, mass media, trainings from participation in community social groups, relatives and extension agents.

Artificial insemination: Artificial insemination is the process by which sperms are collected from a male, processed, stored and artificially introduced into the female reproductive tract for the purpose of conception. It involves the collection of semen from a boar and then the introduction of semen into a sow or gilt at a later stage by means of a catheter (Shehu *et al.*, 2010).

Technology: It refers to the application of knowledge to the practical aims of human life or changing and manipulating the human environment. It is an idea, an object or practice that is supposed as innovative by the members of the social system (Mahajan and Peterson, 1985). It includes the use of materials, techniques, tools and source of power to make life easier or more pleasant and work more productive. It is a systematic application and collective human rationality to the solution of the problems through the assertion of control over nature and all kinds of human processes (Olayide, 1980).

Intensity of adoption: The intensity of adoption is defined as the level of adoption of artificial insemination technology by the households in the study area (Marie *et al.*, 2018).

2.2. The Roles of Livestock in Ethiopian Economy

Researchers and policymakers increasingly recognize that the livestock sector supports the livelihoods of a large proportion of rural households in most African countries and may have an important role to play in rural poverty reduction strategies (Makokha, 2005). The sector contributes a substantial share of Ethiopian economy which is strongly linked to other agricultural activities, through draft power in particular, provides employment to a large number of people and a major source of foreign exchange (Gelan *et al.*, 2012). It is the major contributor directly and indirectly to the Gross Domestic Product (GDP) of many developing countries' economy.

A large number of rural households in developing countries own livestock, which is playing a high role in the economic development of the community (Herrero *et al.*, 2013). Rearing livestock has many functional activities in Ethiopia. Beyond their direct role in generating food and income, livestock is a valuable asset, serving as a store of wealth, collateral for credit and an essential safety net during times of crisis (FAO, 2017). There are many roles of livestock in Ethiopian economy in providing food, soil fertility and input for crop production, raw material for industry, social functions, cash income as well as in promoting saving, fuel and employments (Solomon *et al.*, 2003).

The livestock sector is playing a significant role in contributing to the development of the Ethiopian economy. It provides export commodities, such as live animals, hides, and skins to earn foreign exchanges to the country due to surplus output and preferably of the breeds in the Middle East Countries (CSA, 2011). It is very important in a sustainability of the world's economy and attainment of food security (Marie *et al.*, 2018). It has been making significant contributions to Ethiopia's national economic growth. The sector now makes up 40% of the country's agricultural GDP and 27% of its national GDP (ILRI, 2018).

In Ethiopia, the Livestock sector supports and sustains the livelihoods of approximately 70% of the rural households. It is very important in economic and social both at the household and national levels and provides export earnings (G/Mariam *et al.*, 2010). It is an essential asset and safety net for the poor, especially for women and pastoralist groups, and they offer a

significant source of diet for billions of rural and urban households. These socio-economic roles and others are increasing in importance as the sector grows due to increasing human populations, incomes and urbanization rates (Herrero *et al.*, 2013). Livestock takes part in multiple roles in sustaining the livelihoods of households as the source of income.

Bimrew (2018), revealed that livestock breeds play an important role in economic, social and cultural functions for rural households in developing countries. They also contribute to improve income and wellbeing of the farm family. Livestock helps in food supplying, family nutrition, family income, asset savings, soil productivity, livelihoods, transport, agricultural traction, agricultural diversification and sustainable agricultural production, family and community employment, ritual purposes and social status (Moyo *et al.*, 2010). The authors further explained that livestock dynamically contributes to the sustainability of the agricultural system in many ways, besides acting as reserves to be used in times of need.

The contribution of the livestock sub-sector towards food supply and other needs of the Ethiopian people are less than what is expected due to the low productivity of local cattle. The use of technologies in the livestock sector enhances productivity, reduces threats of diseases and ensures environmental sustainability in productive areas (Kimunya, 2014). Rearing dairy cattle is one of livestock sub-sectors which contribute a high role in improving the livelihood of households.

2.3. Adoption of Dairy Technology

Dairy development in developing countries has played a major role in increasing milk production, improving income level of households in rural areas, generating employment opportunities and improving the nutritional standards of the people, especially for small and marginal farmers (Quddus, 2017). Ethiopia has large potential for the development of dairy production due to the country's favorable climate which supports utilization of improved, high yielding animal breeds and offers a relatively disease free environment for livestock development (Yilma, *et al.*, 2011 and Getabalew, *et al.*, 2019). The development of dairy sector in smallholder farming systems is one of the key strategic important for addressing food security and improved livelihood in developing countries particularly in Ethiopia. There is an

urgent and rising shortage of dairy products in all major cities of Ethiopia. The milk production potential of dairy cattle in most of part of the country is influenced by different factors such as:- shortage of grazing land,disease and parasites,shortage of land for cultivation of improved forage, inadequate veterinary service, low milk production of local zebu cattle, inadequate artificial insemination services and shortage of labor (Getabalew, *et al.*,2019). In order to improve the low productivity of dairy cattle, selection of the most important breeds and crossbreeding of these indigenous breeds with highly productive exotic cattle has been a practical solution(Lijalem, 2015).

The dairy production in Ethiopia is mainly of subsistent type which is largely depends on indigenous breeds of cattle. The current demand for dairy products exceeds supply which is expected to encourage the rapid growth in the dairy sectors(Melesse, *et al.*,2014).

The dairy sector in Ethiopia is mainly traditional and milk production is largely dominated by smallholder households. The smallholder dairy production is characterized by poor genetic potential of dairy cattle herds, inadequate feed resources as well as poor quality and high cost of commercial feeds, low technological input use and low productivity of dairy cattle (Kebebe, 2017). The researcher also further explained that lack of knowledge, limited resources, housing; feeding and extension services were factors that hinder the adoption of dairy technology.

2.4. Adoption of Artificial Insemination Technology of Dairy Cattle

Artificial insemination in animal production was originally developed to control the spread of disease, by avoiding the transport of live animals with potential pathogens to other animal units for mating and by avoiding physical contact between individuals (Kubkomawa, 2018).

Artificial insemination technology plays an important role in enhancing animal productivity, especially in milk yields. Farmers living in rural areas of Ethiopia prefer natural mating than AI for rearing cattle. Because, monitoring of heat in such a system is quite difficult for the farmers as they are engaged in various farm activities (Woldu *et al.*, 2011).

The utilization of AI in Ethiopia exist at a very low level due to several limitations such as infrastructural, managerial and financial constraints and also due to technical problems such as poor heat detection, improper timing of insemination and embryonic death (Mohammed, 2018). Another study also showed that AI technology has been meeting with little success due to various technical, organizational and socioeconomic constraints (Gizaw *et al.*, 2016).

The status of the households in the case of large marginal, small, and landless farmers greatly influences the program of artificial insemination technology of dairy cattle (Kumar, 2005; Temesgen *et al.*, 2017). The share of AI forms in overall breeding methods in Ethiopia is very little and this indicates the dysfunctional nature of the AI system in the country (Duncan *et al.*, 2013).

The factors that affect the implementation of AI in Ethiopia are poor heat detection and AI technicians' effectiveness, poor infrastructure, managerial and financial constraints (Shapiro *et al.*, 2015). On other hands, inadequate heat detection practices, long distance from AI center in peri-urban, lack of farmers' awareness about AI technology and differences in effectiveness of AI technician are identified as major constraints of AI services (Getachew and Tadele, 2015). Another study also indicated that management of dairy cows/heifers, the capacity of farmers and Development Agents (DAs) on handling and low awareness of farmers on estrus synchronization is the major factors affecting the results of synchronization and AI (Gatew *et al.*, 2018). In addition, poor people with poor education, land holding, occupation and mass media exposure have a low level of knowledge on AI of dairy farmers (Gautam *et al.*, 2005).

2.5. Empirical Studies on the Adoption of AI Technologies

The study conducted in Zambia by Mwambilwa, *et al.*(2013) using the general linear model of SAS has identified that poor heat detection, diseases, nutrition, and lack of record keeping and education level of household head were the major contributors for low the performance of artificial insemination technology of dairy cattle.

Dhraief *et al.* (2018) have undertaken their studies on factors affecting adoption of dairy technologies by livestock farmers in arid area of Tunisia using binary logistic regression model. The researchers found that education level of household heads, size of livestock and

off-farm income positively and significantly influence adoption of dairy technology while age of household heads and experience of household heads negatively and significantly affecting adoption decision of dairy technology.

Bobosha (2017) has undertaken research on smallholder dairy production technology transfer and adoption of constraints in mixed farming system in Girar Jarso Woreda of north Showa zone Oromia regional state, Ethiopia using descriptive statistics. The researcher found that scarcity of livestock feed, shortages of grazing land, livestock disease, low genetic potential and lack of livestock development services were factors that affecting adoption of dairy technology.

Taye *et al.* (2017) had conducted their study on factors affecting adoption and intensity use of artificial insemination technology of small dairy farmers in Loma Woreda Dawuro Zone of Southern Nations, Nationalities and Peoples regional state of Ethiopia using Tobit model. The Researchers found that landholding, information accessibility, artificial insemination training, and support have a positive and herd size has a negative statistical significant effect on adoption and intensity of adoption of AI technology. Whereas, Sime *et al.* (2014) had undertaken their study on determinants of artificial insemination on smallholder dairy farmers in Lemu-Bilbilo District of Oromia regional state using double-hurdle model. they found that contacts with extension agents, access to credit, income from milk sales, feeding concentrate to cows and family size affects the likelihood of adoption without influencing the intensity of adoption. While non-farm income affects positively the likelihood and intensity use of AI adoption, distance from the AI station and access to crossbred bull services influences both variables negatively. Education level and efficiency of AI service have a positive impact on the extent of AI use; whereas experience in keeping cross-breeds and years of using the AI influences negatively.

Beshir (2014) conducted a study in southern Ethiopia, on factors affecting small dairy farmers adoption and intensity of adoption of artificial insemination technology, found that landholding, information accessibility, artificial insemination training, and support have a positively effect on the intensity and adoption of AI technology. Whereas, the adoption and intensity use of AI technology is negatively affected by herd size.

Dehinenet *et al.* (2014) analyzed factors affecting adoption of dairy technology and its level of adoption using Heckman two-stage model. they found that family size, farming experience, availability of dairy production, extension services, availability of cross breed cows, accessibility of saving institutions, total income from milk and milk products, availability of training on livestock, age of household head and off-farm activity participation played significant roles on both the probability of adoption of dairy technology and its level of adoption.

According to Khanal and Gillespie (2013), Artificial insemination affects positively the farm profit and negatively affects the cost of milk production, while advanced breeding technologies positively affect milk produced per cows.

Marie *et al.* (2018) studied factors affecting the adoption of artificial insemination technology by small dairy farmers in Rwanda Rwamagana District. The study used descriptive statistics and a binary regression model for analyzing quantitative data and content analysis for analyzing qualitative data. Based on descriptive statistics, they found that Artificial Insemination Technology remains an essential attribute for improving reproductive performance which may ultimately lead to high dairy productivity. Using binary logistic regression, the study described that age, gender, education status, extension services, household income, distance from AI centers and access to credit have positive contributions to the adoption of AI technology among small dairy farmers. Temba (2011) has found those factors such as education level, difficulty in getting AI service, the extent of extension visits and being a member of dairy farmers' group or not are positively related with adoption and intensity use of artificial insemination technology. Whereas, factors like sex and breed of dairy cattle are negatively associated with adoption and intensity use of artificial insemination technology.

Riyad, *et al.* (2017) had conducted their study on the assessment of problems related with artificial insemination service of dairy cattle in Tullo district, west Hararge zone Ethiopia using descriptive statistics. Their result indicated that discontinuation of service on weekends and holidays, shortage of AITs, shortage of input, insufficiency of managerial and technical supports were factors that affect the artificial insemination services of dairy cattle.

Mijena, *et al.* (2017) had conducted their study on the status of artificial insemination delivering in and around Assosa Town of Ethiopia using descriptive statistics. they found that conception failure, distance of AI service from residence, lack of awareness, AI technicians' problem, insufficiency of concerned bodies support, loss of structural linkage between AI center and service giving units, absence of collaboration and regular communication among AI technicians, dairy producers and concerned government bodies, inadequate resource in terms of inputs and facilities and absence of incentives and rewards to motivate AI technicians were factors affecting negatively the delivery of artificial insemination service in the study area.

Baheriw, *et al.* (2013) had undertaken study on assessment of problems associated with artificial insemination service in west Gojjam zone of Ethiopia using inferential statistics. The result of their study indicated that the major constraints associated with artificial insemination technology of dairy cattle in the study area were loss of structural linkage between Artificial insemination centers and service giving units, absence of collaboration and regular communication between dairy owners and artificial insemination technicians, lack of breeding policy and herd recording system, inadequate resource in terms of inputs and facilities and absence of incentives and rewards to motivate artificial insemination technicians.

Bayei and Nache (2014) did their research on the effect of socio-economic characteristics of dairy cattle owners on the adoption of artificial insemination technology in Kaduna State of Nigeria using both descriptive and inferential statistics. They found that education attainment and age of households had a significant and linear relationship with adoption of artificial insemination technology of dairy cattle at less than 5% significant level.

2.6. The Methodological Framework of the Study

According to Swanson (1984), households must have knowledge of how to use the technology correctly for the best productivity of their farming system in order to success the adoption of the technology. Moreover, farmers are assumed to maximize expected utility. According to (Von-Neuman and Morgenstern, 2007), a function defined over wealth(W). When confronted with a choice between two alternative practices, the i th farmer compares the expected utility with modern technology, $Emi(W)$ to the expected utility with the traditional

technology $Eti(W)$. While, direct measurement of farmers' perceptions and risk attitudes on farming technology are not available, inferences can be made for variables that influence the distribution and expected utility evaluation of the technology. These variables are used as a vector 'X' of attributes of the choices made by farmer 'i' and ϵ_i is a random disturbance that arises from unobserved variation in preferences, attributes of the alternatives, and errors in optimization.

Given the usual discrete choice analysis and limiting the amount of non-linearity in the likelihood function, $Emi(W)$ and $Eti(W)$ may be written as:

$$Em_i(W) = \alpha mi X mi + \epsilon mi \quad (1)$$

$$Et_i(W) = \alpha t_i X t_i + \epsilon t_i \quad (2)$$

The difference in expected utility may then be written as:

$$E_i(W) = Emi(W) - Eti(W) = \alpha_i X_i + \epsilon_i \quad (3)$$

A preference for modern technology will result if $E_i = Emi(W) - Eti(W) > 0$; whereas, a preference for the traditional technology will be revealed if $Emi(W) - Eti(W) < 0$. The observed adoption of artificial insemination is hypothesized to be the end result of socio-economic characteristics of households and a complex set of inter-technology preference comparisons made by households (Adesina and Forson, 1995).

2.7. Analytical Framework of the Study

In order to analyze households' decision problem, different analytical models have been applied. As noted by Feder *et al.* (1985), the most commonly used qualitative models to study adoption behavior are the Logit and the probit models. These models specify a functional relationship between the probability of adoption and various explanatory variables (Bekele *et al.*, 2000). The Logit and Probit models are used to determine factors affecting the adoption decision of artificial insemination technologies (Mwabu *et al.*, 2006). But, both models have an inadequacy in the case that they do not measure the extent of technology adoption (Feder *et al.*, 1985).

In order to overcome this shortcoming, the Heckman two-stage models, double-hurdle models, and Tobit models could be used to examine factors affecting adoption decision and intensity of use of artificial insemination technology. The Tobit model is used with the assumption that the two decisions are affected by the same set of factors (Green, 2003). The Tobit model is an extension of the probit model and it is one of the approaches dealing with the problem of censored data (Johnston and Dandiro, 1997). When the decisions are made jointly, the Tobit model is appropriate for analyzing the factors affecting the joint decision (Greene, 2007; Teklewold *et al.*, 2006). Another researcher also advocated this argument as the Tobit model is more suitable for analyzing the condition where the decision to adopt and extent of use of AIT are made jointly and affected by same factors (Murage *et al.*, 2012). However, in principle, the decisions on whether to adopt and how much to adopt can be made jointly or separately.

Tobit model is limited in the sense that it is observed only if it is above or below some cut off level. This implies that it underestimates the intercept and overestimates the slope. Tobit model seems to conceal some information that it tends to combine both the direct and partial effects of the explanatory variables on the dependent variables (Makhura, 2001). The other limitation of the model is its consideration that the two decisions are affected by the same set of factors (Green, 2003). This is not realistic in most conditions. Berhanu and Swinton (2003) argued that adoption and extent of decisions are not necessarily made jointly. For this matter, this study will not use the Tobit model; because the recent empirical studies have shown the inadequacies of the model. Some households adopt artificial insemination technology and some others do not adopt. There is also a difference among the adopters in the level of adoption. The Tobit model might not answer the questions such as why some households adopt and some not and why does the level of adoption differ among the adopters. But, the double hurdle model can answer the questions. Therefore, the double hurdle model is more appropriate than the Tobit model.

Heckman two stages might be another alternative model that could be used for analyzing factors affecting adoption decision and intensity use of artificial insemination technology. One of the important differences between the double hurdle model and Heckman two stages models is regarding the source of zeroes. In the Heckman model, the non-adopters would

never adopt the technology under any condition. But, in the case of a double hurdle model, non-adopters of the technology are considered as a corner solution in utility maximizing model. That means an increase in awareness creation of households on the advantage of artificial insemination technology and the extensive extension contact may encourage non-adopters to adopt the technology. In the case of the adoption of artificial insemination technology of dairy cattle, the Heckman's assumptions seem to be too restrictive (Jones, 1989). Using the double-hurdle model is more appropriate than Heckman's two-stage model. In this study; double hurdle model would be used to analyze factors affecting adoption decision and intensity use of artificial insemination technology of dairy cattle. On other hand, in order to select either the Tobit or double hurdle model, both models should be run separately. After running the models separately, a likelihood ratio test that compares the Tobit with the sum of the log likelihood functions of the Probit and truncated regression models would be conducted using a log-likelihood ratio (LR) test (Greene, 2007).

The LR statistics can be computed using the following formula (Greene, 2003):-

$$\Gamma = -2[\ln L_T - (\ln L_P + \ln L_{TR})] \sim \chi^2_K \quad (4)$$

Where L_T = likelihood for the tobit model; the L_P = likelihood for the probit model; the L_{TR} = likelihood for the truncated regression model, χ^2 is chi-square distribution and k is the number of independent variables in both equations. Based on the survey result and above equation, double hurdle model was preferred than Tobit model. This is due to that the likelihood ratio showed $\Gamma > \chi^2 K$ ($201.642 > 32$).

On other hand, it is important to test Heckman maximum likelihood estimation against double hurdle model using test for non-nested maximum likelihood estimation developed by vuong (1989). As the result of weakness of the standard likelihood ratio test models of non-nested nature, vuong (1989) proposed a modified likelihood ratio test for non-nested maximum likelihood estimators which are based on a transformed value of the log likelihood function, using a simple transformation as

$$Wn = \left(\frac{1}{n}\right) [LR_1]^2 - \left[\left(\frac{1}{n}\right) LR_1\right]^2 \quad (5)$$

Where n is the number of observations, LR_1 is the likelihood statistic formed from the difference between the value of the log-likelihood function for the DHM evaluated at its maximum and the Heckman model evaluated at its maximum and specified as

$LR_1 = LLDH - LLHeck$ With a test statistic which has a standard normal distribution specified as: -

$$\frac{LR_1}{\sqrt{n}} \quad (6)$$

The decision rule is that if the test statistic is greater in the absolute value than a critical value from the standard normal distribution, then the DHM fits these data better than the Heckman model. If the test statistic is smaller in the absolute value than a critical value from the standard normal distribution, then the test cannot discriminate between the two models given the data at hand. Also based on the above statistical test result (Heckman maximum likelihood estimation against double hurdle model), double hurdle model remain accepted with the data (appendix 3).

2.8. Conceptual Framework of the Study

The conceptual framework indicates factors affecting the adoption decision and intensity of use of AI in Bedele Woreda as shown in the following Figure. 1. Adopters should identify the problem for the success of technological adoption in which the technology is proposed to solve as a major constraint to their development. Adoption of technology is the result of several interactions of households' internal and external factors. Demographic factors (sex of household heads, marital status of household heads, age of household heads, labor, educational level of households heads, Dependency ration and experience), socioeconomic factors (livestock holding, Income from crops and non-farm income, landholding and Income from livestock) and Institutional factors (distance to artificial insemination center, amount of credit ,extension contact Livestock policy and Laboratory access) are the main key variables that are hypothesized to influence the adoption of artificial insemination technology in the study area which are summarized in Figure 1.

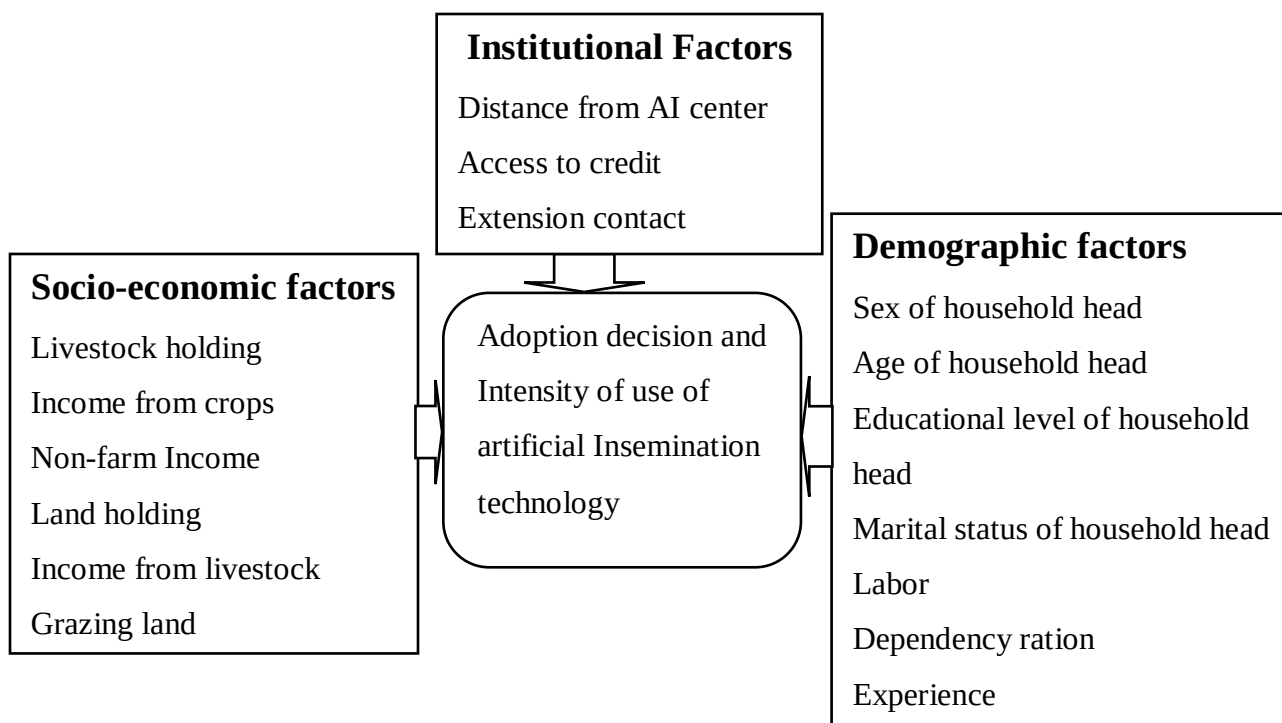


Figure 1: Conceptual framework of the study

Source: Adapted from Temba (2011).

3. RESEARCH METHODOLOGY

3.1. Descriptions of the Study Area

This study was conducted in Buno Bedele zone, Bedele Woreda, Oromia national regional state of Ethiopia. The Woreda is geographically located at a distance of 480 km from south west of Addis Ababa. The Woreda is bordered on the south by Gechi, on the southwest by Chora, on the west by Dega and on the north by Chawaka districts. The altitude of the Woreda is 2,060 m above sea level. The mean annual rainfall of the area is about 1,800 mm and the annual minimum and maximum temperatures are 14.5⁰c and 30.4⁰c respectively (Bedele Woreda Agricultural Office, 2018). According to the Woreda population projection of (2018), the estimated total population was 162,675 of whom 82,698 are men and 79,977 are women; and 8,893 or 5.5% of its population are urban dwellers. The Woreda has a total area of 114,057 km². The primary activity of the population is agriculture and 99% of the population's livelihood depends on mixed farming which is the production of food crops, cash crops, and livestock production (BWAO, 2018).

Bedele Woreda Agricultural Office (BAO, 2018) report indicated that 45% of the Woreda land is arable or cultivable (57% is under annual crops), 8% pasture, 35% is forest covered, and the remaining 12% are considered swampy, degraded or otherwise unusable. Livestock production is the most important agricultural sector which has a total population of 168,396 and among of livestock population 3,580 is improved breed and the remaining are local breeds.

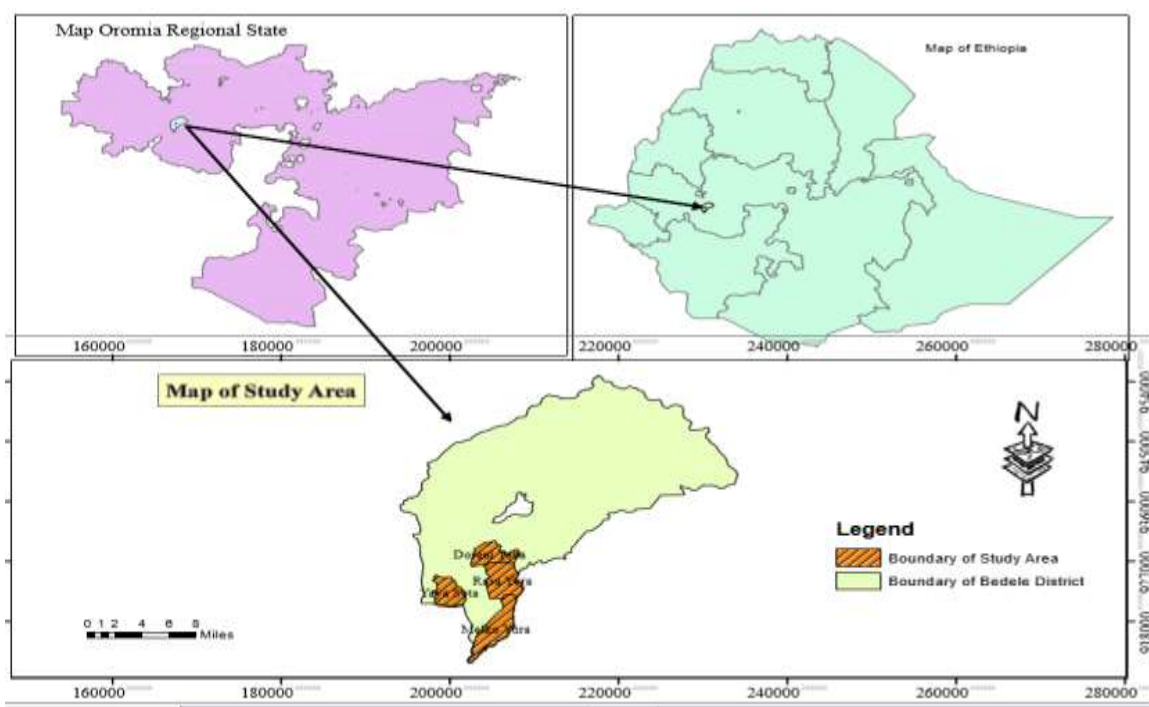


Figure 2: Map of Bedele Woreda

Source: Buno Bedele zone administrative boundaries (2017)

3.2. Types of Data and Method of Data Collection

This study used both primary and secondary data. Primary data were collected from smallholder farmers who are rearing dairy cattle. Secondary data were collected from relevant sources such as books, journals and other related documents from the Bureau of livestock and fishery of the district and other relevant institutions.

The data were collected using a structured questionnaire administered by the trained and experienced enumerators. Before starting the actual data collection some preliminary information about the overall farming system of the Woreda as a whole was assessed through informal survey and discussion was held with key resource persons in some of the Kebeles. Pre-testing the questionnaire was also one part of the informal survey so that appropriate improvement and modification in the questionnaire was made.

The process of primary data collection were conducted through follow up, which enable to gather timely and reliable information on the overall farming operations in the study area. This

was due to the fact that the quality and reliability of the information gathered from the farmers depend on their recalling capacity.

3.3. Sampling Techniques and Sample Size

Two stage sampling technique was employed to select sample households for collecting data. In the first stage, four Kebeles were selected from eleven dairy cattle breeder kebeles using simple random sampling technique together with the Bedele Woreda livestock and fishery office. In the second stage, from list of dairy cattle breeder households in the sampled Kebeles, 174 sample dairy cattle breeders were selected randomly using probability proportional to size using sample size determination formula developed by Cochran (1977) as shown in equation (8). Cochran (1977) formula is more appropriate, since the households in the study area are heterogeneous in different aspects. Simple random sampling technique was chosen rather than other techniques due to that it gives equal chances for Kebeles and households to be included within the sample frame. The formula for Cochran (1977) was written as follows.

$$n = \frac{Z^2 P(1-P)}{e^2} \quad (7)$$

Where n is sample size, Z stands for standard normal deviation (1.96 for 95% confidence level), e is the level of the desired precision set at 5 percent for this study, p is the estimated proportion of an attribute that is present in the population, in this context, the proportion of households who adopt artificial insemination technology of dairy cattle in the study area. But, the population proportion of adopters of artificial insemination technology of dairy cattle in the study area was unknown. The rule for the sample size determination in this case where variability in p unknown was to assume $p=0.5$ (Groebner and Sharon, 2005). In this study, due to time and budget constraint, the variability in p was taken as 0.13 which was used by (Gicuru, 2011) depending on the assumption that randomly selected sample is representative of population in Bedele Woreda, $p = 1 - p = 1 - 0.13 = 0.87$.

Based on Cochran's (1977) formula, the sample size was calculated as follows.

$$n = \frac{(1.96)^2(0.13)(0.87)}{(0.05)^2} = 173.79 \approx 174$$

Based on the number of population of dairy cattle breeders, the following number of sample size was proportionally selected from the population of the four selected Kebeles.

Table 1: The sampling frame and sample size determination

Name of Kebeles	Number of households	The proportion of sampled households (%)	Number of sample households using probability of population proportion size
Raso Yuro	1,662	36	62
Yaya Sota	1,836	40	70
Dorani Teba	513	11	19
Milko Yuro	583	13	23
Total	4594	100	174

Source: own survey 2018.

3.4. Methods of Data Analysis

To address the objectives of the research and analyze the data, both descriptive statistics and Econometric model were employed.

3.4.1. Descriptive statistics

Frequency, percentages, means and standard deviations values of different variables were used to have a clear picture of the characteristics of sample units. Inferential statistics such as chi-square test and t-tests were also used to compare adopters and non-adopters in terms of explanatory variables.

3.4.2. Econometric model

Double hurdle model was employed in order to address the research questions. The main feature of the double hurdle model is that adoption decisions and intensity of artificial insemination technology are assumed to steam from two separate individual choices and the determinants of the two decisions are allowed to differ. Both hurdles of double hurdle have equations associated with them, incorporating the effects of farmer's characteristics and circumstances. Such independent variables may appear in both equations or in either of them. Empirical studies have also indicated that a variable appearing in both equations may have

opposite effects in the two equations. The double-hurdle model has been applied and provided promising results for agricultural technology adoption decisions (Teklewold *et al.*, 2006).

The double-hurdle model consists of two separate stochastic processes that determine the decision to adopt and the intensity use of artificial insemination technology of dairy cattle.

The model has an adoption (D) decision with an equation:

$$D^*_i = Z_i\beta + u_i, u_i \sim N(0, 1) \quad (8)$$

$$\begin{cases} D_i = 1 & \text{if } D^*_i > 0 \text{ and} \\ D_i = 0 & \text{if } D^*_i \leq 0 \end{cases}$$

Where D^*_i is a latent variable that takes the value 1 if a household adopts artificial insemination technology and zero otherwise, Z is a vector of household characteristics and β is a vector of parameters.

The level of adoption decision (y_i) is represented by the equation:

$$y^*_i = \delta X_i + v_i, v_i \sim N(0, \sigma^2) \quad (9)$$

$$y_i = \begin{cases} 1 & \text{if } y^*_i > 0 \text{ and } D^*_i > 0 \\ 0 & \text{otherwise} \end{cases}$$

Where, y^*_i is the latent variable that shows the level of adoption of artificial insemination technology, X_i is a vector of household's socio-economic characteristics and δ is a vector of the parameter.

The log-likelihood function for the double hurdle model is written as follows.

$$\log_L = \sum \ln \left[1 - \Phi \left(\alpha Z'_i \left(\frac{\beta x_i}{\sigma} \right) \right) \right] + \sum \ln \left[\Phi(\alpha Z'_i) \frac{1}{\sigma} \phi \left(\frac{D_i - \beta x'_i}{\sigma} \right) \right] \quad (10)$$

Where, Φ and ϕ are the standard normal cumulative distribution function and density function, respectively (Moffat, 2005). The error terms v_i and u_i are usually assumed to be independently and normally distributed.

It is assumed that for each respondent the decision whether to adopt the technology and the decision about the adoption level are made independently. On the other hand, the independency between the error terms V_i and U_i of the double hurdle model is equivalent to a combination of univariate probit model (9) and the truncated regression model (10). The double hurdle log-likelihood is the sum of the truncated regression and the probit models. A

hypothesis test for the double hurdle model against the tobit model can be made. The test can be made by estimating three regression models (Tobit model, the truncated regression and the probit models) separately and use a log-likelihood ratio (L_R) test. The L_R statistics can be computed using the following formula (Greene, 2003):-

$$\Gamma = -2[\ln L_T - (\ln L_P + \ln L_{TR})] \sim \chi^2_K$$

Where L_T = likelihood for the tobit model; the L_P = likelihood for the probit model; the L_{TR} = likelihood for the truncated regression model and k is the number of independent variables in both equations. Hence, the double-hurdle model was used to estimate households' decisions to adopt AI technology and the extent adoption of artificial insemination.

3.5. Definitions of Variables and Hypothesis

The data covered the necessary information to make farm level indices of socio-economic and institutional factors of adoption decision and the intensity use of artificial insemination technology in the study area. Continuous, discrete and dummy variables were used in economic theories and findings of different empirical studies. Accordingly, the following variables were constructed.

Dependent variables

The decision to adopt AI: The dependent variable for the probit model takes a dichotomous value depending on the households' decision either to adopt or not to adopt artificial insemination technology of dairy cattle.

Intensity of adoption of AI: The dependent variable for the truncated regression model would have a continuous value which is the intensity use of AI technology of dairy cattle (Bimrew, 2018). It is measured by the ratio of number of dairy cattle inseminated by AI to the total dairy cattle households have, both inseminated and non- inseminated by AI.

$$\text{Intensity} = \frac{\text{Dairy Cattle Inseminated by Artificial Insemination Technology}}{\sum(\text{Dairy Cattle Inseminated by AIT} + \text{Dairy Cattle not Inseminated by AIT})} \quad (11)$$

Independent variables

Based on the previous studies conducted on the adoption of artificial insemination technologies and the experience of the farming system in the study area, the following explanatory variables in the table were selected for this study.

The education level of household head: It is a continuous variable measured in years of formal schooling spent by household heads. Education level of household head plays a significant role in the adoption of artificial insemination technology of dairy cattle. This means that more educated household heads may also be more aware of the benefits of modern technologies and may have greater ability to learn new information and easily adopt new technologies. In addition, formal education enhances farmers' ability to perceive, interpret and respond to new events in the context of risk. Educational level of the household heads has a positive effect on the status, intensity and speed of technology adoption (Sisay, 2016). Therefore, education was hypothesized to have a positive effect on adoption decision and intensity use of artificial insemination technology of dairy cattle.

Sex of the household head: This is a dummy variable that takes a value of one if the household head is male and zero otherwise. Female-headed households are not efficient and able to adopt new technology as compared to male (Asmelash, 2014; Samuel *et al.*, 2017). Male headed farmers were expected to adopt dairy technology more than female-headed. Because, male headed households were expected to have more access and exposure to get information about dairy technology than what female headed households do. Therefore, the male headed household was expected to have a positive effect on the decision to adopt and intensity of adoption of artificial insemination technology.

Marital status of household head: It is a categorical variable which takes the value zero if household head is single, one if married, two if widowed and three if divorced. Married couples are assumed to have a positive influence on the adoption of artificial insemination technology as compared with households who were divorced or widowed. This is because, the couples are likely to be more productive due to labor reinforcement. They can use and compliment the funds and other resources they own effectively and share managerial skills. According to Matata *et al.* (2010), the association between marriage and the adoption of

artificial insemination technologies is important to meet increased household needs as a result of marriage by increasing production. So, marital status was hypothesized to have a positive effect on adoption decision and intensity of use of artificial insemination technology as compared with single, divorced or widowed household heads.

Experience of household head in dairy farming: It is a continuous variable which refers to a number of years a household spent in utilizing artificial insemination technology of dairy cattle in the study area. The primary objective of using AI technology is to acquire better breed in terms of high milk production. It is likely that this technology was adopted by farmers having cattle with poor genetic potential in terms of milk production. It enriches the farmer on the major production aspects such as sound knowledge of involved practices (Namwata *et al.*, 2010). Therefore, the experience of household on utilization of artificial insemination technology of dairy cattle was expected to have positive effect on the adoption decision and intensity of adoption of AI technology.

Income from crops: It is a continuous variable measured by Ethiopian birr obtained from the sale of crop excluding income obtained from sale of livestock in a given production season after meeting family requirements. It is the main source of capital for purchasing agricultural inputs. Households with a relatively higher level of farm income are likely to purchase essential agricultural inputs. This implies that the household with a higher level of farm income is more adopters of agricultural technology (Kassa, 2006). Therefore; farm income was expected to affect the adoption decision and intensity of adoption of AI technology positively.

Non-farm income: It is a continuous variable measured in birr households gained from non-agricultural activities. Additional income earned from outside agricultural activities increases the farmers' financial capacity and expected to increase the probability of investing in new technologies. Household heads getting high non-farm income is considered as more adopters to dairy technologies than those getting low amount from non-farm income (Barry, 2010). Hence, non-farm income was expected to affect the adoption decision and intensity of use of AI positively.

Amount of Credit: It is a continuous variable which refers to the amount of credit that the households receive from the financial institutions. Credit relaxes the financial constraint of the

household to invest in dairy cattle. Households having large amount of credit may overcome their financial constraints and buy inputs. Having large amount of Credit positively affects the adoption of improved technologies (Leake and Adam, 2015). The introduction of AI with complementary practices requires a significant amount of capital for the purchase of improved cows and inputs like feeds and veterinary services (Marie *et al.*, 2018). Hence, having large amount of credit was expected to influence the adoption decision and intensity of use of AI technology of dairy cattle positively.

Distance from artificial insemination center: It is a continuous variable and measured in a kilometer. An increasing distance to AI center leads to increase cost and time to acquire the AI service. Distance from AI center has a negative effect on the adoption of AI (Sime *et al.*, 2014). Therefore; it is hypothesized that distance from AI center was negatively associated with adoption decision and intensity use of AI technology of dairy cattle.

Age of household head: It is a continuous variable and measured in years. It is one of the factors that affect adoption decision and intensity of use of AI technology. This implies that older households are relatively reluctant to new technology than young and middle-aged farmers. As the age of the household head increased, the probability of adoption decreased. Because, they are inactive to participate in the new technology dissemination process and most likely influenced by culture (Dehinenet *et al.*, 2014). On the contrary to this concept, older households can have a good experience and learn more from their practice so they can adopt technologies sooner than the young farmers (Miruts and Debebe, 2016). Therefore, the age of the household was hypothesized to have negative or positive effect on adoption decision and intensity use of AI technology of dairy cattle.

Family size: It is a continuous variable measured in adult equivalent (Strock *et al.*, 1991). This implies that the availability of active labor force in the household, which affects a farmer's decision to adopt artificial insemination technology. Family labor is the main sources of farm labor. Accordingly, a household with more active labor forces tended to adopt artificial insemination technology than the household with less active labor forces which in turn increased milk production of the households. Households with a large active labor workforce have the capacity to relax the labor constraints required for a labor-intensive dairy enterprise. Larger adult equivalent increases the probability of technology adoption as well as

intensity of adoption of artificial insemination technology of dairy cattle (Shiferaw, 1998). Therefore, the access to labor in adult equivalent was hypothesized to have positive effect both adoption decision and intensity of adoption of artificial insemination technology of dairy cattle.

Dependency ratio: The dependency ratio is a continuous variable measured as the ratio of dependents 'household members who are younger than 15 or older than 64 years to the working age households members whose ages are between 15 and 64 years (Tahir, 2018). A household with relatively more dependent members participate less in adoption decision and intensity use of artificial insemination technology of dairy cattle. Therefore, it was hypothesized that high dependency ratio which indicates the low proportion of productively active members was negatively affect adoption decision and intensity use of artificial insemination technology of dairy cattle.

Landholding size: It is a continuous variable and measured in hectares excluding size of grazing land. It is hypothesized that there is a direct relationship between the size of land held by farm households and adoption of artificial insemination technology of dairy cattle. Households with less land were expected not to be willing to adopt artificial insemination technology since they are thinking that the production they get from land could not enable them to produce more crop production for improving the productivity of their dairy cattle by purchasing AI inputs. On other hand, farmers with large land size can adopt new agricultural technologies than smallholders (Merga, 2009). It was hypothesized that the size of landholding by farm households and the adoption of artificial insemination technology have a direct relationship. Therefore, it is hypothesized that landholding size was affected both adoption decision and intensity use of AI technology of dairy cattle positively.

Grazing land: It is continuous variable measured in hectares. Grazing land is an important sources of livestock feed in Ethiopia (Benin and Pender, 2002). Households having more grazing land expected to adopt and use artificial insemination technology than households having less grazing land. Therefore, it is hypothesized that size of grazing land is positively affected adoption decision and intensity use of artificial insemination technology.

Access to extension services: - It is dummy variable which takes a value one if the household received extension service and zero otherwise. Extension is a source of information about

better adoption of new technology. It is believed to be the main source of information, knowledge, and advice to smallholder households in the country. The households who visited by an extension agents in a given time would be more exposure to information about artificial insemination technology. This implies that Access to extension services has an influence on households' adoption decision of artificial insemination technology (Hassen *et al.*, 2012). Therefore, it was hypothesized that access to extension contact affects adoption decision and intensity use of artificial insemination technology of dairy cattle positively.

Livestock holding size (TLU): It is the continuous variable measured in TLU that shows the total number of livestock excluding dairy cattle. so to avoid double counting of the variable, since the variable was considered in computation of intensity use of artificial insemination technology of dairy cattle. Those households that own larger number of the livestock are relatively rich as compared to those who own less number of livestock. A household with large livestock holding can obtain more cash income from the sales of animal products to purchase inputs needed for the adoption of artificial insemination technology. Farmers with larger herd size are assumed to have more cash to invest in dairy production and thus the variable positively influences the adoption of the technology (Abebe, 2018). Therefore, the adoption decision and intensity use of artificial insemination technology was hypothesized to be affected positively by tropical livestock unit.

Income from livestock: it is continuous variable which is measured by the amount of birr annually obtained from the sale of livestock and livestock products. It is assumed that as income obtained from livestock increase, the probability of adoption and intensity use of artificial insemination technology increases (Sapkota *et al.*, 2016). Therefore, Income from rearing of livestock was expected to have positive effect on adoption and intensity use of artificial insemination technology of dairy cattle.

Table 2: The hypothesized explanatory variables and their expected signs

No	Name of the variable	Types	Unit of measurements	Expected sign
1	Education level household head	Continuous	Years of formal schooling	+
2	Sex of household head	Dummy	1 if male,0 otherwise	+
3	Marital status	categorical variable	0 if, Single, 1 if. Married, 2 if Widowed, 3 Divorced	+
4	Experience of household in using AI	Continuous	year	+
5	Income from Crops	Continuous	Birr	+
6	Non-farm income	Continuous	Birr	+
7	Distance from AI center	Continuous	Kilometer	-
8	Age	Continuous	Year	+/-
9	Access to labor	Continuous	adult equivalent	+
10	Land holding	Continuous	Hectare	+
11	Livestock holding size	Continuous	TLU	+
12	Amount of credit	Continuous	Birr	+
13	Access to extension services	Dummy	1 if access to extension advice ,0 otherwise	+
14	Dependency ratio	Continuous	Ratio	-
15	Income from livestock	Continuous	Birr	+
16.	Grazing land	Continuous	hectare	+

Source: Empirical reviews (2018)

4. RESULTS AND DISCUSSION

This chapter presents the main findings and discussion of the study. It is divided into descriptive and econometrics sections. Descriptive statistics was the first section which discusses the nature of socio-economic and demographic characteristics of sample households. In the second section of this chapter, the econometric model was used to analyze factors affecting adoption decision and intensity of adoption of artificial insemination technology of dairy cattle in the study area.

4.1. Results of Descriptive Statistics

4.1.1. Demographic and socio-economic characteristics of sample households

From total sample households in the study area, 73.56% of them were male-headed and 26.44% of them were female-headed. Concerning the participation status of households on adoption of artificial insemination technology of dairy cattle by their sex, they found that 84.38% of participants on adoption of artificial insemination technology of dairy cattle were male-headed households while the remaining 15.62% were female-headed households. Regarding non-adopters of households, 67.27% and 32.73% of the respondents were male and female headed households respectively. The chi-square test analysis indicates that there were statistically significant differences between adopters and non-adopters of AIT in terms of sex of the respondents.

According to the result of the study, the majorities (71.26%) of respondents were married as observed from the survey conducted in the case of Bedele Woreda. Out of the 124 households who got married, 77 respondents were non-adopters of artificial insemination technology whereas, 47 of the respondents who get married were the adopters of the AI technology. There were also a few divorced and widowed household heads which are 18.97% and 9.77% respectively. The probability reason here was that married households had more advantages over the other categories on effective utilization of own resources, sharing ideas and managerial skills within the family and provision of the labour force. The chi-square test analysis of the three marital statuses indicates that there was no statistically significant

difference between adopters and non-adopters of artificial insemination technology in terms of marital status.

Regarding access to extension contact of households in the study area that 78.16% of sample households got extension contact whereas, 21.84% did not get extension contact. Concerning the participation of household on adoption of artificial insemination technology in terms of extension contact, they found that 85.94% of adopters got extension contact and 14.06% of non-adopters got extension contact.

The chi-square test analysis of the study indicated that there were statistically difference between adopters and non-adopters of artificial insemination technology of dairy cattle in terms of extension contact.

Table 3: Demographic and Institutional characteristics of sample households for dummy and discrete variables

Variables		adopters (N=64)		non-adopters (N=110)		total (N =174		χ^2 -test
		No	%	No	%	No	%	
Sex	Male	54	84.38	74	67.27	128	73.56	6.1**
	Female	10	15.62	36	32.73	46	26.44	
Marital status	Married	47	73.44	77	70	124	71.26	0.47
	Divorced	12	18.75	21	19.1	33	18.97	
	Widowed	5	7.81	12	10.9	17	9.77	
Access to	Extension	55	85.94	81	73.64	136	78.16	3.59*
No access to	Extension	9	14.06	29	26.36	38	21.84	

** and * indicate significance at 5% and 10% respectively

Source own survey result, 2018

According to the result of this survey, on average the adopters of sampled household heads have about eleven grades of formal education. Whereas, non-adopters of the artificial insemination technology of dairy cattle in the study area have about grade five. The t-test of the result describes that education level of households was found to be significant between adopters and non-adopters of artificial insemination technology of dairy cattle which implies

that there is statistical mean difference between adopters and non-adopters of artificial insemination technology of dairy cattle in terms of education level.

Accordingly the result of this study, the mean age of sampled household heads who were adopters of artificial insemination of dairy technology in the study area was found to be 40.2 years while the mean age of sampled household heads who were non-adopters of artificial insemination technology was found 51.1 years. The t-test of age between adopters and non-adopters of artificial insemination technology of dairy cattle was found to be significant. It shows that there is a statistical mean difference between adopters and non-adopters in terms of age.

Access to labor is one of the independent variables that may characterize the behavior of households in terms of adoption of new technology. According to the result of the survey, labor in Adult equivalent of households who were the adopters of the artificial insemination technology of dairy cattle was 4.43 people and the average of the labor in Adult equivalent for non-adopters were about 4.1 people. The result of a t-test of Adult equivalent was found significant which shows that there was difference between adopters and non-adopters of artificial insemination technology in terms of labor in adult equivalent.

On the average, the adopters had about seven years of experience for engaging in the adoption of artificial insemination technology. On the other hand; non-adopters of artificial insemination technology had zero year of experience in adoption of artificial insemination technology. The result indicated that adopters had more years of experience of using AI than non-adopters. The t-test of the result illustrated that experience of households in adoption of artificial insemination technology was found statistically significant between adopters and non-adopter which implies that there was a mean difference between adopters and non-adopters in terms of experience in utilizing artificial insemination technology of dairy cattle.

According to the result of the survey, on average, the total landholding size for adopters of AI technology was 1.82 hectares whereas the total land holding size of non-adopters of artificial insemination technology was 0.85 in hectares. The t-test of land holding size of household was found statistically insignificant between adopters and non-adopters of artificial insemination technology of dairy cattle in the Woreda. This means that there is no statistical mean

difference between adopters and non-adopters in adoption of artificial insemination based on land holding size in the study area.

According to the result of the study, on average, the livestock holding was 11.1TLU and 6.78TLU for adopters and non-adopters of AI technology of dairy cattle respectively. The t-test of livestock holding between adopters and non-adopters was found statistically significant. This shows that there was statistical mean difference between adopters and non-adopters in terms of livestock holding.

The survey result indicated that on average, the annual income from non-farm income for adopters of AI technology was 41,049.28 birr with the standard deviation of 29,370.1 birr and the mean annual income from non-farm income by non-adopters of the AI was 20,647.22 birr with the standard deviation of 26,824.75 birr. The t-test of off-farm income between adopters and non-adopters was found statistically significant. This implies that there was mean difference between adopters and non-adopters of artificial insemination technology of dairy cattle in terms of non-farm income.

The result of the survey pointed out that the mean annual income obtained from crops is 51,400.66 birr with a standard deviation of 54,681.23birr for adopters of artificial insemination technology and mean annual income from farm income was 55,674.92 birr with 41,832.28 birr for non-adopters of artificial insemination technology. The t-test of the survey showed that the difference between adopters and non-adopters of artificial insemination technology of dairy cattle was found statistically significant in terms of farm income. This implies that there was a mean difference between adopters and non-adopters of artificial insemination technology of dairy cattle in terms of income from livestock.

Distance from artificial insemination center was another factor affecting the probability of adoption decision of artificial insemination technology of dairy cattle in the study area. According to the result of the study, the mean distance from artificial insemination center to households' home was 2.4 km and 5.6 km for adopters and non-adopters of artificial insemination technology respectively. The t-test result of the study indicated that there was statistical mean difference between adopters and non-adopters of artificial insemination technology at 1% significant level in terms of distance. The implication of this result indicated

that as the distance from artificial insemination center to household's home increase, the probability of adoption of artificial insemination technology of dairy cattle decrease.

According to the survey results, on average adopters of artificial insemination technology of dairy cattle in the Woreda borrowed 16,567.81birr with the standard deviation of 14,494.29 birr whereas, non-adopters borrowed 1,585.46 birr with a standard deviation of 4960.54 birr. The t-test result of this study showed that the amount of credit between adopters and non-adopters of artificial insemination technology of dairy cattle was found as significant which shows that there was a mean difference between adopters and non-adopters of artificial insemination technology in terms of the amount of credit.

The result of the study showed that the mean dependency ratio were 0.33 and 0.39 persons for adopters and non-adopters of artificial insemination technology of dairy cattle respectively. The t-test of the survey indicated that there was no statistically difference between adopters and non-adopters of artificial insemination technology of dairy cattle in terms of dependency ratio.

According to the result of this study, on average the annual Income obtained from livestock was 92,063.6 birr and 53,444 birr for adopters and non-adopters of artificial insemination technology of dairy cattle respectively. The t- test of this study showed that there was statistical mean difference between adopters and non-adopters of artificial insemination technology of dairy cattle in terms income from livestock.

The result of the study indicated that the mean amount of land allocated by households for grazing was 0.647 and 0.386 hectares for adopters and non-adopters of artificial insemination technology respectively. The t- test showed that there was statistical mean difference between adopters and non-adopters of artificial insemination technology of dairy cattle in terms of grazing land.

Table 4. Demographic and Socio-economic characteristics of sample households for continuous variables

Variables	Adopters (N=64)		Non-adopters(N=110)		t-test
	Mean	Std	Mean	Std	
Age	40.2	5.1	51.1	8.4	9.43**
Education	10.78	2.75	4.63	3.56	-11.93***
Adult equivalent	4.43	1.46	4.1	1.23	-1.94*
TLU	11.1	3.96	6.78	2.49	-8.81***
Income from crops	51,400.66	54,681.23	25,529.4	27,728.22	-1.79***
Nonfarm income	41,049.28	29,370.1	20,647.22	26,824.75	-4.67***
Landholding	1.82	0.74	0.85	0.89	-7.32***
Grazing land	0.647	0.677	0.386	0.4168	-3.15***
Experience	7.22	2.18	0	1.45	-24.40***
Distance	2.4	2.40	5.6	1.50	10.86***
Amount of credit	16,567.81	14,494.29	1,585.46	4960.54	-11.00***
Dependency ratio	0.33	0.27	0.39	0.32	1.20
Income livestock	92,063.6	73,508.64	53,444	41,973.98	-4.41***

*** indicates significance at 1%

Source survey result, 2018

4.2. Econometric Results

4.2.1. Factors affecting adoption decision and intensity of use of artificial insemination

Double-hurdle model was used to analyze the factors affecting adoption decision and intensity use of artificial insemination technology of dairy cattle. In the first stage, a probit regression model was used to assess the independent variables that influence the sampled respondents' adoption decision of artificial insemination technology of dairy cattle. While, in the second stage truncated regression model was used to analyze the factors of those independent variables on intensity use of artificial insemination technology of dairy cattle.

Tests of model selection were performed using log likelihood ratio and Vuong's tests. To select the model that best identifies the factors affecting the households' adoption decision and intensity use of artificial insemination technology of dairy cattle, a series of model specification test were carried out using the joint decision criteria of log likelihood test. The test statistics for log likelihood ($\Gamma=201.642$) was higher than the chi-square value (32) at 16 degree of freedom and at 1% statistical significance level which shows the superiority of

double hurdle model than tobit model. On other hand, the result of vuong's test indicated the superiority of double hurdle model than Heckman models as shown in appendix 3. In addition, there was no sample selection biased because, the inverse mill ratio (IMR) of the Heckman model was 0.128 which is statistically insignificant as indicated in appendix 5.

Double hurdle model was used to identify factors affecting both adoption decision and intensity of use of artificial insemination technology of dairy cattle by households in this study. As indicated in the table: 5. the result of double hurdle model indicates that education level of household head, non-farm income, landholding size, experience, access to credit and extension contact have positive and significant effect while sex of household, family size distance from AI center, age of household and the dependency ratio of household members have negative and significant effect on adoption decision of artificial insemination technology of dairy cattle in the study area.

The six factors are statistically increasing the probability of adoption decision of artificial insemination technology of dairy cattle positively and significant at 1%, 1%, 1%, 1%, 1% and 5% of significant level respectively. While the latter four factors were negatively and significantly affected the probability of adoption decision of artificial insemination technology at 5%, 10%, 10%, 1% and 5% significant level respectively. The explanatory variables such as Educational level of household head, landholding, experience of household heads, access to credit and extension contact positively and significantly affected the intensity use of artificial insemination technology of dairy cattle at 1%, 1%, 1%, 1% and 10% significant levels respectively. While, age of household head, grazing land and distance from artificial insemination center negatively and significantly affected the intensity use of artificial insemination technology of dairy cattle at 5%, 10% and 1% significant levels respectively.

Table 5: Estimated Results of Double Hurdle Model

Variables	Probit Regression			Truncated Regression		
	Coefficient.	Robust Std. Err.	Marginal Effect	Coefficient.	Std. Err.	Marginal Effect
Sex	-1.1775**	0.4710	-0.0861	-0.0043	0.0289	-0.0043
Age	-0.1404***	0.0470	-0.0051	-0.0035**	0.0017	-0.0036
Marital status	-0.2608	0.4440	-0.0094	-0.0038	0.0189	-0.0038
Education	0.2177**	0.1004	0.0079	0.0188***	0.0039	0.0188
Family size(Ae)	-0.4358*	0.2370	-0.0157	-0.0009	0.0112	-0.0009
Livestock holding in TLU	-0.1645	0.1183	-0.0059	0.0025	0.0041	0.0025
Income from crops	1.4376	1.1592	0.0519	0.0355	0.0303	0.0355
Non-farm income	0.9366***	0.2821	0.0338	0.0091	0.0066	0.0091
Landholding	1.4413***	0.4377	0.0520	0.0654***	0.0167	0.0654
Size of grazing land	0.5215	0.6475	0.0188	0.0511*	0.0270	0.0511
Experience	0.4027***	0.0986	0.0145	0.0474***	0.0057	0.0474
Distance	-0.2589*	0.1524	-0.0093	-0.0236***	0.0066	-0.0237
Amount credit	0.5116***	0.1503	0.0185	0.0385***	0.0068	0.0385
Extension contact	1.2268***	0.4640	0.0265	0.0615*	0.0301	0.0615
Dependency ratio	-1.7219**	0.7797	-0.0622	-0.0007	0.0469	-0.0008
Income livestock	-0.0795	0.1175	-0.0028	-0.0074	0.0081	-0.0074
Constant	-4.2096	4.6834		0.0199	0.1939	
Sigma				0.1570***	0.0084	

Number of obs=174
Wald chi2 (16) =147.61
Prob>chi2=0.0000
Log likelihood= -7.42
PseudoR2=0.935

lower limit =0
upper limit=+inf
Number of obs=64
Wald chi2 (16) =1169.40
Log likelihood= 77.899
Prob>chi2=0.0000

Source: Own estimation result of the survey, 2018

Sex of household head: according to the result of the study, sex of household heads had a negative and significant influence on the adoption decisions of artificial insemination technology of dairy cattle at 5% significant level in Bedele Woreda. This study implies that being female headed household resulted in decreasing the probability of adoption of artificial insemination technology of dairy cattle by 8.46%. This was due to the fact that male-headed households have better disclosure of any extension activities to utilize artificial insemination technology than female-headed households. Female-headed households were less likely to adopt new technology than male-headed households. The possible reason could be that being female-headed household had less accessibility of information about the artificial insemination technology. They may also have resource constraints such as capital and labor. This result was contradicted with those of Temba (2011) who found that the probability of adoption of artificial insemination technology by female headed household was higher than male headed household.

Age of household head: age was negatively related to the adoption decision and intensity of use of artificial insemination technology of dairy cattle at 1% and 5% significance level respectively. According to the result of this study that one more unit (year) increase in household heads' age results in decrease the probability of adoption decision and intensity of use of artificial insemination technology of dairy cattle by 0.51% and 0.36 respectively. This is due to that older people are risk averters since cross breed cows are more sensitive to disease than local cows. Risk might be one of the possible reasons for the negative relationship between age of household heads and the adoption decision and intensity of use of artificial insemination technology of dairy cattle. Sapkota *et al.*(2016) and Yehalaw *et al.* (2018) have also got the same result in which the age of households have a negative relationship with the adoption decision and level of adoption of new technology.

Education level of household head: Education level of the household had a positive and significant relationship with adoption decision and intensity adoption of artificial insemination technology at 5% and 1% significant levels respectively. In this regard, adoption decision and intensity use of artificial insemination technology of dairy cattle by households increases with household's formal education level. The result of the survey indicated that as the education level of household increase by one year, the probably of adoption decision of artificial

insemination technology of dairy cattle increased by 10%. This implies that the household with higher academic qualification in the community exposed to leading position in the hierarchy of the Kebele's administrative unit. Due to this, they could be the first households in the community to receive the technology and commence to be considered as the role model for the higher ruling body. In addition, they would have better chance to get the technology. In the same way an increase education level by one year resulted in an increased intensity of adoption of artificial insemination technology of dairy cattle by 1.88%. This indicates that as education level of household increase the capability of interpreting the information, and understanding what they read, heard and analyze the condition of household heads would be increased. This means that the households aware more about the advantage of artificial insemination technology to increase the productivity of their dairy cattle. This result was supported by other previous studies such as the findings of Temba (2011) and Dehinenet *et al.* (2014) in which an increase educational level of households increases both probability and intensity use of artificial insemination technology of dairy technology.

Family size (adult equivalent) family size was found one of the factors affecting adoption decision of artificial insemination technology of dairy cattle negatively and significantly at 10% significant level. This might be that households having more adult equivalent prefer working other income generating activity than participating on adoption of artificial insemination technology of dairy cattle.

Non-farm income: Non-farm income was found to be an important factor that affects the adoption decision of artificial insemination technology of dairy cattle which had positive effect on the probability of adoption decision of artificial insemination technology at 1% significant level. The result of the study showed that an increase in non-farm income by one birr would result an increase in the likelihood of adoption of AI by 3.38%. Because households could resolve the financial constraints using non-farm income for purchasing dairy cattle inputs such as feed, semen as well as covering labor and medical treatment costs. This result agreed with Dhraief *et al.*(2018) and Tamrat *et al.*(2019) studies in which an increasing in non-farm income would result in an increasing the probability adoption of innovative technologies by households.

Landholding size: The result of this study indicated that the landholding of the household heads positively and significantly affected the probability of adoption decision and intensity of use of artificial insemination technology of dairy cattle at 1% and 1% significant level respectively. This implies that one-hectare increase in the size of land increases the probability of adoption decision and intensity of use of artificial insemination technology by 5.2% and 6.54% respectively. Therefore, voluntary households could purchase and use improved dairy cattle. The study conducted by Herana and Kumari, (2017) confirmed that land holding size has positive effect on the probability of adoption decision and intensity of use of artificial insemination technology of dairy cattle.

Size of grazing land: the result of the study indicated that the size of grazing land affecting the intensity use of artificial insemination technology of dairy cattle positively and significantly at 10% significance level. This might be that households having more grazing land produce more forage for their dairy cattle.

Experience of household head: According to the result of this study that farm experience of household head related to the probability of adoption decision and intensity of use of artificial insemination technology of dairy cattle at 1% and 1% significant level respectively. This showed that each additional year of household heads' experience in utilizing artificial insemination technology increases the probability of adoption decision and intensity of use of artificial insemination technology by 1.45% and 0.57% respectively. This implies that household heads that have more years of experience in utilizing artificial insemination technology were more likely to adopt and use of artificial insemination technology of dairy cattle than those household who have fewer years of experience. Higher skills of household increase the opportunity cost of rearing traditional dairy cattle. This is due to that Households having higher experience in adoption of artificial insemination technology appear to have full information, better awareness and capacity to evaluate the advantage of using artificial insemination technology. Mohammed (2018) also confirmed that the experience of the household was positively associated with the adoption of artificial insemination technology of dairy cattle. This finding is also in conformity with priori expectation and the findings of Bayei and Nache, (2014) that indicates the intensity of use of artificial insemination technology of dairy cattle increase as the experience of household in utilizing artificial

insemination technology increases.

Amount of credit: According to the result of the study, the amount of credit obtained from financial institutions positively and significantly influenced the probability of adoption decision and intensity use of artificial insemination technology at 1% and 1% significant level respectively. this result indicated that as the amount of credit received by households increased by one birr, the probably of adoption and intensity use of artificial insemination technology of dairy cattle increased by 1.85% and 3.85% respectively. This study showed that households who have got more credit from microfinance and bank were more likely to adopt artificial insemination technology of dairy cattle as well as use artificial insemination technology of dairy cattle. This is due to that better credit can relax the financial constraints of households and encourage them to purchase dairy cattle and inputs such as feed for dairy cattle and semen. Households may use credit for constructing the dairy houses, hiring labor and treatments for their dairy cattle. Temesgen *et al.* (2017) and Ingabire (2018) also confirmed that access to credit was positively associated with adoption decision and intensity use of artificial insemination technology of dairy cattle.

Distance from artificial insemination center: - According to the result of this survey that distance from AI center negatively and significantly affected both adoption decision and intensity of use of artificial insemination technology of dairy cattle at 10% and 1% significant level respectively. The survey result indicates that as the distance from artificial insemination center increases by one kilometer, the probability of adoption decision and intensity of use of artificial insemination technology of dairy cattle decreases by 0.93% and 2.37% significant level respectively. The Possible reason may be households who are far away from artificial insemination technology center might face greater transportation costs and lack of information on the latest released technology provided by extension systems. This is agreed with previous studies by Sime *et al.* (2014) and Mushonga and Dusabe(2017) who found that distance from artificial insemination station affected adoption decision and intensity of use of artificial insemination technology of dairy cattle negatively.

Extension contact: Accordingly the result of this study, extension contact positively and significantly affected the probability of adoption decision and intensity of use of artificial

insemination technology of dairy cattle at 1% and 10% significant level respectively. The result of the study showed that households who have got extension service from extension agent are more participants in adoption of artificial insemination technology of dairy cattle than those households who did not get extension service from extension agents. This indicated that households who were visited by extension agent were more likely to adopt and use artificial insemination technology of dairy cattle than those households who were not visited by extension agent. This result is similar to the studies conducted by Prakashkumar *et al.* (2017) and Niraj Kumar *et al.* (2014) that confirms access to extension service had positively influenced the probability of adoption and intensity of use of artificial insemination technology of dairy cattle.

Dependencies ratio: The result of the survey showed that dependency ratio affected negatively and significantly the adoption decision of artificial insemination technology of dairy cattle at 5% significant level. This result also indicated that as the number of dependency in the household increase by one dependency ratio, the probability of adoption of artificial insemination technology of dairy cattle decreased by 6.22%. This implies that as the number of dependency ratio of household members increase, the economically active household members focus on feeding those economically inactive households rather than participating in adopting artificial insemination technology of dairy cattle. This result go with the finding of Patel *et al.* (2017) which stated that dependency ratio was negatively related with the probability of adoption of technology of dairy cattle.

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary and Conclusion

There has been an increasing effort to improve the productivity of dairy cattle through utilization of artificial insemination technology of dairy cattle. However, this technology has not been well adopted by many households for several reasons. This calls for improving adoption of artificial insemination technology and intensity of use of artificial insemination technology of dairy cattle by households in order to bring sustainable livelihood improvement and increase their income. This study was intended to identify factors affecting adoption decision and intensity of use of artificial insemination technology of dairy cattle in Bedele Woreda. To achieve the aforementioned research objective, primary data was collected from 174 randomly selected household heads through semi-structured questionnaires. Secondary data also collected from relevant sources such as books, journals and the Woreda's unpublished reports. In this study, both descriptive statistics and econometric model were employed for analytical purpose. Different analytical techniques such as percentage, frequency, means, standard deviation, chi-square and t-test were used to discuss the demographic and socio-economic characteristics of sample households. Chi-square and t-tests were used to compare adopters and non-adopters of artificial insemination technology in terms of explanatory variables. Double hurdle model was used to identify factors affecting household' adoption decision and intensity of use of artificial insemination technology of dairy cattle.

In general, the descriptive analysis of households' socio-economic characteristics indicated that 73.56% of participants was male headed households and 26.44% of participants were female headed households who were participated in adoption of artificial insemination technology of dairy cattle. The result of inferential analysis revealed that there were significant differences between adopters and non-adopter of artificial insemination technology of sampled households in terms of sex of household head, age of household head, access to extension contact and distance from artificial insemination centers.

Factors such as education level of household heads, land holding size, experience of household heads, access to extension contact and amount of credit are positively and significantly affected the households' adoption decision and intensity of use of artificial insemination technology of dairy cattle, while age of household heads and distance from artificial insemination centers were negatively and significantly influenced the households' adoption decision and intensity of use of artificial insemination technology of dairy cattle. But, income from non-farm activities positively and significantly affected only adoption decision of artificial insemination technology, while sex of household heads, family size and dependency ratio negatively and significantly affected only adoption decision of artificial insemination technology. But, the intensity of use of artificial insemination technology was not affected by income from non-farm activities, sex of household heads and dependency ratio but negatively affected by grazing land size.

5.2. Recommendations

Based on the empirical findings of this study, the following recommendations are suggested to be considered in the future intervention strategies as follows:

Sex of household heads negatively and significantly affected adoption decision of artificial insemination technology of dairy cattle. This might be that female headed households have more burdens to care their family members than male headed households. In addition, female headed households generally lacked access to extension services and information on the artificial insemination technology and have resource constraints such as capital and labor. It is therefore, recommended that paying attention for gender equality by empowering female-headed households is needed. In addition, female headed households should be encouraged through the provision of continuous training on adoption of artificial insemination technology of dairy cattle.

Educational level of household heads positively and significantly affected adoption decision and intensity of use of artificial insemination technology of dairy cattle. This implies that households with more education level have better opportunity for source of information, and become more efficient in evaluating and interpreting information about the artificial insemination technology of dairy cattle than households having less education level. Hence,

the existing provision of formal education should be strengthened and expanded to rural areas of the Woreda. The Bureau of agriculture should strengthen learning opportunities of households through farmers training centers in rural areas of the Woreda. Furthermore, there should be households teaching centers that aimed to promote their educational levels in all issues related with artificial insemination technology.

Age of household head negatively and significantly affected adoption decision and intensity of use of artificial insemination technology of dairy cattle. This showed that as the age of household head increases, the probability of adoption of artificial insemination technology would be decreased. This is due to that elder households are more risk averters to new technology than younger households. Therefore, awareness creation needs to be given for elder households on the utilization of artificial insemination technology for increasing the productivities of their dairy cattle.

The findings of this study pointed out that the amount of income obtained from non-farm activities influenced the adoption decision of artificial insemination technology of dairy cattle positively and significantly. Because, households with relatively higher level of non-farm income are more likely to purchase artificial insemination inputs, purchase fodder for dairy cattle and hire labor. On other hand, households with better non-farm income are able to relieve capital constraints to purchase dairy cattle. Therefore, households should be encouraged to generate higher amount of non-farm income to enhance adoption of artificial insemination technology of dairy cattle. In addition, concerned stakeholders such as NGOs have to work to improve the accessibility of alternative income generating activities such as non-farm income that can help to improve the livelihoods of households.

Experience of households in utilization of artificial insemination technology positively and significantly affected the probability of adoption and intensity of use of artificial insemination technology of dairy cattle in Bedele Woreda. This indicates that as households' experience get increases the households acquire new information, know the benefit of new technologies and develop confidence to use artificial insemination technology of dairy cattle. Thus, concerned bodies should give emphasis to involve households to exercise and use AI technologies through demonstration, training and field days. In addition, development agents, local leaders

and other stakeholders should support households to enable them to stay in dairy farming by solving the problem they face in utilizing artificial insemination technology.

According to the result of the study, Distance from artificial insemination center to households' home affected negative and significant both adoption decision and intensity of use of artificial insemination technology of dairy cattle in Bedele Woreda. This is due to that as distance from artificial insemination centers to households' home gets increase, the cost incurred by household for transportation increases which hinders household from adopting and use of artificial insemination technology. In addition, farness of artificial insemination centers from households' home results for the failure of AI due to the delay of insemination by extension agent. In order to solve the problem of farness in being distant from artificial insemination centers, the concerned body should construct artificial insemination centers nearer to households' home or develop infrastructures facilities and supplying the services in each kebeles of the Woreda. In addition, the government policies and strategies should encourage investment on construction of rural roads and repairing the existing one and fulfill transportation system in the study area.

Amount of credit positively and significantly affected both adoption decision and intensity of use of artificial insemination technology of dairy cattle in the study area. This indicated that as amount of credit borrowed by household increases, the households could purchase artificial insemination inputs and inseminate their dairy cattle. Therefore, the provision of credit at required amount and time through credit system as well as at affordable interest rate needs to be facilitated by concerned bodies. In addition, Borrowers should be encouraged to save or contribute as matching fund to reach the limited resources over a large number of needy households.

Extension contact affected positively and significantly the adoption decision and intensity of use of artificial insemination technology of dairy cattle. This implies that extension visits helps to reinforce the message and enhance the accuracy of the implementation of artificial insemination technology. In addition, the influence of extension agents can counter balance the negative effect of lack of years of formal education in the overall decision to adopt artificial insemination technology. Therefore, extension exposure should be expanded by

providing frequent training for development agent about artificial insemination technology of dairy cattle. In addition, the extension coverage should be widened by establishing additional extension centers. The Woreda should deploy adequate number of extension workers in order to solve the problem of covering households' home due to shortage of labor.

Dependency ratio negatively and significantly affected adoption decision of artificial insemination technology of dairy cattle. This was due to that an increase in the number of dependents results in increasing the expenditures of households' consumption that results in decreasing in investment into adoption of artificial insemination technology due to shortage of capital for purchasing artificial insemination inputs. Hence, it needs government and religion leaders' intervention in creating awareness among households about the utilization of family planning programs to solve the problem of increased dependency ratio.

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6. APPENDICES

Appendix table 1: Conversion factors used to compute the tropical livestock unit (TLU)

Types of livestock	Tropical Livestock Unit (TLU)
Cows/oxen	1
Horse/mule	1.10
Donkey (adult)	0.70
Donkey (young)	0.35
Sheep/goat	0.13
Camel	1.25
Calf	0.20
Heifer	0.75
Chicken	0.013

Source storck *et al.*, (1991)

Appendix table 2: Conversion factors used to estimate adult equivalent (AE)

Age group	Male	Female
<10	0.6	0.6
10-13	0.9	0.8
14-16	1.0	0.75
17-50	1.0	0.75
>50	1.0	0.75

Source storck *et al.*, (1991)

Appendix table 3 . Test of Hypothesis among Double Hurdle, Tobit and Heckman Models

Test	Likelihood ratio test	Vuong's test for model specification
Hypothesis	H ₀ = Tobit model best fit data H ₁ = Double hurdle model best fits data	H ₀ =no difference between Heckman model and DHM H ₁ =DHM preferred than Heckman model
Test statistic	201.642	0.626
Critical value	$\chi^2(16,32 ***)$	0.172
Decision	Reject H ₀	Reject H ₀

Source: the model results 2018

Appendix table 4 Estimated Result of Tobit Model

Tobit regression Number of Obs = 174

F (16, 158) = 29.64

Prob> F = 0.0000

Log pseudo likelihood = -30.188

Pseudo R2 = 0.8137

ADOPTION	Coefficient.	Std. Err.
Sex	-0.0196673	0.1090815
Age	0.0190601***	0.0045971
Marital status	-0.060184	0.0515772
Education level	0.0220758*	0.0113542
Adult equivalent	-0.0113043	0.0243967
TLU	0.0014299	0.0082589
Farm income	0.0616511	0.058699
Nonfarm income	0.0560635*	0.0307567
Landholding	0.1405733***	0.0483401
Grazing land	0.1320831**	0.0592716
Experience	0.0757056***	0.017059
Distance	-0.0381392*	0.0204352
Access to credit	0.685347***	0.0211636
Extension contact	0.077254	0.0698455
Dependency ratio	0.260947*	0.1290557
Income livestock	0.11052	0.0167477
cons	-0.022736	0.4304515
/sigma	0.2929086	0.0409466

Obs. summary: 110 left-censored observations at ADOPTION<=0

64 uncensored observations

0 right-censored observations

Source own survey 2018/19

Appendix table 5 . Heckman two-step result for sample selection bias

Heckman selection model -- two-step estimates (regression model with sample selection)		Number of obs	=	171
		Censored obs	=	109
		Uncensored obs	=	62
		Wald chi2(12)	=	131.56
Prob> chi2		= 0.0000		
	Coefficient.	Std. Err.	P> z	
Adoption				
Sex	-1.177452	1.743808	0.500	
Age	-0.140416	0.0948027	0.139	
Marital status	-0.2608136	0.8986501	0.772	
Education level	0.2177727	0.271947	0.423	
Adult equivalent	-0.4358814	0.6746366	0.518	
TLU	-0.1645473	0.299108	0.582	
Farm income	1.432374	2.527274	0.593	
Non-farm income	0.9365559	0.5459926	0.086	
Landholding	1.441349	0.9524273	0.130	
Grazing land	0.5215845	1.623334	0.748	
Experience	0.4026744	0.2169335	0.063	
Distance	-0.2589919	0.2859358	0.365	
Access to credit	0.5116246	0.3090238	0.098	
Extension contact	1.22684	1.898147	0.518	
Dependency ratio	-1.721913	3.162829	0.586	
Income livestock	-0.0794966	0.4021521	0.843	
cons	-4.209603	12.30601	0.732	
INTENSITY				
Gender	0.0113524	0.0412946	0.783	
Age	0.0042645	0.0031511	0.176	
Marital status	0.0077622	0.0257113	0.763	
Education	0.0401764	0.0060343	0.000	
Adult equivalent	-0.0081811	0.0128539	0.524	
TLU	-0.0042156	0.0039177	0.282	
Farm income	0.0223788	0.0291969	0.443	
Non-farm income	-0.0276345	0.0126131	0.028	
Landholding	0.006878	0.0207526	0.740	
Grazing land	0.0098439	0.0256198	0.701	
Experience	0.0020155	0.0074427	0.787	
Distance	0.0024851	0.0068079	0.715	
Access credit	0.0220715	0.0083913	0.009	
Extension contact	-0.0399819	0.0411932	0.332	
Dependency ratio	-0.0757342	0.0631348	0.230	
Income livestock	0.0230571	0.009318	0.013	
cons	0.4510224	0.2170181	0.038	
mills				
lambda	-0.1068993	0.070189	0.128 Non-significant	
rho	-1.00000			
sigma	0.12347078			

Source the study result of 2018/19

Appendix table 6 . Heckman Maximum Likelihood Estimation Result for Factors Affecting Probability and Intensity Use of AI

Variables	<u>Probit (1st stage)</u>		<u>Truncation (2nd stage)</u>	
	Coefficient	Std. Error	Coefficient	Std. Error
Sex	-0.8733258	0.5654979	0.0411744	0.0351104
Age	-0.1127224**	0.048109	0.0031758	0.0036215
Marital status	-0.3752993	0.3953931	0.0089561	0.0275759
Education level	0.2484723***	0.076943	0.0463001***	0.0058206
Family size	-0.3168975	0.1933856	-0.0137646	0.0085925
TLU	0.0829312	0.072665	0.0048314	0.0036341
Livestock income	0.0703742	0.1206866	-0.0191126*	0.0076315
Farm income	0.42883	0.9356413	0.0079205	0.0287928
Non-farm income	0.8493791***	0.2112193	-0.0183436*	0.0109108
Landholding	1.367519***	0.4044905	0.0049076	0.0159596
Grazing land	0.0531445	0.4467948	0.0093445	0.0197717
Distance	-0.075327	0.1752308		
Experience	0.422067***	0.1022317	0.0017155	0.0057898
Dependency ratio	0.0171514	0.9808426		
Extension contact	0.4571581	0.8961456	0.0388109	0.0559809
cons	-4.654459	4.4791	0.5232345	0.1939219
Rho	-0.5024266	0.6112104		
Sigma	0.0944983	0.0107301		
Lambda	0.0474785	0.0601567		
Number of observation		174		
Censored observation		10		
Uncensored observation		68		
Wald $\chi^2(12)$		194.25*		
LR test of independent eqns. $\chi^2(1), pr > \chi^2$		0.46		

***, ** show significance at 1%,5% respectively. note that some variables were missed due to convergency problem.

Source: the result of the model 2018

Household interview schedule questionnaire

Dear respondent, I am Master of Science Student in Agricultural Economics at Haramaya University. Currently, I am conducting research entitled '**Adoption of Artificial Insemination Technology of Dairy Cattle by smallholder households in Bedele Woreda of Buno Bedele Zone**'. The purpose of this Questionnaire is to collect data for the master thesis research. You are one of the respondents selected to participate in this study. It is very crucial to give the correct and complete information to represent the finding on the current status of the factors affecting the adoption of artificial insemination technology. Your participation is entirely voluntary and the questionnaire is completely anonymous.

Finally, I confirm that the information that you share me will be kept confidential and only used for the academic purpose. No individual's responses will be identified as such and the identity of persons responding will not be published or released to anyone.

Thank you very much for your kindly cooperation and dedicating your time.

Respondent's (Farmer's) name _____ kebele _____

1. INFORMATION ON DEMOGRAPHIC FACTORS OF RESPONDENT

1.1. **Sex** of household 1. Male 2. Female

1.2. What is your **age** in year _____?

1.3. **Marital status** of the household

1). Single 2). Married 3 the). Divorced 4). Widowed

1.4. What is your **level of education**? _____

1.5. What is your religion? 1. Christen 2. Muslim 3. Protestant 4. wakefata

1.6. What is the size of your **family**? Male ____ Female ____ total ____

Age group	sex	
	Male	Female
(0–14)		
(15–30)		
(31–50)		
(51–64)		
(>64)		
total		

1.7. Did your active family members participate in dairy farming activities? 1. Yes 2. no

2.2.Farm Income

2.2.1. What was the estimated income did you get from **farm activities** in the production season of 2017/18 in birr —————?

2.2.2. What amount of income did you get from crop sales during 2017/18?

Crop	Unit	Quantity sold	Price per unit	Total
Maize				
Sorghum				
Sweet potato				
Chat				
Teff				
Coffee				
Other (specify)				

2.3.Non-Farm Income

2.3.1. Did anyone of the HH members engaged in non-farm activities? 1). Yes, 2).No

2.2.2 If your answer is yes, which types of activities? 1. Handcraft, 2.Cattle trading, and 3.

Grain trading, 4. Petty trade, 5. Other (specify)—————

2.2.3. What is the Annual income did you earn from non-farm activities?—————birr.

3. Farm characteristics

3.1.Landholding and utilization

3.1.1 Indicate the amount of utilization and source of land you have in the following table

utilization	Amount in hectare	Source			
		Kebele	Inherited	Rent	Other
Cultivated					
Fallow					
Grazing					
Under hay production					
Cultivated for fodder beet					
Rented out					
Wood/bush/forest lots					
Rent in					
Total Land In Hectare					

3.2.Dairying Experience of Households

3.2.1. How many **years of Experience** do you have in traditional dairy farming?———years, amount of milk———liters per cow per year if (dairy cattle).———birr from sale if (local oxen).

3.2.2. How many **years of Experience** do you have in utilizing artificial insemination technology?———years, milk———liters per cow per year if (improved dairy cattle).———birr from sale if (improved oxen).

4. Institutional Factors

4.1.Distance from Artificial Insemination Center

4.1.1. How far is the **distance from** home to the nearest Artificial Insemination service Centre———km?

4.2.Adoption status of households

4.2.1. Did you adopt artificial insemination technology?———

1. Yes, 2. No

4.2.2. If your answer in question no.4.3.1is yes, how many dairy cattle did you inseminate in this year of 2017/18?———

4.2.3. How many calves did you get by inseminating your dairy cattle in the year2017/18?———

4.2.4. Access to Credit

4.2.5. What was the amount of **credit did** you get **from credit** services during last year? ——
——— Birr.

4.3.Extension Contact

4.3.1. Do you get advisory services from extension agents on the adoption of artificial insemination technology of dairy cattle? 1) Yes 2) No

4.3.2. What is the **frequency that the extension agents** visit you within a year? ——

4.3.3. How far is the **distance of the extension center** from your home in Km———?