



**FACTORS AFFECTING ADOPTION OF DAIRY TECHNOLOGIES AND THEIR
IMPACT ON FARM HOUSEHOLD INCOME AND ASSET HOLDINGS:
THE CASE OF TEHULEDERE DISTRICT, SOUTH WOLLO ZONE,
AMHARA REGION, ETHIOPIA**

M.Sc. THESIS

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**HAWASSA UNIVERSITY
COLLAGE OF AGRICULTURE**

**HAWASSA, ETHIOPIA
MARCH, 2017**

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MASTERS OF SCIENCE IN RURAL DEVELOPMENT**

**MARCH, 2017
HAWASSA, ETHIOPIA**



DEDICATION

I dedicated this thesis manuscript in loving memory to my Families.

STATEMENT OF AUTHOR

First, I declare that this thesis is my *bona fide* work and that all sources of materials used for this thesis have been duly acknowledged. This thesis is submitted in partial fulfillment of the M.Sc. degree at Hawassa University and to be made available at the University's Library under the rules of the Library. I solemnly declare that this thesis has not been submitted to any other institutions anywhere for the award of any academic degree, diploma, or certificate.

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LIST OF ABBREVIATIONS AND ACRONYMS

ATT	Average Treatment Effect on Treated
AI	Adoption Index
AIS	Artificial Insemination Services
ANRS	Amhara National Regional State
BOA	Bureau of Agriculture
CSA	Central Statistical Authority
DAs	Development Agents
DTs	Dairy Technologies
ESAP	Ethiopian Society of Animal Production
ETB	Ethiopian Birr
FGD	Focus Group Discussion
GDP	Gross Domestic Product
ha	hectares
IGAD	Inter Governmental Authority on Development
ILRI	International Livestock Research Institute
KAs	Kebele Administrations
KII	Key Informants Interview
Km	kilometer
LPM	Limited Probability Model
LIVES	Livestock Irrigation Value chain for Ethiopian Smallholders
MOA	Ministry of Agriculture
NGO	Non Governmental Organization
TASHEVAFT	Total Asset Holding Estimated Value After Technology
TLU	Tropical Livestock Unit
TOTAFICM	Total Annual Farm Income
PADETES	Participatory Agricultural Demonstration and Training Extension System
PSM	Propensity Score Matching
T&V	Training and Visit
VIF	Variance Inflation Factors
TWOA	Tehuledere Woreda Office of Agriculture

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ABSTRACT

The objective of this study was to assess the overall factors influencing adoption decision, the intensity of adoption and its impact on household income and asset holdings in Amhara region Tehuledere district. Improved dairy technologies (breed, feed, AIS, housing and regular vaccination) and training were provided for rural smallholder farmers in different time in the study area; adoption of this technologies and their impact were not known. This study was initiated to fulfill the information gap for responsible bodies. Tehuledere has 19 rural and 2 town kebeles, among them 6 kebeles are potential to participate on dairy technologies and 3 kebeles were randomly selected for the study. The sampling frames of this study were 230 households. The sample selection method was proportional to size and employed three stage sampling techniques. Hence, both primary data were collected from 230 households (110 dairy technology user for at least three years and 120 non-users households that didn't ever accessed any of the technologies) using questionnaire schedule and interview of sample respondents. Secondary data were collected from different relevant literatures such as reports, research results documents and publications. Descriptive and econometric analyses were used for analyzing both quantitative and qualitative data using STATA Version 14 econometric software. Additionally, narrations and case studies were incorporated. Factors affecting adoption and the intensity were analyzed using Tobit model whereas impact of technology on households' income and asset holdings was analyzed using Propensity score matching (PSM) methods. The results of Tobit model revealed that, dairy technology participant and non-participant households had combination of personal and demographic, economic, institutional and social influencing factors that hinder the probability of adoption. Among Influencing factors, sex of the respondent was negatively significant whereas farm land size, market distance and tropical livestock unit were positively significant variables in the model. The results of PSM indicated that dairy technologies had positive and significant impact on participant households' total annual farm income and estimated asset holdings increment in average by 49.35% and 100% respectively than non-participants. The sensitivity analysis shows that the impact results estimated by this study are assertive to unobserved selection bias. Therefore, attention should be given to major factors that affect dairy technology adoption by livestock and fishery development office to increase production and productivity of the sector.

Key words: - Factor, Adoption, Dairy Technology, Impact, Income, Asset, Tobit, PSM

1. INTRODUCTION

1.1 Back ground of the study

The contribution of agriculture to total Growth Domestic Product (GDP) in Ethiopian economy is nearly 47% Central Statistical Authority (CSA, 2011/12). Among agricultural components, livestock is an important one. Livestock production is an integral part of Ethiopian agricultural system. The sub-sector contributes about 22% of the total GDP and 47% of total agricultural GDP (IGAD, 2010/11). The country ranks top of the list of African countries with large livestock populations. The estimated population were 39,714, 653 cattle, 14, 326, 206 sheep and 11,155, 218 goat (CSA, 2006). Another record revealed that, Ethiopia possesses the largest livestock population in Africa. Estimation of farmers holding in rural areas including that the country has about 56.71 million heads of cattle, 29.11million goats, 29.33 million sheep, 2.03 million horses, 7.43 million donkeys, 0.4 million mules, and 1.16 million camels (CSA, 2014/15).

A study conducted by IGAD showed that the value of animal draught power input into arable production is about a quarter (26.4%) of the value of annual crop production, and if the value of draught power services is included, the sector contributes up to 45% of agricultural GDP (Behnke and Metaferia, 2011). In Ethiopia dairy production depends mainly on indigenous livestock genetic resources, more specifically on cattle, goats, camels and sheep. Cattle have largest contribution (81.2%) of the total national annual milk output, followed by goats (7.9%), camel (6.3%), and sheep (4.6%), (CSA, 2009). According to the CSA (2011) estimation, the total cow milk production (excluding milk suckled) for the rural sedentary areas of the country during the reference period, is about 4.06 billion liters average lactation period per cow during the reference period at country level was estimated to be about six months and average milk yield per cow per day was about 1.85 liters. The recent report by CSA (2014/2015) again indicated that the total population of cow milk is about 3.03 billion liters, and this translates to an average dairy milk production/cow of 1.35 liters/day. As a result per-capita milk consumption of the country is only 19.2kg (MOA, 2012), which is much lower than Africa and would per-capita average of 27kg/year and 100kg/year respectively (CSA, 2014/2015).

Despite its potential and large population, the contribution of the Ethiopian livestock sector in general and dairy sector in particular is low at both the national and household level (Berhanu *et al.*, 2007). This low production level of the sector is attributed to inefficient productivity of the livestock as a result of the traditional method of production, poor breeds, poor feeding, poor housing condition, inferior health care and services, and low capital investment. Since then, different dairy technologies has been transferred through both governmental and NGOs and private sectors and even large efforts have been made to disseminate dairy technologies through the support of governmental and non-governmental organizations in different parts of the country including the study areas, the rate of adoption of dairy technologies by farm households varies widely across different agro-ecologies and within the same agro-ecology on various technological and non-technological factors. Accordingly, the contribution and benefits of dairy technologies differ among farm households. Hence, for policy design and effective management of extension programmes, information on factors affecting adoption of dairy technology and impact of dairy technology adoption on the livelihoods of smallholder farmers is very important and would help to come up with workable recommendations to improve the performance of the sector. So, to improve the intervention, it was important to assess adoption and intensity of adoption of improved dairy technologies such as use of improved breed, Artificial Insemination Services (AIS) improvement of housing, use of improved feed or forage development, and regular vaccination at smallholders' level and their impacts on farm household income and assets in the study area.

1.2. Statement of the problem

The north eastern part of Amhara region is characterized by severe soil erosion, low productivity, small landholding, most of forest land became devoid and deforested and peculiar to less use of productive inputs. The environment is very fragile as well as frequently hit by drought and hence it is one of the food insecure zones. The major constraints for annual crop production are shortage of cultivable land, drought, pest and soil erosion as well as inefficient use of productive inputs. Using this Agro ecology and soil situation, farmers are growing a variety of crops. These are done at rain fed agriculture on piece of land with poor management practices. On the contrary, increase in population growth with the increase demands for farm land and other productive assets. Due to erratic and insufficient amount of rain fall and other factors, the

amounts of yield obtained cannot reliable to sustain with the increasing population. To avert the food security problem, government at all stage give attention to increase the production and productivity of livestock sector (MOA, 2012).

Amhara National Regional State (ANRS) was designing and implementing consistently a five year Growth and Transformation Plan (GTP) to improving the dairy production and productivity based on the milk shed area for the second time. Among selected potential woredas, Tehuledere is included. The district cattle population is estimated at 50,677 local and 3897 improved cattle breeds respectively (TWOA, 2015). Rearing of cattle is mostly on extensive grazing system. For dairy production cut and carries systems including forage feeds are common practices. In line with government intention to increase agricultural productivity, different governmental and NGOS (including ILRI - LIVES Project) has been trying to promote improved dairy technologies to improve smallholders' livestock production and productivity i.e breed improvement, feed including forage development, AIS including synchronization, housing condition, regular vaccination and other issues in the sector.

In the study area, dairy farming is important and highly valued due to the reason for small land holding size that diversifies farmers' to engage in crop–livestock integrated mixed farming system. Improved dairy technologies promotion efforts has made by different organization because the woreda is potential and close to urban market centers and the presence of milk cooperatives in the area. In order to increase the supply of milk for users and milk collector cooperatives, improved dairy technologies has been distributed for farmers that selected as dairy package participants for a long time in the past. In the woreda dissemination of technologies and training has been offered for farmers and professionals by government and LIVES project. Although efforts have been made, the supply of dairy product including milk is not still satisfactory as compared to the prevailing demand. Therefore, there is no sufficient current information in the study area on factors influencing the overall adoption and intensity of adoption of dairy technologies, the characterization of dairy technology supply and level use by small holder farmers; and the impact of dairy technology adoption on household income and asset holdings for responsible bodies. Due to its multi-dimensional importance, it is essential to assess these to full fill the information gap, and that lesson can be learnt for future improvement of intervention in the sector.

1.3 Objectives of the Study

1.3.1 General objectives

The general objective of the study was to assess the overall factors influencing adoption decision, intensity of adoption and its impact on household income and asset holdings.

1.3.2 Specific objectives

The specific objectives are:

1. To characterize dairy technology supply and level of utilization by small holder farmers;
2. To identify factors determining adoption and intensity of adoption of dairy technologies;
3. To assess the impact of dairy technology adoption on household income and asset holdings;

1.4 Research questions

1. What are the characterization of dairy technology supply and level of utilization by small holder farmers?
2. What are the factors that determining adoption and intensity of adoption of dairy technologies;
3. What are the impacts of dairy technologies on farm household income and asset holdings?

1.5 Significance of the study

The recently formulated Rural Development policies and strategies stress that; an efficient domestic agricultural commodity system is fundamental to stimulating and sustaining growth and development in the food and agriculture sector (Aklilu Woldu, 2004). The policy clearly states the prospect for economic growth rest with successful transformational development of the agricultural system to provide greater market incentives for the millions of poor smallholder farmers to participate efficiently and consistently in the domestic food and agricultural market oriented extension as commercially oriented and demand driven producers. Realization of this vision presently requires development practitioners should be able to either judge their efforts to promote dairy technology thereby improving farmers' livelihood or to develop new insights for further improvement of dairy sector. This study would help them to better design for development projects or programs aimed at benefiting smallholder farmers in the future. Policy

makers would be also benefited from the research output because they require micro-level information to formulate suitable policies, through justifying whether increased necessary support or allocation of fund is needed in this sector, by quantifying the status of farmers adoption, and identifying major factors that influence uptake of improved dairy technologies as well as its impact on income and asset building. The result of this study could also be used as a reference for other similar areas and as a bench mark for further studies. Generally, the study would be expected to generate grass roots information for different stakeholders in order to promote well informed research and sustainable development strategies that curb their draw backs and other associated issues in this study.

1.6 Scope and limitation of the study

This study was limited to assess factor affecting adoption of dairy technology and their impact on farm household income and asset holdings in single woreda of Amhara Regional State. The adoption of dairy technologies in the district was studied in three representative kebele by surveying a sample of 230 farm households. Therefore, its scope was limited in terms of coverage owing to financial and time resources available. The limitation of this study were the PSM econometric model used to measure the impact of dairy technology adoption was based on matching participant with non-participant households on the basis of observable characteristics while ignoring unobservable characteristics of the households that may create bias in the result.

1.7 Organization of the paper

This thesis is organized into five chapters. Chapter one deals with introductory part of the research includes the background, statement of the problem, objectives, research questions, scope and limitation of the study and significance of the study. Following this, Chapter two presents review of literatures that provides broader view on conceptual and theoretical perspectives of dairy production system, adoption related concepts, theoretical and empirical studies of adoption and the impact of dairy technologies on households' income and asset. Chapter three dealt with methodology and chapter four devoted to the presentation and discussion of the major findings of the study. The final chapter five summarizes and concludes the findings of the study with certain policy recommendations and strategic considerations.

2. LITRATURE REVIEW

2.1 Over view of dairy production in Ethiopia and worldwide

Dairy production is an important component of livestock in Ethiopia. It is an important source of food, income and creates job opportunities for many people in rural and urban areas. However, despite its huge number, the performance of sub-sector in general is low compared to its potential and the direct contribution it makes to the national economy is limited (Sintayehu *et al.*, 2008). In Ethiopia currently the national average milk yield/cow/day is 1.35 liters for indigenous cows and the per-capita milk consumption in the country is about 19.24 kg/year respectively (CSA, 2014/2015; MOA, 2012). According to the report of the (CSA, 2010) the indigenous cattle breeds accounted for 99.1%, while the hybrids and pure exotic breeds accounted for about 0.72% and 0.09%, respectively. Despite its large livestock resources base and an ecological setting suitable for dairy production, it is not yet self sufficient in milk production. Although it was difficult to trace the ownership of improved dairy animals, it is essential to that state and private farmers own a total of 128,745 improve and pure female dairy animals of which the small holders sector owns 32,203 crosses and improved female dairy cattle (CSA, 2010). The indigenous zebu breeds produces about 400-680 kg of milk/cow/ lactation period to grade animals that have the potential to produce 1,120-2,500 liters over 279-day lactation (Mohamed *et al.*, 2004). As world views on dairy development, Africa, south of the Sahara is expected to register 3.3 % increase in demand for milk and milk products in 2020 (Delgado *et al.*, 2000). Delgado *et al.*, (2001), projected the annual growth rate of milk production in developing countries are between 1997-2020 to be 2.73 % and a 4% annual growth in milk production was projected between 1993 and 2020 in Sub-Saharan Africa. Nevertheless, a number of factors will continue to limit the development of the dairy industry in the Sub-Saharan Africa.

2.2 Dairy production systems in Ethiopia

In Ethiopia dairy production can be broadly categorized into four major systems. These are lowland pastoral dairy production system, rural highland smallholder dairy production system, urban and peri-urban small scale dairy production system and large scale dairy production system Upton (2004).

2.2.1 Rural highland smallholder dairy farming

There are two types of dairy systems in the Ethiopian highlands. The traditional system that is based on indigenous breeds and the market oriented system that is based on crossbred dairy cattle. The average lactation yield for indigenous cows is 524 liters for 239 days and the average age at first calving is 53 months and the average calving interval is 25 months. As literature (CSA, 2003) Quoted and most respondents of this study confirms, the average age at first calving for the native cow in the Amhara region is usually put at 3 to 4 years. Farmers, however, strongly emphasis that age at first calving are highly influenced by the nutritional environment. The milk produced is mainly consumed by the household in the traditional system while most of the milk is sold to generate income in the market oriented system.

Small-scale dairy is an important avenue for income generation for mainly subsistence farmers in the Ethiopian highlands. Dairy products are a traditional urban consumption item, ensuring continued and growing demand. Smallholders who are estimated to contribute approximately 98% and 97% of total and marketed milk production dominate dairy production in Amhara Region, similar to other part of Ethiopia, (CSA, 2003). In the region, these are farmers who, besides growing crops for subsistence and for sale, mostly keep 1 to 3 cows with their followers on land sizes typically of about 1ha in the intensively farmed Dega and woinadega agro ecology zones and about 1.5ha in the extensively farmed Kolla areas (Biomass, 2002). The milk production was estimated at 493 million liters of which below 1% was marketed 41% was consumed at home and the rest 58% processed into butter and other derivative of dairy products (CSA, 2003). Considering milk has no close substitute, the estimated total population of 3.5 million of dairy cows in approximately 3 million smallholders (BOA, 2003; CSA, 2003) suggests this sub-sector employs many poor farmers in the region who drive regular source of cash income and balanced nutrition.

2.2.2 Urban and peri-urban small scale dairy farming

This system is developed in and around major cities and towns located mainly in the highlands of Ethiopia. The main feed resources are agro-industrial byproducts and purchased roughages. The system comprises small and medium sized dairy farms that own cross breed dairy cows. Farmers use all or part of their land for forage production. The primary objective of milk production is generating additional cash income to the household (Ketema and Tsehay, 1995).

2.2.3 Large scale dairy farming

This system is a specialized market oriented dairy operation practiced by the state sector and very few private commercial farms. Most of these farms are located in and around Addis Ababa and basically keep exotic dairy stock (Ketema and Tsehay, 1995).

2.3 Feed resources and nutrient requirement of dairy cattle

2.3.1 Feed resources

The urban and peri-urban dairy operation depends on the natural pasture hay as a source of roughage feed in the central highlands of Ethiopia (Fekede *et al.*, 2013). The major roughage feed resources for dairy animals across all the different production systems include natural pasture/grass lands, grass hay, crop residues, and non-conventional feed resources (Asaminew and Eyassu, 2009; Yitaye ., 2009; Azage *et al.*, 2013). The crude protein content of pastures most often is lower than 7%, which could not support maintenance requirements of ruminants (McDonald *et al.*, 2002). Good grass and legume hays are adequate for maintaining most classes of livestock, particularly those in a non-productive state (Streeter *et al.*, 2006). Therefore, dairy cows which depend on poor quality basal feed will not express their full genetic potential. According to Azage *et al.*,(2013), agro industrial by-products such as brain, middling, oil seed cakes and molasses are fed as supplement to crossbred dairy cows in urban and peri-urban areas.

2.3.2 Nutrition requirement of dairy cattle

Nutrition has a profound influence on productivity and production performance of dairy cattle. Because of high metabolic rate and requirement for milk secretion, lactating, cows have special demand for nutrient supplement (Indetie, 2009). In practice milk yield and composition are influenced mainly by the dietary supplies of energy and protein (Tadesse *et al.*, 2003). Energy and protein, of feeds are central in determining nutritional adequacy and feeding levels for different classes of livestock (Streeter, 2006).

2.4 The prospects of dairy farming in Ethiopia

An increased in total human population and accelerated rate of urbanization characterize the Ethiopian society in the coming 25 years. The urban community with high purchasing power represents the main target milk market. There will be, therefore, an increase in demand for milk and milk products in the future in urban areas and hence, large commercial and market oriented small-holder peri-urban dairy production systems have tremendous potential for development.

The potential of livestock to reduce poverty is enormous. Livestock contribute to the livelihoods of more than two-thirds of the world's rural poor and to a significant minority of the peri-urban poor. The poorest of the poor do not have livestock, but if they can acquire animals, their livestock can help start them along a pathway out of poverty (Holmann *et al.*, 2003).

Roles of livestock keeping revolve around storing wealth, contributing to food and nutritional security, providing draught power, transport and manure, and serving traditional social functions. In some situations, the "livestock ladder" may allow the poor to progress from modest livestock holdings, such as a few poultry, to acquiring sheep and goats or pigs, or even cattle (Ahmed *et al.*, 2003). Livestock production provides a constant flow of income and reduces the vulnerability of agricultural production. Results from different study show that small farmers perceive cattle as a contribution to the improvement in the quality of life. The milking cow is one of the factors that contributes the most to well-being due to the role it plays within the farm such as supply of milk and beef for household consumption, utilization of labor with low opportunity cost, security against crop failure, liquidity against financial crisis, as collateral for informal credit, and as a protection against inflation (Holmann *et al.*, 2003).

2.5 Definition of Adoption related concepts

Agricultural extension still remains one of the services delivered as public goods by the government. Extension on livestock development is hence part of this huge service delivery component run by the BOA and some projects under them to support it. The structure of extension service shows that the department of livestock and fisheries development under the BOA to be the core body for tailoring the information to be disseminated through woreda and development centers under them. The system of extension promoted earlier used to be the

Training and Visit (T&V) system whereby the Development Agent (DAs) dealt with contact farmers. The system, however, was later evaluated and found to be non-participatory and consequently ineffective in changing the day to day life of the poor smallholder farmers. It was therefore replaced by the Participatory Agricultural Demonstration and Training Extension System (PADETES) in 1995/2012. The main feature of this system is the participation of a technology packages for each commodity and the restructuring of the recipient farmers into successive layers of model farmers. Due to this intervention, adoption will begin later (BOA, 2012). Adoption is a mental process through which an individual passes from first knowledge of an innovation to the decision to adopt or reject and to confirmation of this decision (van den Ban and Hawkins, 1998).

According to (Rebecca Homes and Nicolas Jones, 2009; World Bank and IFPRI, 2010) states that the adoptions of new technologies are often influenced by the farmers access to extension services. On average female households reported fewer visit by extension agents than male households. Despite the fact that, Ethiopia has one of the highest ratios of agricultural extension staff to farmers globally (IFPRI, 2009), female access to extension services is relatively low. An individual may decide to discontinue the use of an innovation for a variety of personal, institutional or social reasons. One of which could be the availability of an idea or practices that is better in satisfying his or her needs. Adoption process is the change that takes place within individual with regards to an innovation from the moment that they first become aware of the innovation to the final decision to use it or not. However, as emphasized by Ray, (2001) adoption does not necessarily follow the suggested stages from awareness through knowledge; trial does not always lead to adoption. In some cases, particularly with environmental innovations, farmers may hold awareness and knowledge but because of other factors affecting the decision-making process, adoption does not occur.

Adoption is a decision-making process, which an individual goes through a number of mental stages before making a final decision to adopt an innovation. Decision-making process is the process through which an individual passes from first knowledge of an innovation, to forming an attitude toward an innovation, to a decision to adopt or reject, to implementation of new idea, and to confirmation of the decision (Ray, 2001). The adoption or rejection of an innovation is the consequence of diffusion of an innovation (Ray, 2001). An innovation is an idea, method or

object which is regarded as a new by an individual, but which is not always the result of recent research (van den Ban and Hawkins, 1998) diffuses within a social system through its adoption by individuals and groups. The differences in the diffusion rates of innovations in a community can be largely explained by the differences in the traits of innovation, as perceived by potential adopters such as relative advantage, compatibility, complexity, trial ability and observe ability (Ray, 2001). These are defined as follows:

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

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

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

Trial ability: The degree to which the innovation could easily be tried by farmer on his/her farm.

Observe ability: The degree to which results of innovation are visible to farmers.

The adoption pattern to a technological change in agriculture is a complex process (Ray, 2001).

A larger number of personal, situational and social characteristics of farmers have been found to be related to their adoption behaviour. According to (Ray, 2001), adopters have a high rate of literacy and higher level of formal education, operate large sized holding own the land they operate, have a relatively high income and economic status, are commercial in farming operation, have relatively high level of extension contact, and belong to upper socio-economic status categories. On the other hand, non-adopters have a low rate of literacy and level of formal education, operate smallholdings, are mostly small and marginal farmers, belong to low income group, have a low level of socio-economic status categories.

2.5.1 Theoretical Perspectives of Adoption

The adoption of an innovation within a social system takes place through its adoption by individuals or group. According to Feder et al., (1985) adoption may be defined as the integration of an innovation into farmers' normal farming activities over an extended period of time. This implies that an individual may decide to discontinue the use of an innovation for variety of personal, institutional and social reasons one of which might be the availability of another practice that is better in satisfying farmer's needs. He classified adoption as individual (farm

level) adoption and aggregate adoption. Adoption at the individual level is defined as the degree of use of new technologies and its potential. In the context of aggregate adoption behavior they define the diffusion process as the spread of new technologies within a region. This implies that aggregate adoption is measured by the aggregate level of use of specific new technologies with a given geographical area or within a given population.

Rogers (1983), defines the adoption process as the mental process through which individual passes from knowledge of the innovation (first hearing about an innovation) to final decision to adopt or reject the technologies. This indicates that adoption is not a sudden event but a process. Farmers don't accept technology immediately; they need time to think over things before reaching a decision.

2.5.2 Innovation Decision Model

According to Rogers (1983), the present model of innovation-decision process consists of five conceptual stages:

Knowledge: Occurs when an individual (or other decision-making unit) is exposed to the innovation's existence and gains some understanding of how it functions.

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

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

Implementation: Occurs when an individual (or other decision-making unit) puts an innovation into use.

Confirmation: Occurs when an individual (or other decision-making unit) seeks reinforcement of an innovation-decision already made, but he or she may reverse this previous decision if exposed to conflicting messages about the innovation. The innovation-diffusion model, following from the work of Rogers, holds that access to information about an innovation is the key factor determining adoption decisions.

The appropriateness of the innovation is taken as given, and the problem of technology adoption is reduced to communicating information on the technology to the potential end users (Andesine and Zinnah, 1993). However, (Rogers, 1983) has explained that the diffusion of innovations attracted many scholars in that though an innovation is found having an obvious advantage; it is

often very difficult to be adopted by farmers. There is a gap between what is known and the actual practice /use of the object. He moreover indicated that the innovation diffusion involves considerable deliberation by most adopters even in the case of an innovation with spectacular results. His statement indicates that there is a need to approach the adoption decision process with other additional paradigms.

2.6. Empirical study of adoption

As stated in the study of Gebrehiwot Woldegebrel *et al.*, (2012), improving the living standard of rural households and insuring food security at the household and national level requires the intervention and transfer of agricultural technologies through extension services. The roles of age in farmers' decisions to adopt technology have been shown in previous studies. (Berhanu, 2002) has shown that years of farming experience has significant effect on the adoption of crossbreed dairy cows. Some studies reported positive relationship between age and adoption behavior of farmers, (Mesfin, 2005) and (Yenealem, 2006) found age is significant in explaining the adoption of new technology. However, a study conducted by (Bulale, 2000) on adoption of dairy production technologies in Arsi highlands indicates that age had no influence on adoption of dairy production technologies but formal education does have a positive and significant influence.

Tesfaye *et al.*, (2001) reported that number of livestock owned had a significant and positive influence on the adoption of improved maize. A study by Chilot *et al.*, (1996) on the adoption of improved wheat technologies also indicated that the size of livestock holding was the main determinant for the adoption of improved wheat varieties. A study in Tanzania confirmed that farmers' adoption of crossbred technology depends positively on his access to credit (Abdulai and Huffman, 2005). Berhanu, (2002) has shown that total livestock holding and off-farm income has significant effect on the adoption of cross breed dairy cows in his study area. Yenealem, (2006) found positive and significant influence of TLU on adoption decision. A study in Sera-Leone by (Adesina and Zinnah 1993) showed that farmers perception of specific characteristics of a technology significantly condition adoption decision. They further indicated that omission of such variables in adoption models might bias the results of factors determining adoption decisions of farmers by ignoring their possible and important influence.

Itana, (1985) explained that distance to the extension center, education, farm size and adequacy of rainfall as major factors that affect the adoption of fertilizer and improved variety. (Kenneth *et al.*, 2005/6), Social scientists investigating farmers' adoption behavior have accumulated considerable evidence showing that demographic variables, technology characteristics, information sources, knowledge, awareness, attitude, and group influence affect adoption behavior. Farmers who have more frequency of contact with development agent were able to access time oriented information and able to update their knowledge, skill, and experience via training, demonstration and visiting another farmer's field (Gebrehiwot Weldegebrial, 2012).

A wide range of economic, social, physical, and technical aspects of farming influences adoption of agricultural production technologies (Oladele, 2005). Farmers' adoption decision can be influenced by many economic, social, and physical factors, which vary from area to area, and their effect on adoption decision are often not uniform. Because of this, the reaction of farmers to new technology is often not necessarily the same (Chilot *et al.*, 1996). As reported by Van Den Ban and Hawkins (1998), adoption of improved technologies are strongly affected by the policy environment like input supply, market, credit, price policies and improved supply system, Poor linkage between research and extension, high cost, low return, inappropriateness of technologies, lack of credit facilities, the prevalence of animal diseases, absence of transport and marketing infrastructure are some of problems affecting diffusion of technologies. The decision to adopt any single innovation depends on the availability of interrelated inputs. Input availability is the most important influencing factor of the use of improved technologies (Chilot *et al.*, 1996).

Berhanu, (2002) has reported that input availability had positive and significant influence on adoption decisions of farmers. Habtemariam, (2004) and Million and Belay, (2004) results indicated that farmer's education had positive and significant influence on adoption. Each additional year of education increases the probability of adoption of improved seed increases.

Distance from market has significant effect on the adoption of crossbred dairy cows in the area as indicated by (Bulale, 2000) and (Yenealem, 2006) had shown that market distance is negatively and significantly related to adoption decision.

2.7 Definition of livelihood assets related concept

The most widely accepted concept of livelihood is pointed out by Chamber and Conway, (1992), "A livelihood comprises the capabilities, assets (stores, resources, claims and access) and

activities required for a means of living; a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contribute net benefits to other livelihoods at local levels in the short and long term”.

Household’s choice of livelihood strategies depend up on the nature and mix of the assets they have available to them. According to DEFID (1999), livelihood assets are classified into five and their description is given below as follows:

Financial assets: It denotes the financial resources that people use to achieve their livelihood objectives. It includes income; saving and loan that enables people to adopt different livelihood strategies.

Physical assets: It defined as physical goods and facilities which comprise both public and private that support livelihoods. Public physical capital, often called infrastructure includes affordable transport systems, water supply and sanitation facilities that make energy affordable and good communication and access to information. Whereas physical capital at household level includes shelter, productive assets, household goods, utensils, etc.

Natural assets: Defined as natural resource stocks (trees, land, clean air, coastal resources, etc.) upon which people rely. Benefits these stocks are both direct and indirect. For example, land, and trees provide direct benefit by contributing to income and people’s sense of well-being. The indirect benefits that they provide include nutrient cycling and protection from erosion, and storms.

Social assets: Defined as the formal and informal social relationships (social resources) from which various opportunities and benefits can be drawn by people in their pursuit of livelihoods. The social resources are developed through interactions (through work or shared interests) that increase people’s ability to work together, membership of formal groups in which relationships are governed by accepted rules and norms, relationships of trust that facilitate cooperation transaction costs and sometimes help in the development of informal safety nets amongst the people.

Human assets: defined as skill, knowledge, health, and education etc. of individuals / households that enable them to set livelihood strategies and achieve livelihood outcomes.

2.8 Impact evaluation

Theoretical framework describes impact evaluation rely on econometric and statistical models. There are three main kinds of impact evaluation designs; includes experimental, quasi-experimental and non-experimental with which are respectively associated with control groups, comparison groups and non-participants. Impact evaluation rigorously measures the impact that a project has on beneficiaries.

The fundamental interest in all program evaluation efforts is whether a particular intervention, as designed, is effective in accomplishing its primary objectives or not. The main challenge of a credible impact evaluation is the construction of the counterfactual outcomes, that is, what would have happened to participant in the absence of treatment. Since this counterfactual outcome is never observed, it has to be estimated using statistical methods. To overcome this problem Propensity Score Matching (PSM) is considered as the best statistical method. It uses information from a pool of units that do not participate in the intervention to identify what would have happened to participating units in the absence of the intervention. By comparing how out comes differ for participants relative to observationally similar non-participants, it is possible to estimate the effects of the intervention. In recent years, facilitated in part by improvement in computing capacity and associated algorithms, approaches that directly match participants with non-participants who have similar characteristics has replaced regression as one of the preferred methods for estimating intervention impacts using comparison group data (Carolyn *et al.*, 2010). Propensity Score Matching constructs a statistical comparison group that is based on a model of the probability of participating in the treatment, using observed characteristics. Participants are then matched on the basis of this probability, or propensity score, to non-participants. The propensity score is a conditional probability that expresses how likely a participant is to be assigned or to select the treatment condition given certain observed characteristics. In a propensity score analysis, this conditional probability is used to condition observed data, e.g., through matching on the propensity score (Shahidur *et al.*, 2010). The aim of conditioning on the propensity score is to achieve balance on the observed covariates, and recreate a situation that would have been expected in a randomized experiment (Felix and Eun, 2009). With matching methods, one tries to develop a counterfactual or control group that is as similar to the treatment group as possible in terms of observed characteristics. The idea is to find, from a large group of non-participants, individuals who are observationally similar to participants in terms of

characteristics not affected by the program. Each participant is matched with an observationally similar to non-participants, and then the average difference in outcomes across the two groups is compared to get the program treatment effect. If one assumes that differences in participation are based solely on differences in observed characteristics, and if enough non-participants are available to match with participants, the corresponding treatment effect can be measured (Shahidur *et al.*, 2010).

2.9 Impact of dairy on household assets

2.9.1 Impact on financial assets of households

In the urban and peri-urban areas dairy production is practiced mainly as a source of income. Animal and animal products are critical sources of income for many smallholders of developing countries. Dairy production in particular served as a dominant income generating means for many of them. For instance, in semi-arid areas of Mali, livestock contributes 78 percent of cash income (Li- Pun and Shapiro, 1998, cited in Haji Biru, 2003). The income is used for the purchase of food as well as agricultural inputs. Animal products are not only served as a source of good quality food but they are also a source of income for many smallholder farmers in developing countries for purchase of agricultural inputs like fertilizers, seeds and pesticides. Bulale (2000) also forwarded that livestock contributes about 47 percent of gross farm income, out of which 46 percent is from milk and milk products.

2.9.2 Impact on physical assets of households

Intervention designed to improve the well-being of rural households often focus on expanding asset ownership and access based on the view that it is the households low asset position that limits its ability to take advantage of opportunities. Since assets determine the economic activities of a household in a given context, an intervention that improves a household's asset position is not likely to be path neutral; that is, such interventions are likely to promote participation in certain income generating activities and thus a particular path for improving household livelihood (Paul *et al.*, 2009).

2.9.3 Impact on human assets of households

Human capital is one of the most important livelihood assets which contain the household members' skills, knowledge, and ability to work all enabling people to pursue different livelihoods strategies. Livestock husbandry, especially, dairy farm, is a labor-intensive activity. As man-to -land ratio increases due to population growth; it can offer a viable option to absorb the redundant labor and can minimize the rural underemployment and unemployment problem. The better the households' income, the better the households' attains education and health services. It also impact on health and educational status of the smallholder farmers

2.10 Conceptual Framework of the Study

The conceptual framework of this study was discussed and as revealed (see figure-1) below based on the assumption that dairy technology adoption of small scale farmers are having a great role in improving farm household income and asset holdings. The linkage between adoption of promoted improved dairy technologies, its impact on financial, physical and human assets and variables assumed to affect households probability to adopt and participation in dairy technologies. It was assumed that influenced by personal and demographic, economic, institutional, and social-participation related factors. Conceptual framework model of the study was presented as follows:-

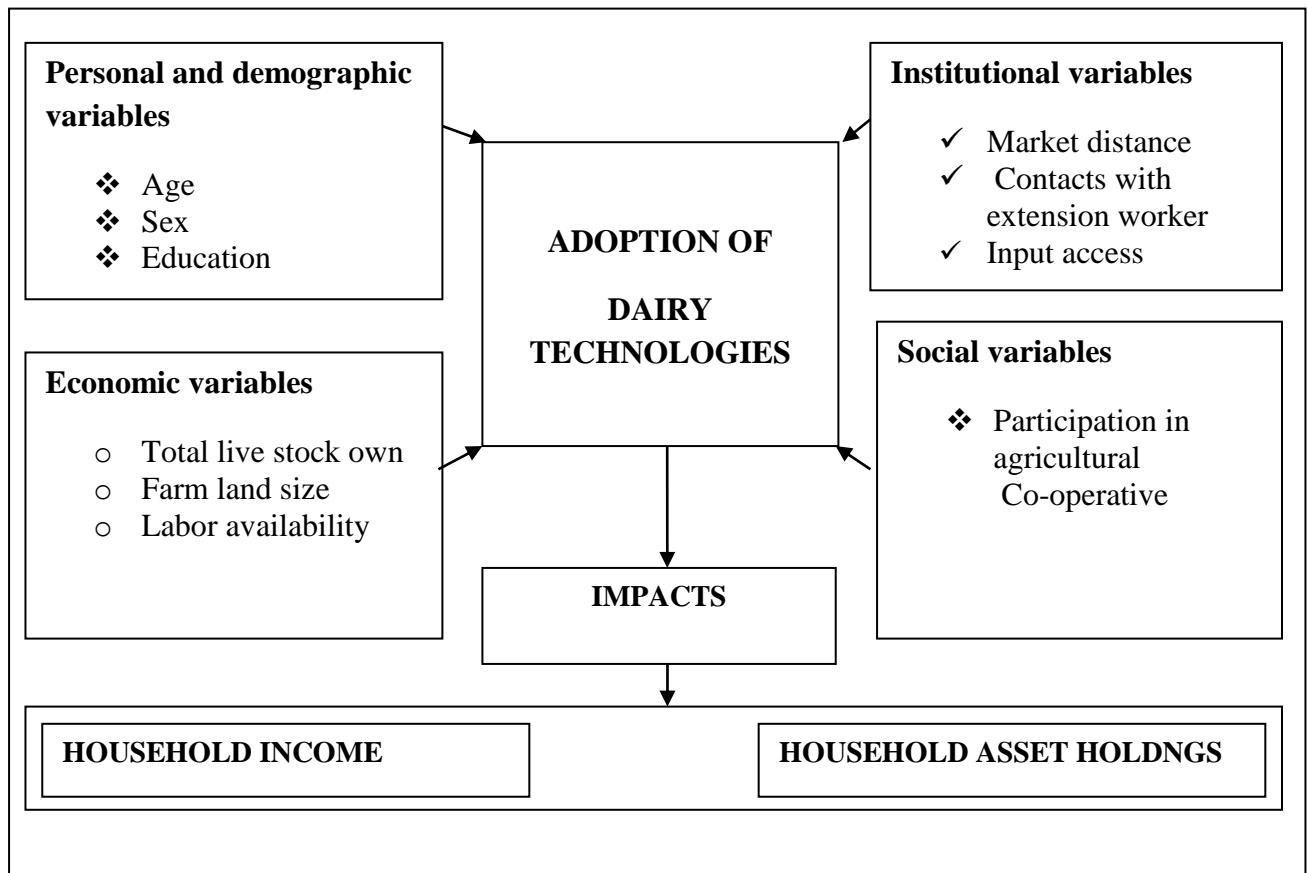


Figure 1: conceptual framework of the study

Source: Own conceptual framework of the study (2016)

3. RESEARCH METHODOLOGY

3.1 Description of the study area

This study was carried out in three kebles in the district. Tehuledere ditrict is one of the 22 districts of the South wollo Zone in Amhara National Regional State. The woreda is located in the north at a distance of 430 km from Addis Ababa on the main road to Mekele. Its location is 11°, 17' N latitude and 39°, 40' E longitude. The woreda has a total area of 44,030 hectares. It shares borders in the north with Ambassel, in the south with Dessie zuria, in the east with worebabo and in the west with Kutaber and Ambassel woreda. The place is subdivided into nineteen rural and two small urban kebeles (the bottom administrative structure). The capital of the woreda, called Haik (now town administration) is located at a distance of 30km from Dessie. The woreda has different Agro-ecological Zone varies from Dega to Kolla. Dega covers 2,979 ha (13%) woyina dega covers 32,651 ha (72%) and kolla covers 8,380 ha (15%). In terms of topography, about 5,853.33 ha (13.3%) constitutes flat, 17,322.336 ha (39.36%) roling and 5,413.23 ha (12.3%) gorge, 11,618.64 ha (26.4%) mountainous and 3,802.464 ha (8.64%) covered by bush and grasses. The soil is mostly black (25%) and clay (10%) sandy loam (65%) in texture. Its average annual rain fall is 1030 mm and has average temperature of 9°C - 21°C per annum (TWOA, 2016).

According to the recent wereda population report, 107,689 is the total population of the wereda. The total number of agricultural households is 25,380, of the total rural households, 20,884 are male and 4,496 are female headed. The total rural population is 104,842 out of which, 56,650 are male and 48,192 are female. Out of the total land coverage, 16,133 ha are used for crop production, 583 ha for grazing, 13,823 ha forests and bush land, 3,800 ha water body and, 978 ha is wasteland. The average land holding per household is estimated 0.5ha. Altitude of the wereda ranges from 1,400-2,900 m.a.s.l (TWOA, 2011 & 2015). Tehuledere has two rainy seasons, the one is the short rainy season known as “belg” from February to end of May and the main rainy season or long rainy season known as “Meher” from July to end of September. The two rainy seasons are separated by the month of June. Using this Agro-ecology and soil situation farmers are growing a variety of crops such as teff, sorghum, wheat, maize barely beans etc. The most important crop in the district is sorghum followed by teff and maize. The lower and middle altitude cereals (sorghum, teff and maize) cover the largest share of grain production. The main

pulses are chick peas, vetch and haricot beans sometimes inter cropped with sorghum and maize. Vegetables have been introduced during the last decades in areas where farmers have started small-scale irrigation, especially around Haik and Ardibo lakes and use of rivers and water ponds that fruits and vegetables are grown. Another feature of the farming system in Tehuledere area is the expansion of cash crops such as chat and coffee (coffee is subsistent). Due to shortage of farm land, crop-livestock mixed farming (diversification) system is the major characteristics of district agricultural practices.

Crop production today continues to be the major economic activity followed by livestock production and still livestock is the status symbol for farmers in the district. Types of livestock kept by the farmers include cattle, mules, donkey, horses, shoats, poultry, camel and bees are important livestock species that were reared. Among these, the cattle population is estimated at 50,677 local and 3,897 improved cattle breeds respectively (TWOA, 2016). During the periods of high feed availability, which is mainly during crop harvest and crop weeding periods, the livestock body conditions become good and sale of livestock and their products earns a reasonably good income. The feed sources commonly used for livestock, include natural grazing, crop residues and in rare cases byproducts (concentrates) from industries and some improved forages.

The contribution of natural pasture as sources of feed is very limited due to the extensive coverage of the land by crops. But the crop residues have great value for livestock as main sources of feed in this regard. Livestock play a significant role in the mixed farming system of the area. Their main contribution is in providing draft power, cash generation, food (example milk, eggs), for asset reserves, and for prestige in kola region. Oxen are kept to provide draught power, cows to (sometimes for draught power) provide farm households with milk and butter for consumption and sale, donkeys for transporting goods, whilst shoats and poultry are mainly kept for sale as well as for their meat.

Since the woreda has different agro-ecology, regular and recurrent cross boarder disease outbreaks are economically important occurrences in the district. Among them are foot and mouth disease, shoat and fowl poxes, lump-skin disease, anthrax, a highly infectious Newcastle disease in poultry and other regular disease(including metabolic disease) that affect different animals. Due to these occurrences, emergency and regular vaccination and other veterinary

services should be given by veterinarian to prevent mortality and morbidity of animals. Regarding their susceptibility of animals, improved animals are highly susceptible to disease and need great care by farm households. Technology distribution such as improved breed, feed (forage), AIS (estrus synchronization), veterinary services (regular vaccination) and other management (improving housing condition) practices are promoted by different organization and projects (LIVES are the main one). Generally, in the study area, crop-livestock mixing farming is the most day to day economic activities and almost 90% of the populations are employed in the sector but livestock products availability are limited compared to population and become expensive in some areas. So, it was important to study whether the promoted technologies are effective or not on smallholder farmers' adoption and the intensity level as well as the impacts on households' income and asset holdings.

This study was conducted at Bededo, ketie and Hitecha KAs as depicted below.

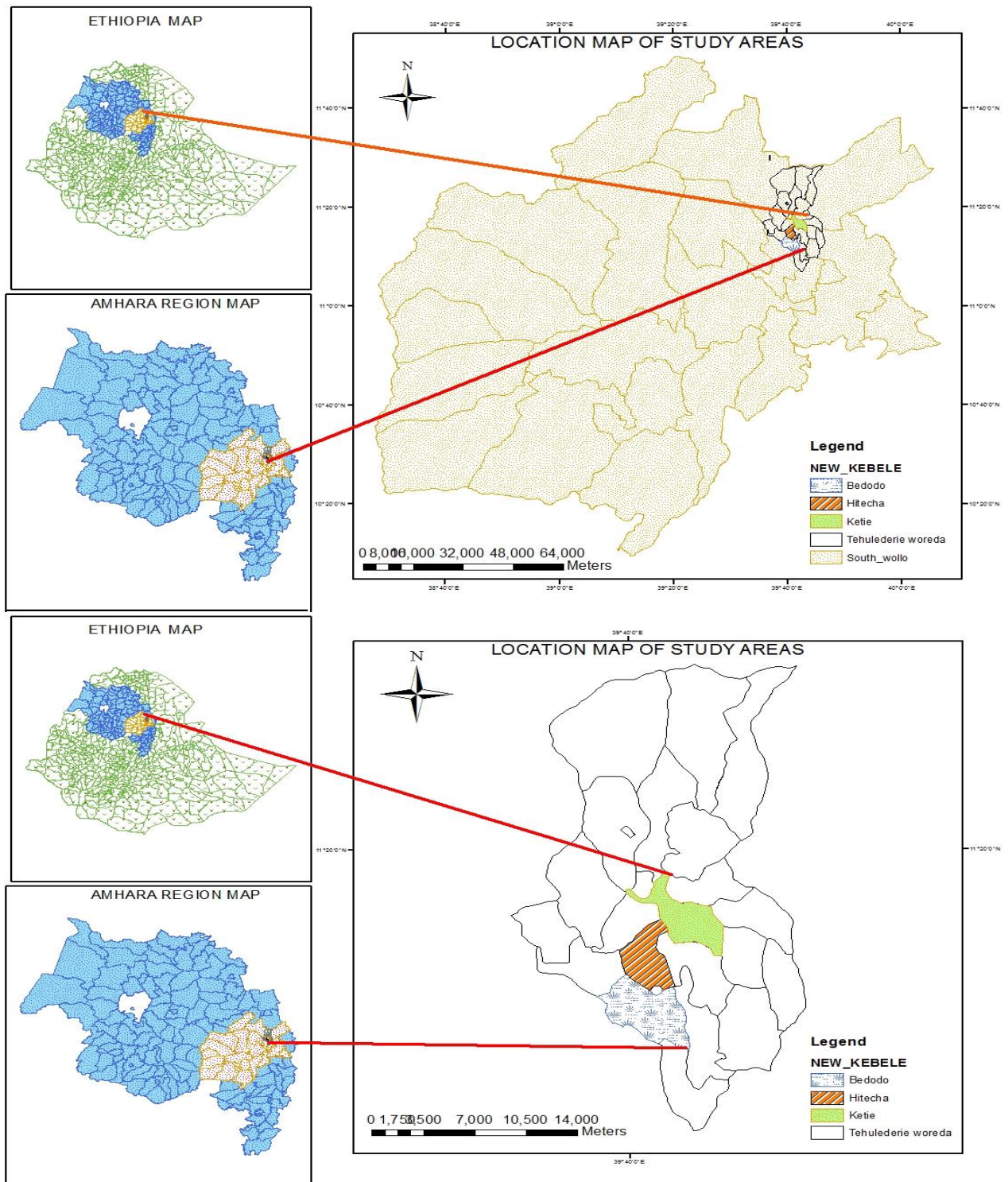


Figure 2: Map of the study area

Source: Tehuledere District Bureau of Agriculture (2016)

3.2 Research design

The research design for this particular study was survey design with quasi-experimental techniques encompasses adopter and non-adopter that means the treatment groups (Technology user households) and control groups (non- user households) would be analyzed. Based on the objectives and the nature of research questions of the study, quantitative data collection and analytic techniques was employed which was substantially supplemented by qualitative data in order to make the result sound.

3.3 Sampling techniques

Sample helps us to draw inferences about the population since reaching the population proved expensive and unrealistic in many cases. This means sampling technique helps us to understand the characteristics of the population by examining only a small part of it. But the sample size and the sample selection process/procedure should assure the representativeness of the population. Sample size determination has its own scientific approach. Various factors such as time, research cost, human resource, topography, environmental conditions, accessibility and availability of transport determine the sample size. Sampling procedure, three stages sampling was employed. Among twenty one kebeles, in the first stage, only six kAs are selected randomly. In the second stage of sampling, three kAs were selected randomly. Farmers in the three kAs were stratified into participants and non-participants based on the information recorded from kebele administrations. Then, to give equal chance in the selection of the sampling unit from each category, probability proportional to size was applied across each category. This was help to draw sampling unit representatively from each kAs according to the number of participant and non-participant households. In the third stage, simple random sampling was applied to select the sample household farmers. In these samples, a total of 230 samples were selected (110 and 120 farm households were participants and non-participants respectively).

In general, to select the sample for this study, three stages sampling was employed. In the first stage, six KAs were selected randomly. In the second stage, three KAs were selected randomly. In the third stage, within three KAs, households was stratified into two groups (participant and non-participant in project intervention), which was considered as sampling frame of the study. The households are included in the participant stratum were those who had at least three years

participation status in LIVES-project and other promoted improved dairy technologies intervening projects (because over lapping in the study area) and those who did not consider as non-participant stratum.

To identify sample size for the study, rule of thumb suggested by Green (1991) was followed. He suggests that $n > 50 + 8m$ (where n is sample size of the study and m is a number of independent variables). From this, the sample size for this study should be greater than 130 as there were 10 identified independent variables. Based on this, for the purpose of this study, 230 households (110 technology participants and 120 non-participants) were selected as a sample size of the study. The main reason was to get enough number of matches that enables to give generation on research objectives. To determine respective samples from three KAs for each stratum, probability proportional to size of population sampling method was used. Finally, representative sample for each stratum selected by using probability proportional to size was applied across each category.

Table 1: Distribution of Sample Respondents probability proportional to size by KAs

KAs code	Total households in each KAs	Participants households		Non-participants households		Total sample size
		Total	Sample	Total	sample	
01	968	218	48	750	49	97
05	653	136	30	517	34	64
08	719	146	32	573	37	69
Total	2340	500	110	1840	120	230

Source: Own survey result (2016)

3.4 Data sources, types and collection methods

The study was generated relevant data from both primary and secondary sources. As primary data, it was collected through questionnaire from sample respondents. The questionnaire was prepared based on the study objectives. Following this, interview schedule was used to collect data from the selected respondents. In addition to interview schedule, key informants interview

(KII) was employed to collect the required primary data that guide discussion with the concerned bodies to obtain in-depth information about different issues related to the study objectives. The key informant interview for this particular research was obtained staff members of LIVES project. With regard to secondary sources; data was collected from review of different documents includes research works, books, office documents, journals, articles, etc. that had been written by different scholars on the related issues.

Primary data were collected through personal interviews by trained enumerators were pre-tested 136 respondents (66 from technology users and 70 from non-users) at the time of survey using semi-structured survey questionnaire from 230 selected households'. The questionnaire was used to collect information based on socio-economic, technical, institutional and environmental characteristics on explanatory variables i.e., include use of improved dairy technologies, factors influencing on it and their benefit from them as well as impact on farm household income and asset holdings. Both quantitative and qualitative data were collected using interview and focus group discussions with group of farmers and agricultural extension staffs to collect opinion, qualitative and quantitative description about the research questions. The enumerators and respondents were given training to equip them with the necessary interviewing techniques. Finally enumerator was resume collecting data using the survey (questionnaire) with close supervision of the researcher.

3.5 Methods of Data Analysis

Number of studies had been investigated the influence of various socio-economic factors on the willingness of the decision makers to adopt new technologies. In most of these studies on adoption behavior of the decision maker can be captured using the dependent variable defined as dummy having value of one or zero or constrained to lie between one and zero otherwise and the models used were exponential functions. The decision to adopt new technologies could be very effectively captured using binary choice models. Binary choice models are appropriate when the choice between two alternatives depends on the characteristics of the problem. The farmer's decision to adopt or reject new technologies is influenced by the combined effects of factors related to farmer's objectives and constraints such as farmer specific variables (age, sex, educational level, farm land size, labor availability, market distance, extension contact, tropical livestock unit, farmer's participation on agricultural cooperatives and input access).

The hypotheses were adoption of dairy technologies has whether that impact on the smallholder income and asset holdings or not which were measured by different livelihood impact indicators (generalized of household income and asset holdings). In this case decision making on dairy technologies adoption were a binary variables. The quantitative data analysis and presentation was involved the use of descriptive statistics. Descriptive statistics such as mean, standard deviation, percentages, frequency distribution and inferential statistics such as chi-square test (for categorical variables) and F/t-test (for continuous variables) were applied. These were mainly used to evaluate the significance of the relationship between dependent and explanatory variables and test the hypothesis. Pearson correlation was used to see the strength and direction of association between variables. In addition, Tobit and PSM models were used to determine the relative influence of various explanatory variables on the dependent variable as well as impact of technologies on household income and asset holdings respectively.

Adoption is a decision to make full use of an innovation at best appropriate course of action available (Rogers, 1983:176). For multiple practices (technology package), there are two options of measuring adoption:

Adoption index (AI=measures the extent of adoption at the time of the survey) or Adoption quotient (measures the degree or extent of use with reference to the optimum possible without taking time into consideration). In this study, the first option was employed. Accordingly, adoption index which shows to what extent the respondent farmer has adopted the whole set of technology package was calculated using the following formula.

$$AI_i = \frac{\sum_{j=1, i=1}^{m, n} \left(\frac{breedadscore_{ji}}{BREDADOMAX_j} + \frac{feedadoscore_{ji}}{FEEDADOMAX_j} + \frac{houseadosore_{ji}}{HOUSADOMAX_j} + \frac{aidascore_{ji}}{AIDOMAX_j} + \frac{vetadoscore_{ji}}{VETADOMAX_j} \right)}{NTP}$$

Where: AI_i = Adoption index of the i^{th} farmer

$i = 1, 2, 3, 4, 5 - n$, and n = total number of respondents

$j = 1, 2, 3, 4, 5 - m$, and m = total number of major components of the improved dairy technology

$breedadscore_{ji}$ = improved dairy breed adoption score of i th farmer

$BREDADOMAX_j$ = the maximum potential score for improved dairy cow adoption

$Feed adoscore_{ji}$ = recommended feed practice adoption score of i th farmer

$FEEDADOMAX_j$ = the maximum potential score for recommended feed technology components

Houseadoscore_{ji} = the current housing practice adoption score of ith farmer

HOUSADMAX_j = the maximum potential score for current housing technology components

Aidoscore_{ji} = farmers current breed improvement with AIS

AIDOMAX = the maximum potential score for current breed improvement with AIS

vetadoscore_{ji} = the veterinary practice adoption score of ith farmer

VETADOMAX_j = the maximum potential score for veterinary practice components

NTP = Number of technology components

On the basis of adoption index, respondent farmers were classified into five categories, very low, low, medium, high and very high adopters. Adoption index is thus a continuous dependent variable which is affected by different factors to be investigated.

In this study, the dairy technological package, which has been promoted in the woreda, consists of five technological package components. The components were, breed (use of crossbred cows), feeding (concentrates, forage and standardized crop and hay supplements), housing (feeding trough, gutter, floor, side walls and roofing), AIS (synchronization, bull service and regular artificial insemination services), veterinary service practices (anthrax, black leg, and other prevalence diseases).

The study focuses on cumulative adoption of the five technological package components which have equal weight. For this study, all of the five technological package components were used for calculating the Adoption Index (AI). Adoption index was computed by adding the adoption score of each practice and dividing it by the number of technological packages to know the level of adoption of each sample households. The score of breed adoption was computed by giving a value of 1 for a farmer who has at least one cross bred cow and 0 otherwise.

The results of adoption score finally used to compute adoption index for the whole technological packages. The adoption score for each technological package components was calculated by the ratio of actual practice applied to the maximum recommended score which indicates the extent to which an individual farmer has adopted the practices. The breed technological package was a distinguishing point for adopter and non adopter, since adopter was defined as a farmer who has at least one cross bred cow which is the fundamental component of the technological package.

The adoption index score 0 point implies non adoption of dairy technological package components. The adoption index score of 1 implies the respondents adopted all practices

according to the recommendation. The final adoption index of sample adopter households were categorized into three adopter groups namely low, medium and high. The non-adopter group was given a score of 0 and kept as separate category to investigate factors influencing adoption of dairy technological package practices. This makes up five distinct categories on the basis of mean value of adoption index across which adoption and intensity of adoption of dairy technological packages were assessed. The adoption index score ranges used to classify respondents into very low, low, medium, high and very high adopters were 0.00, 0.35-0.45, 0.5-0.7, 0.71-0.9, and 0.91-1 respectively. The actual adoption index score ranges from 0 to 1.

Following data collection, the collected data was coded, edited and made ready to data entry. Based on objectives of this study, both descriptive and inferential statistics; Tobit and PSM econometric model was applied for data analysis.

Descriptive statistics: - It employed summary statistics such as graphs, percentages, table of frequencies distribution, mean and standard deviations.

Inferential statistics: - Inferential statistics such as chi-square was used to see the difference between participant and non-participant households across discrete explanatory variables of the study. Besides, independent F and t-test was used to compare mean differences between two groups across continuous and discrete explanatory variables. Data which obtain from key informants discussion was analyzed using narration and case study.

The Tobit econometric model

For this study, Tobit model was used to analyze factors affecting the adoption and it intensity of use of dairy technologies. Tobit model is an extension of probit model and it is one of the approaches dealing with the problem of censored data (Johnston and Dandiro, 1997). Some authors call such model limited dependent variable model, because of the restrictions put on the values taken by the regressed (Gujarati, 1995). Tobit model is superior over the other dichotomous regression models in that the later only attempts to explain the probability of adoption of agricultural technologies by the farm households rather than the intensity or extent of adoption. However, adoption of improved technologies alone is not sufficient enough since improvement in production and productivity of farm households depends not only on adoption but also on the intensity of use of the technologies.

In such cases, Tobit model, which has both discrete and continuous part, is appropriate because it handles both the probability and intensity of adoption at the same time. In the present study, Tobit model was used to examine factors affecting adoption and intensity of use of improved dairy technologies. Moreover, because of the significant number of observations on dependent variable having a value zero, Tobit model was found to be appropriate to deal with such censored data and used to analyze the intensity of use of improved dairy technologies in preference to multiple regression models.

Model specification

The econometric model that applied in this study for analyzing factors influencing adoption and intensity of adoption of improved dairy technologies was the Tobit model. In principle, the decisions on whether to adopt and how much to adopt could be made jointly or separately. The standard Tobit model assumed, among other things, that the dependent variable is censored at zero. The Tobit model also called a censored regression model because it is possible to view the problem where observations of the latent variable at or below zero are censored (Johnston and Dinardo, 1997). This model was chosen because, it has an advantage over other adoption models (LPM (Limited probability method), Logistic, and Probit) in that, and it reveals both the probability of adoption and intensity of use of improved dairy technologies. This was used to estimate the adoption and its intensity of use of participate on particular technologies. According to Gujarati (1995) this model helps to examine the factors affecting adoption and intensity of use after the practice is adopted simultaneously. The Tobit model, therefore measures not only the probability that a farmer will adopt the new practice but also the intensity of use once it is adopted or of the introduced technologies. Therefore a direct application of the Tobit estimation sufficiently provides the needed information on the probability and intensity of adoption of technologies.

The five steps that econometric model applied for analyzing factors influencing adoption and intensity of adoption of dairy technologies was the Tobit model shown in equation (1). Following (Amemiya 1985) and (Johnston and Dandiro, 1997), the Tobit model for the continuous variable adoption index, can be defined as:

$$AI_i^* = B_0 + B_i X_i + U_i$$

$$AI_i = AI_i^* \text{ if } B_0 + B_i X_i + U_i > 0 \dots\dots\dots (1)$$

$$=0 \text{ if } B_0 + B_i X_i + U_i \leq 0$$

Where: AI_i^* is the latent variable and the solution to utility maximization problem of intensity of adoption subjected to a set of constraints per household and conditional on being above certain limit,

AI_i is adoption index for i^{th} farmer

X_i = Vector of factors affecting adoption and intensity of adoption,

B_i = Vector of unknown parameters, and U_i is the error term which is normally distributed with mean 0 and variance σ^2 . The model parameters are estimated by maximizing the Tobit likelihood function of the following form (Maddala, and Amemiya, 1997).

Note that the threshold value in the above model is zero. This is not a restrictive assumption, because the threshold value can be set to zero or assumed to be any known or unknown value (Amemiya, 1985).

$$L = \prod_{AI_i^* > 0} \frac{1}{\sigma} f\left(\frac{AI_i - \beta_i X_i}{\sigma}\right) \prod_{AI_i^* \leq 0} F\left(\frac{-\beta_i X_i}{\sigma}\right) \dots \dots \dots (2)$$

Where f and F are respectively, the density function and cumulative distribution function of AI_i^* .

$\prod_{AI_i \leq 0}$ means the product over those i for which $AI_i^* \leq 0$, and $\prod_{AI_i > 0}$ means the product over those i

for which $AI_i^* > 0$.

Econometric software known as “STATA Version 14 software” was employed to run the Tobit model. Hence, one has to compute the derivatives of the estimated Tobit model to predict the effects of changes in the explanatory variables. As cited in (Maddala, 1997), (Johnston and Dinardo, 1997) proposed the following techniques to decompose the effects of explanatory variables into adoption and intensity effects. Thus change in X_i (explanatory variables) has two effects. It affects the conditional mean of AI_i^* in the positive part of the distribution, and it affects the probability that the observation will fall in that part of the distribution. Similarly, in this study, the marginal effect of explanatory variables was estimated as follows:

1. The marginal effect of an explanatory variable on the expected value of dependent variable is:

$$\frac{\partial E(AI_i)}{\partial X_i} = F(z)\beta_i \dots \dots \dots (3)$$

Where, $\frac{\beta_i X_i}{\sigma}$ is denoted by z, following Maddala, (1997)

2. The Change in the probability of adopting a technology as independent variable X_i changes is:

$$\frac{\partial F(Z)}{\partial X_i} = f(z) \frac{\beta_i}{\sigma} \dots\dots\dots (4)$$

3. The change in the intensity of adoption with respect to a change in an explanatory variable among adopters is:

$$\frac{\partial E(AI_i / AI_i^* > 0)}{\partial X_i} = \beta_i \left[1 - Z \frac{f(z)}{F(z)} - \left(\frac{f(z)}{F(z)} \right)^2 \right] \dots\dots\dots (5)$$

Where, $F(z)$ is the cumulative normal distribution of Z , $f(z)$ is the value of the derivative of the normal curve at a given point (i.e., unit normal density) and Z is the z-score for the area under normal curve, β is a vector of Tobit maximum likelihood estimates and σ is the standard error of the error term.

Before running the Tobit model all the hypothesized explanatory variables were checked for the existence of multicollinearity problem. There are two measures that are often suggested to test the existence of multicollinearity. Variance Inflation Factor (VIF) for association among the continuous explanatory variables and contingency coefficients for dummy variables. In this study, variance inflation factor (VIF) was used to test multicollinearity problem for continuous and dummy variables respectively. According to (Maddala 1992), VIF can be defined as: VIF

$$(X_i) = \frac{1}{1 - R_i^2}, \text{ Where } R_i^2 \text{ is the squared multiple correlation coefficient between } X_i \text{ and the other}$$

explanatory variables. The larger the value of VIF, the more troublesome it is. As a rule of thumb, if the VIF of a variable exceeds 10 (this will happen if R_i^2 exceeds 0.95), that variable is said to be highly collinear (Gujarati, 1995).

Propensity Score Matching (PSM)-Econometric models

In this study, income and asset holding impact was analyzed using econometric model of Propensity Score Matching (PSM) analysis using “STATA Version 14” software.

Model specification

In the case of this study, the interventions were the effect of promoted improved dairy technologies on farmer household income and assets in the program. However, the problem is to identify that lookalike (Shahidur *et al.*, 2010). To deal with this problem, the Propensity Score Matching (PSM) technique was used, which gained popularity in recent years for its potential to remove substantial amount of bias from non-experimental data. This model was employing for measuring the impact of promoted improved dairy technologies adoption (i.e breed, feed, AIS service, regular vaccination, housing.) on participant farmers household income and assets holdings. Propensity score matching is very important techniques in evaluating the impact of certain intervention in social science. The main reason for employing this technique is that firstly, it helps to adjust for initial differences between a cross-section of participants and non-participants groups by matching each participant unit based on similar observable characteristics.

According to (Shahidur *et al.*, 2010), the implementation of PSM involves six steps. These are estimation of propensity score, defining region of common support, choosing matching algorithm, testing matching quality, calculating average treatment effect on treated and sensitivity analysis. Accordingly, application system for the purpose of this study is discussed as follows for each step:

Estimation of propensity score

When estimation of propensity scores two choices have to be made. The first one concerns the model to be used for the estimation, and the second one is about the variables to be included in that model (caliendo and kopeinig, 2008). Concerning about the model, since this study has binary treatment (participation and non participation in improved dairy technologies), application of logit model was appropriate. According to (Gujarati ,2004), in estimating the logit model, the dependent variable should be dummy (participation in improved dairy technology in this case) which takes a value one if the household is participant in improved dairy technology programme and zero otherwise. The logit model was mathematically formulated as follows:

$$p_i = \frac{e^{z_i}}{1 + e^{z_i}} \dots \dots \dots 1$$

Where, P_i is the probability of participation in improved dairy technology

$$Z_i = \beta_0 + \sum \beta_i X_{i+U_i} \dots \dots \dots 2$$

Where, $\beta_0 =$ Intercept

$\beta_i =$ Regression coefficient to be estimated

$X_i =$ Variables and

$U_i =$ Disturbance term

The probability that a household belongs to the non- participant group is:

$$1 - P_i = \frac{1}{1 + e^{z_i}} \dots\dots\dots 3$$

The odds ratio can be written as

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{z_i}}{1 + e^{-z_i}} = e^{z_i} \dots\dots\dots 4$$

The left hand side of equation (4), $1 - P_i$, is simply the odds ratio in favor of participating in improved dairy technologies. It is the ratio of the probability that the household would participate in improved dairy technologies to the probability that it would not participate in the technology.

By taking the natural log of equation (4) the log of odds ratio can be written as:

$$L_i = L_n \left(\frac{P_i}{1 - P_i} \right) = L_n (e^{\beta_0 + \sum_{j=1}^n \beta_j X_{ij}}) = L_n e^{z_i} \dots\dots\dots 5$$

Where, L_i is log of the odds ratio in favor of participation in improved dairy technologies, which is not only X_{ij} linear in but also linear in the parameter. As indicated above, the logit model for this study was identified as follows with variables of the study:

$$Y_i = \alpha + \beta_1 \text{ AGE} + \beta_2 \text{ SEX} + \beta_3 \text{ EDULEVEL} + \beta_4 \text{ FRMLSZ} + \beta_5 \text{ LABRAV} + \beta_6 \text{ FPACOO} + \beta_7 \text{ MRKDIS} + \beta_8 \text{ INPUTACC} + \beta_9 \text{ EXTCON} + \beta_{10} \text{ TLU-u} \dots\dots\dots 6$$

Average Treatment effect on Treated

The impact of treatment on individual i , δ_i , is the difference between potential outcomes with and without treatment.

$$\delta_i = Y_{1i} - Y_{0i}$$

Where, states 0 and 1 correspond to non-treatment and treatment, respectively.

To evaluate the impact of a program over the population, we may compute the average treatment effect (ATE):

$$ATE = E[\delta_i] = E (Y_1 - Y_0)$$

Most often, we want to compute the average treatment effect on treated (ATT):

$$ATT = E(Y_1 - Y_0 \mid D = 1)$$

Where $D = 1$ refers to treatment. The problem is not all of these parameters are not observable, as they rely on counterfactual outcomes. For instance, we can rewrite ATT as

$$ATT = E(Y_1 \mid D = 1) - E(Y_0 \mid D = 1)$$

The second term is the average outcome of treated individuals had they not received the treatment. We cannot observe that, but we do observe a corresponding quality for the untreated, and can compute

$$\Delta = E(Y_1 \mid D = 1) - E(Y_0 \mid D = 0)$$

The difference between ATT and Δ can be defined as

$$\Delta = ATT + SB$$

Where SB is the selection bias term: the difference between the counterfactual for treated units and observed outcomes for untreated units. For the computable quality Δ to be useful, SB must be zero. But selection bias in a non-experimental context is sizable.

In other cases, the bias may not arise due to individuals self-selecting into treatment, but being selected for treatment on the basis of an interview or evaluation of their willingness to cooperate with the program. This gives rise to administrative selection bias or program placement bias (Christopher F Baum, 2013).

In this study, the roles of improved dairy technologies to rural household were to support the households' income and asset holdings. These dairy farming technologies was faced by certain challenges for decades and the demand of the product now increasing through time. These promotion activities were done by different actors and by farmer themselves. The effects of change by the dairy technologies were not analyzed on farm household income and asset holdings in the study area. Therefore, this section provides evidence as to whether or not the dairy technologies has brought significant changes on income and asset holdings (physical, financial, and human assets) of participant households with their counter parts. Participant households' annual income earned was conducted as indicator of financial (total annual farm income). Whereas productive and non-productive assets of household valued in monetary terms was considered as indicator of physical assets building of the households. Similarly, improvements of children schooling and health condition of the family were considered as indicator of human asset building of households during data processing. But in this study, the

impact analysis was analyzed and conducted by summarizing the general annual farm income and asset holdings (physical and human asset) of the households.

3.6 Definition of variables and working hypothesis

The data were covered information necessary to make farm level indices of economic, institutional, social and institutional factors that influencing dairy technologies adoption in the study area. Both continuous and discrete variables were used on economic theories and findings to answer the research questions of this study, the following variables were constructed.

3.6.1 Dependant Variable

A bundle or packages of technology of different technological elements such as improved cross breed, improve forage feeding, artificial insemination services (AIS), improved housing and regular veterinary vaccination were provided or transferred to smallholder farmers. For the household who participate/adopts dairy technologies the variable takes the value of one where as it takes the value of zero for the household who does not participate/adopt (respondent category whether he/she participant or non-participant). However, cross breed cow adoption was taken a proxy for this study. The dependent variable for this study was farmers' adoption of improved dairy technologies. This takes the value one for these who participate and zero otherwise.

The Adoption index (AI) as a continuous dependent variable was used to see the proportion or extent of improved dairy technologies adoption. The following dependent variable was considered as adoption and intensity of adoption of farmer's participation on improved dairy technologies (farmer's adoption behavior of dairy technologies (technical efficiency) would be discussed. Intensity of adoption refers to adoption index indicating farmers' level of use of multiple practices from the recommended improved dairy technology components (breed, feed, housing, AIS (including Synchronization) and regular veterinary services) and they benefited from them. Adoption score of farmers on dairy technologies (Adoption index of (the average of 5) = the rank of: very high, high, medium, low, very low = (One farmer has at least one improved dairy cow, current level use of AIS , current level use of recommended feed practice, current level use of improve dairy housing, current level use of regular vaccination activities.

3.6.2 Outcome Variables

It can be a continuous variable that represents the probability of the household whether they that can be benefited from dairy technologies or not. These benefits or impact indicators that were examined include impacts on household income (financial assets) and asset holdings (physical, human assets). Based on scope of the study, the following hypotheses were made for outcome variables.

Financial Assets: it is defined as the amount of annual income and saving of households. One of the primary objectives of using improved dairy technologies is increasing income and saving of the household. Annual income and saving was considered as indicator of financial assets of the households. Thus, it was hypothesized that improved dairy technologies had positive impact on annual income and saving of participant households.

Physical assets: It is defined as the productive and non-productive assets that household owned at a point of time. Bothe productive and non-productive assets valued in birr were considered as indicator of physical assets of the household. It includes productive, non-productive and durable assets. It was hypothesized that participation in use of improved dairy technologies program would improve physical assets of the participant households.

Human assets: It is about children schooling that enables them to achieve livelihood comes from dairy income. Annual children schooling expenses were considered as indicator of human asset of the household. Improved dairy technology has significant effect in capacitating of this technology users to spend more items for their children as compared to non-technology user. Thus, it was hypothesized that improved dairy technology participants spend more on expenditure on families.

In general, the impact (outcome) dependent variable was: Impact on income -TOTFICM (Total farm estimated income after use of dairy technologies), Impact on assets-TASHEVAF (Total asset holding estimated value in birr after use of dairy technologies)

3.6.3 Independent (Explanatory) Variables

Independent variables are variables that stand alone and are not changed by the other variables but cause change in dependent variable(s). The independent variables for this study were identified based on review of different literatures and carefully identified only those affects households decision to participate in improved dairy technologies and outcome considered by the study. To reduce bias, considering relevant variables that would be included in the Tobit and PSM model are very vital. However, empirical evidences and different theories were used to identify variables that affect improved dairy technologies participation and outcome considered by the study. Based on this, those include household's personal and demographic variables; economic variables; institutional variables; and social variables were identified as independent variables for this study. The following independent variables (as shown in conceptual framework) would be explained that most probably to influence the adoption of promoted improved dairy technologies in the study area and impact on household income and assets holdings. Those include household's personal and demographic variables; economic variables; institutional variables; and social variables.

3.6.4 Definition of independent variables and their hypothesized relations with adoption

1. Age (AGE)

It is continuous variable and measured in number of years. Age of a farmers can generate or erode confidence. With age farmers can become more or less risk averse to new technologies. However, there are mixed results as to the direction of influence. It is assumed that households with an older age have control over more resources and more experienced, a better reputation, and more responsible. In other words, as the age of the household head increases, the probability of adoption decreases. Because, with age, a farmer can become more risk averse and then tend to be reluctant to new technologies. Therefore, in this study it is hypothesized that age of household head are more likely to affect dairy technologies negatively/positively.

2. Sex of the household (SEX)

It is the maleness and femaleness of household head. It is nominal variable used as dummy, which take a value of one if male, zero if female. Gender difference is found to be one of the

factors influencing adoption of new technologies. Due to many socio-cultural values and norms, male have freedom of mobility and participation in different extension programs and consequently have greater access to information. Therefore, it is hypothesized that male farmers are more likely to adopt package (Mesfin, 2005, and Taha, 2007)

3. Education level (EDUCLEV)

It is defined as the number of schooling in years maintained by the respondents. It is continuous variable. It enables farmers to have access to new information and idea. Formal education of household in the family would increase the farmer's ability to use information relevant to the adoption of improved technologies (Haji, 2003). Based on his study, household head's educational level was thus expected to influence the probability of adoption of dairy technologies positively. So it plays an important role in adoption of innovations/new dairy technologies. Further, education is believed to improve the readiness of the household to accept new ideas and innovations and get updated demand and supply. Therefore, the more educated the household head, the higher the likelihood to decide for dairy technology adoption. It is hypothesized that education of household head has a positive impact on adoption of improved technologies.

4. Farm land size (FRMLSZ)

In the present investigation farm size is defined as the total farm size owned and rented by the household in hectares. It is a continuous variable and farmers with less land were expected not to be willing to adopt dairy technologies since they were thinking that the technologies need more land to grow various fodders and can be used for grazing. Farm size is an indicator of wealth and social status that influence within community. Farmers with large land size can adopt new agricultural technologies than smallholders (Kaba, 2009). It is hypothesized because there is a direct relationship between the farm size of land held by farm households and dairy technologies adoption. Therefore, it is hypothesized that land size would initiate to adopt improved dairy technologies.

5. Labor availability (LABRAV)

Those farmers who have access to labor are expected to adopt innovation more than those who lack labor, since improved technologies required more labor. This is dummy variable having the

value of one if it is available and zero otherwise. As active labor accessibility increases, adoption is also expected to increase and positively influence adoption and intensity of dairy package (Yishak, 2005).

6. Farmers Participation in agricultural co-operative (FPACOO)

Most farmers' cooperatives are served as an important source of credit and input as well as information. Due to this, a farmer who is a member of cooperative has more chance to get credit and farm input or information. It is a dummy variable which takes value one if a farmer is member and zero otherwise. Therefore, being member of cooperative, farmers will be expected to have positive and significant relationship with adoption of dairy package, (Taha, 2007)

7. Market distance (MARKDIS)

It is the location of farm household from the nearby market to buy dairy inputs and sale of products. It is measured by kilometer and continuous variable. Distance from the market center was expected to affect the adoption of dairy technologies. Households located near to market tend to buy inputs and they can have easy access to sale their dairy products. The farthest the market distance, the least the dairy technologies could be happened; the closer the market to farm household the lesser would be the transportation charges and loss due to spoilage better access to market information and facilities. This improved return to labor and capital; increase farm-gate price incentive to participate in dairy technologies adoption. As market distance increases, adoption and intensity of adoption were expected to decrease (Dereje, 2006 and Rahmeto, 2007).

8. Input access (INPUACC)

Input availability and potential to use is among the factors influencing adoption. Availability of input for dairy technologies is very important in dairy cows rearing. The inputs such as crossbred cow, artificial insemination service, feed, housing and veterinary services are very crucial for who engaged in the activities. However, required inputs may not be available in accessible local markets. Timeliness and availability of input in the market facilitate the adoption rates and intensive use of dairy technologies and hence intensity of adoption decision would be significantly and positively related with input access. It is measured as a dummy variable as if input is available for a farmer a value of one and zero otherwise. Consequently, input availability

is assumed to influence adoption positively. Access to input was, thus, hypothesized to be positively related to adoption of dairy technologies.

9. Extension Contacts (EXTCON)

This refers to contact between the extension agents and the farmer. The more frequent the contact between extension agent and farmer for dissemination of knowledge, the more the dairy technology participants are exposed to information and the more likely they are to be influenced in using the technology components and create farmers' awareness about new technologies.

This variable was measured as a continuous variable taking a value based on the frequency of contact households with the extension agent. It was expected to affect dairy technology adoption. A household head that had an access to dairy technologies extension services was more prone for technology adoption than the farthest one. Extension services widen the household's knowledge with regards to the use of improved dairy production technologies which leads to adopt more. Farmers contact with extension agent was assumed to increase the adoption and extent of use of dairy technologies and was hypothesized to influence positively.

10. Tropical livestock Unit (TLU)

Households that have more large number of livestock are likely to adopt more innovations than others who have less number of livestock because the farmers with more number of livestock have better opportunity to get credit. In this study it was assumed that livestock ownership and adoption would be related positively. Therefore, it is expected that number of livestock owned would have positive influence on the adoption and intensity of dairy technologies. As livestock ownership increases adoption and intensity of adoption was expected to increase and correlate positively (Birhanu, 2002). It is continuous variable and measured in Tropical Livestock Unit (TLU). Live stock ownership is hypothesized to be positively related to the adoption of dairy technologies because it serves as proxy for wealth status (Chilot *et al.*, Van Den Ban and Hawkins, 1996; Habtemariam, 2004). It is thus assumed to be positively associated with innovativeness.

Table 2: Explanatory variable description and its expected sign

Explanatory Variables	Nature of variables	Measurements	Expected sign
Age of the household (AGE)	Continuous	Year	-/+ve
Sex of the household (SEX)	Dummy	0 for female 1 for male	-ve
Educational level (EDULEVEL)	Continuous	year	+ve
Farm land size (FRMLSIZ)	Continuous	Hectare	+ve
Labor availability (LABRAV)	Dummy	0 for No 1 for Yes	+ve
Farmers' participation in Agricultural cooperative (FPACOO)	Dummy	0 for No 1 for Yes	+ve
Market distance	Continuous	Kilometer	-ve
Input access (INPUTACC)	Dummy	0 for No 1 for Yes	+ve
Extension contact (EXTCON)	Continuous	number	+ve
Tropical Livestock Unit	Continuous	TLU	+ve

Source: Literature review (2016)

4. RESULT AND DISCUSSION

This chapter presents the main results and discussions of the study. It divided into four sub-sections. The first sub-section describes the characteristics of sample household with respect to

identified explanatory variables of the study and current level of adoption and intensity of adoption of dairy technologies while the second and third sub section describes Tobit model for factors that influencing adoption of dairy technologies and estimation of propensity score matching (PSM) model for identification of dairy technologies adoption impact on household income and asset holdings. In case of propensity score, this includes estimation of propensity score, common support region, matching algorithms, balancing test, average treatment effect results and sensitivity analysis respectively. Finally, the fourth section discusses the constraints (factors) that affect participation/adoption of improved dairy technologies.

4.1 Result of Descriptive and Inferential Statistics

This sub-section has been discussed the association of various variables with adoption and intensity of adoption of dairy technologies by using descriptive and inferential statistics. They are important tools to present research results clearly and concisely. They can also help one to have a clear picture of the characteristics of sample units. As describe the Sample households' characteristics, the two groups of sample respondents were compared and contrasted with respect to personal and demographic, institutional, economic and social characteristics so as to draw some important conclusions. In this study, ten independent variables were identified with adoption of dairy technologies such as age, sex, educational level, farm land size, labor availability, market distance, extension contact, tropical livestock unit, farmer's participation on agricultural cooperatives and input access.

4.1.1 Age of the respondent (AGE)

In this study, Age of the households in table 3 revealed that the minimum and maximum age of the respondents were 25 and 70 respectively. The mean age of the household head was found 45.38 with standard deviation of 8.16. It was found that majority of the respondents in both groups were in active age group where 98.18% of improved dairy technology participants and 98.33% of non-participants fall in age category of 25-64. Only 1.74% of participant households and non-participants was fall in dependent age category (above age 64). The t-test result indicates that, there was no significant mean difference between two groups in their age.

Table 3: Age distribution of the respondent household head

Age category	Participant		Non-participant		Total		t-value
	Frequency	percent	Frequency	percent	Frequency	percent	
Age 18-64	108	98.18	118	98.33	226	98.26	
Age above 64	2	1.82	2	1.67	4	1.74	
Total	110	100	120	100	230	100	
Mean	45.3		45.45		45.38	0.1389	

Minimum	25	28	28
Maximum	65	70	70

Source: Own survey result (2016)

4.1.2 Sex of the respondent (SEX)

Table 4 revealed that the sex distribution of sampled households. From total sampled households, 82.17% of them were male and 17.83% of them were female headed. With regard to participation status of the sample respondents on improved dairy technologies by sex, they found that 82.73 % of improved dairy technology participants were male household head while the rest 17.27% was female. Concerning of non-participant household heads, 81.67% and 18.33% of the respondents were male and female respectively. The chi-square test analysis describes that there was no statistical significant differences in the sex of the respondent between technology participant and non-participants at 5% significant level.

Table 4: Sex of the respondents

Sex	Participant		Non-participant		Total		χ^2
	Frequency	percent	Frequency	percent	Frequency	percent	
Male	91	82.73	98	81.67	189	82.17	
Female	19	17.27	22	18.33	41	17.83	
Total	110	100	120	100	230	100	0.0441

Source: Own survey result (2016)

4.1.3 Educational level of the households (EDUCLEV)

Practical and theoretical evidences shows that households with better educational status could determine were one works to earn better income and accumulate wealth. Due to such valid importance, respondents in this study were categorized into five groups with respect to their educational level; including those who have no formal education, completed grade 1-4, 5-8, 9-10, and 11-12 respectively. Table 5 revealed that majority (71.30%) of the respondent in the study area has no formal education where as only (28.70%) of those who had formal education. From improved dairy technology participant household group 64.55% of them have no formal education where as the rest 35.45% have formal education. In the similar manner, out of non-technology participant group of respondents, it was found that 77.5% of them have no formal education while the rest 22.5% of them have formal education. This indicates formal education in participant group was better (35.45%) than in non-participant (22.5%) groups. Statistically the t – test indicated that educational level was significant difference between two groups at 1% significant level.

Table 5: Educational status of the respondent

Educational level	Participant		Non-participant		Total		t-value
	Frequency	%	Frequency	%	Frequency	%	
No formal education	71	64.55	93	77.5	164	71.3	
1-4	10	9.1	7	5.83	17	7.39	
5-8	13	11.82	12	10	25	10.87	
9-10	12	10.91	7	5.83	19	8.26	
11-12	4	3.64	1	0.83	5	2.17	

Total	110	100	120	100	230	100
Mean	2.6		1.36		1.95	2.86***

Source: Own survey result (2016) *** significant at 1%

4.1.4 Farm land size holding of respondents (FRMLSZ)

The minimum and maximum land holding was found to be 0.08 and 2.5 hectares respectively. The statistical t-test was conducted to examine whether there was significant mean difference in land holding between the two group respondents or not. As presented in the Table 6 below, it was found that there was significant mean difference in land holding between two groups. The difference was significant at 1% of statistical significant level. In the study area dairy technology participants were found to have more land holding than non- participants. The possible reason for this could be large land holder farm households considered as more adaptors'/participant of the technologies than counter parts.

Table 6: Farm land size holdings of respondents

Land size	Participants	Non-participants	Total	t-value
Mean (Ha)	.897	.712	0.80	4.42 * * *
Minimum	0.25	0.08	0.25	
Maximum	2.5	1.25	2.50	

Source: Own survey result (2016) *** significant at 1%

4.1.5 Labor availability (LABRAV)

Farmers who have access to labor are expected to adopt innovation more than those who lack labor, since improved dairy technologies required more labor. Based on Table 7, as labor accessibility increases, adoptions is also increase and positively influence adoption and intensity of use of these technologies. The finding indicated that 85% participants in dairy technology affirm the availability of labor while only 48% of the non-participants did the same.

Table 7: Labor availability of the respondents

Labor Availability	Participant		Non-participant		Total		χ^2
	Frequency	Percent	Frequency	Percent	Frequency	Percent	
Yes	94	85.46	57	47.5	151	65.65	
No	16	14.55	63	52.5	79	34.35	
Total	110	100	120	100	230	100	36.66***

Source: Own survey result (2016)

***significant at 1%

4.1.6 Market distance of respondents household (MRKDIS)

In this study, the total average physical market distance of sampled households away from large cities was 8.73km. The average market distances of participant and non-participant households away from town was (8.52km) and (8.92km). As indicated in the Table 8, it was found that there was no statistically significant difference between two groups. The t-value (0.78) gives enough evidence for that there was no significant mean difference between two groups.

Table 8: Market distance to respondents household

Distance	Participant	Non- participant	Total	t-value
Mean	8.52	8.92	8.73	0.78

Source: Own survey result (2016)

4.1.7 Respondents Contact with the extension services (EXTCON)

Tehuledere district experts and different NGOs are who provide different extension services related with dairy production development at kebele level for rural households. They offered different training and supports to dairy technology participants, consult and motivate those who didn't accessed extension services the respective organization due to lack of information and awareness. A household who has access to dairy production extension service is more likely to go for technology adoption than those who has no access. Extension service widens the household's knowledge with regard to the use of improved dairy production technologies which leads to participate on more improved practices.

Despite variations of extension services, the district government and other stakeholders' were provided these services for small holder farmers to promote improved dairy technologies. Respondents were asked to respond on whether they contact with development agents in the last recent months or not. The finding presented in Table 9 revealed that the contact frequencies made by the respondents with development agents. It is obvious that households who contact more with the development agents know more about the benefits of the extension services delivered by the agents. The average number of contact respondents made with the extension development agents in months was 1.63. The average number of contacts made by dairy technology participants was 2.83 while the average number of contacts made by non-participants was 1.2. This shows that, there was difference between the two categories in terms of number of contact made with the development agents. Moreover, out of the total sampled household 33.91% of respondents made no contact with development agents. Similarly, 14.55% of dairy technology participant households and 51.67% of non-participant households made no contact with DAs.

Among dairy technology participants, none of the participants of them made contact with DAs at 1 time, while only 4.17% of non-participants made the same time contact. Out of dairy technology participants, 5.46% of them 2 times number of contact with DAs, while 20.83% of dairy technology non-participants made same time. Similarly, 48.18% dairy technology participants and 19.17% of non-participants made 3 times contact with DAs, while 31.82% of participants and 4.17% of non-participants made 4 times contact with DAs per months. The t-test was conducted to examine whether there was significant mean difference between two groups in terms of number of contact made with DAs or not. As indicated in the same table, there was statistically significant difference in number of contact made by technology participant and non-participant households with extension providers at 1% of statistical significance level.

Table 9: Respondents contact with extension service

Frequency of contact	Participant		Non-participant		Total		t-value
	Frequency	%	Frequency	%	Frequency	%	
No contact	16	14.55	62	51.67	78	33.91	
1	0	0	5	4.17	5	2.17	
2	6	5.46	25	20.83	31	13.48	

3	53	48.18	23	19.17	76	33.05
4	35	31.82	5	4.17	40	17.39
Total	110	100	120	100	230	100
Mean	2.83		1.2		1.63	9.3***

Source: Own survey result (2016) ***significant at 1%

4.1.8 Livestock ownership of respondent household (TLU)

Livestock ownership of the rural farm households is very important for income generation, for food, for traction power, for social security, for organic fertilizer and asset holding. This study was directly related to focuses on identifying the constraints of farm household production and productivity on use of improved dairy technologies. For simplicity of this analysis, number of livestock owned by respondent households was converted into tropical livestock unit (Appendix I). As indicated in Table 10, both sample respondents in the study area have an average of (3.87) tropical livestock unit. The mean tropical livestock unit of dairy technology participants was (4.48) while non-participants were (3.32). The statistical t-test (6.03) in the same table indicated that there was statistically significant mean difference between the two categories (technology participant and non-participants) in terms of livestock owned statistically at 1% of level of significance.

Table 10: Livestock owned by household respondents in TLU

TLU	Participant	Non- participant	Total	t-value
Mean	4.48	3.32	3.87	6.03 * * *

Source: Own survey result (2016) ***Significant at 1%

4.1.9 Participation in co-operative (FPACOO)

This variable was expected to influence the dairy technologies adoption because dairy technologies need very high initial investment cost which households may not afford easily and reliable input and output market is precondition which can be provided by collective organization like cooperatives. Ideally, cooperatives can overcome the financial constraint of the household to invest on dairying and supply information as well as inputs. Based on this respondents were asked to respond on whether they are participated in agricultural cooperative in the past five years or not. As indicated in Table 11 below, 55.22% of the respondent households participated in agricultural cooperatives while the rest 44.78% didn't participate on it. Majority (86.36%) of dairy technology participants respond that they participated in agricultural cooperatives while the rest (13.64%) of the respondents respond that they didn't participate. Similarly, out of dairy technology non-participant respondents, only (26.67%) of them participated in agricultural cooperatives while the rest (73.33%) of them didn't participate.

The Chi-square was employed to examine statistical significant difference between dairy technology participants and non-participants on participation of cooperative organizations. As indicated in Table 11, it was found that, there was significant ($\chi^2=82.71$) difference between dairy technology participant and non-participant in terms of participation at 1% level of significance.

Table 11: Respondents participation in agricultural cooperatives

Participation in cooperative	Participant		Non-participant		Total		χ^2
	Frequency	Percent	Frequency	Percent	Frequency	Percent	
Yes	95	86.36	32	26.67	127	55.22	
No	15	13.64	88	73.33	103	44.78	

Total	110	100	120	100	230	100	82.71 * * *
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Source: Own survey result (2016) ***significant at 1%

4.1.10 Access to technology/Input availability (INPUACC)

Input availability and farmer’s potential to use technologies are among the major factors that influencing adoption. Availability of input for dairy technologies is very important in dairy cow rearing. The inputs such as crossbred cow, AIS, animal feed, housing material and veterinary services are very crucial for who engaged in these activities. However, rural households in many occasions, required inputs may not be available in local markets. Timeliness and availability of input in the nearby market is crucial to facilitate technology adoption. Hence, input availability was the other determining factor in which /participant and non- participant seen to differ in their degree of agreement for the presences or absences of dairy technology inputs/technological availability. As revealed in Table 12, among the total respondents, 58.70% of participant households were respond availability of input positively while the rest 41.30% didn’t. In other words, 17.27% of participants and 63.33% of non-participants said that there was no dairy technology input and 82.73% of participant and 36.67% % of non-participant was disagreement with these responses. The chi-square test result revealed that ($\chi^2=50.22$) there is significant relationship/difference between two groups/ between input availability and adoption/participation of dairy technology at 1% significant level. The reason could be participants/adopter farmers can afford to purchase input from far places or having chances supported by motivating agencies. Hence, this needs great attention to strengthen cooperatives by stakeholders.

Table 12: Input access

Input access	Participant		Non-participant		Total		χ^2
	Frequency	Percent	Frequency	Percent	Frequency	Percent	
Yes	91	82.73	44	36.67	135	58.70	
No	19	17.27	76	63.33	95	41.30	

Total	110	100	120	100	230	100	50.22 * * *
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Source: Own survey result (2016) ***significant at 1%

4.2 Current level of adoption of dairy technology components

Dissemination of agricultural innovations to technology users are/is one of the priority areas that deserve attention in agricultural and rural development endeavors. The application of improved techniques, (innovations) whether it is introduced from within the social system or outside, is important for farmers to achieve/increased production and productivity. New technologies / practices are usually recommended in a set or technological package form to use by farmers. However, for several reasons, farmers usually adopt only certain components of the technologies. Moreover, in most cases there is variation in intensity of on given technology or practice. Diversity among farmers in their level of technology adoption could be related to many factors (economic, social, personal, institutional and social). Understanding why farmers adopt one component of the technology while rejecting the other as well as the underlying reasons for their variation is of a paramount importance.

The result on mean adoption index across adoption categories is provided in Table 13. It clearly indicated that the mean adoption index scores of adopters participants low, medium and high adopter groups are 0.41, 0.61 and 0.78 respectively. The result of one way ANOVA revealed that there is significant mean difference ($F=96.85$, $P<0.0000$) among the three adoption categories (based on the high mean value) at 1% significant level which indicates difference in level of adoption among the three adoption categories. From the total sampled household heads, 2.73% had adoption index ranging from 0.35 to 0.45 (which was lowest adoption category) whereas 92.73% of the respondents had adoption index score ranging from 0.5 to 0.7 (lied under medium adoption category) and 4.55% them had adoption index score ranging from 0.75 to 0.9 (which was the highest adoption category). This indicates majority of participant households was medium adaptors and adoption differ statistically at 1% significant level in each adopter households.

Table 13: Distribution of respondents by level of dairy technologies

Adoption category	N	%	Adoption Index range	Mean Adoption Index	SD	F	P
Low	3	2.73	0.35-0.45	0.41	0.06		
Medium	102	92.73	0.5-0.7	0.61	0.03		
High	5	4.55	0.75- 0.9	0.78	0.07		
Total	110	100		0.61	0.06	96.85***	0.0000

Source: Own survey (2016) *** Significant at 1% level

4.2.1 Adoption of breed component

Regarding status of adoption of dairy technology practices, respondents who use each practice were used to assess the status of adoption. In this analysis, only participant categories were included. The optimum recommended level was used as a reference to assess status of adoption. Out of the recommended dairy technologies, breed component is the fundamental component introduced in the area. In this technology component, there was no significant difference between the very low, medium, high and very high adopter categories because, every adopter has at least one cross bred cow which is the recommended technology practice. Therefore, the adoption index score value for all breed components is 1. There was no other technology component used to differentiate between the adopter categories. The reason for this was that, the breed improvement in the study area was conducted in two ways. Thus were Extensive use of Artificial Insemination Services (AIS) and distribution of crossbred heifers from different ranches. In the case of utilization of AIS, currently and for the past time, the breed types which were in use are different in their breed type and blood levels. Among the breed types Holstein Frisian and Jersey breed was the major promoted ones in the study area.

The current status of the breed level adoption was assessed in each sample KAs. As the result, Table 14 clearly revealed that adoption of crossbred simply in Bededo, Kete and Hitecha were 22.5%, 20.8%, and 20.3%, respectively. This result indicated that the percentage of breed technology participant going on an improvement but still they need high intervention of the non-participants groups.

Table 14: Current status of adoption of breed technology in sampled KAs (N = 2340, n = 230)

Kebele Name	Number of HHS with dairy cows	Number of HHs with			
		Local Cows	%	Crossbreed cows	%
Bededo	968	750	77.5	218	22.5
Kete	653	517	79.2	136	20.8
Hitecha	719	573	79.7	146	20.3
Total	2340	1840	78.6	500	21.7

Source: Own survey (2016)

4.2.2. Adoption of feeding technology component

The feeding technology is one of the important components in dairy production. In this technology component, the major recommended feeding practices for dairy herders included such as feeding of industrial by product and feeding of forage legumes and standardized crop and hay supplements were assessed. Regarding feeding technology adoption, the score for all feed components was computed for all adopter categories and the result of adoption index for feeding technologies indicated in Table 15. It revealed that farmers were using feeding technology components at different rates. The analysis indicates that there is significant in the use of this recommended feed component among the adopter categories. The average mean value of feeding technologies was 0.61 with standard deviation of 0.06. The mean status value of feeding practices for very low, low, medium, high and very high adoption categories was 0, 0.45, 0.61, 0.73 and 0 respectively. The finding of this study indicated that there is significant variation ($F=106.32$, $P<0.000$) among adoption categories at 1% probability significant level. The proportion of the respondents for adoption of recommended feed showed that 5(4.55%) low feeding, 96(87.27%) medium and 9(8.18%) high feeding of improved dairy cows. From the result, the adoption of feed technology component adoption rate was medium when compared with the recommended rate. This may be due to lack of supply of industrial by products and other feed components.

Table 15: Respondents total score for adoption of recommended feeding technology components

Adoption categories	frequency	%	Mean	SD	F	P
Very low	0	0	0	0		

Low	5	4.55	0.35	0.06	
Medium	96	87.3	0.61	0.03	
High	9	8.18	0.73	0.07	
Very high	0	0	0	0	
Total	110	100			106.32 *** 0.0000

Source: Own survey (2016) ***Significant at 1% level

4.2.3. Adoption of recommended housing technology component

Adoption of housing technology components consists of improving of the recommended housing conditions including adoption of feeding trough, gutter, floor, side walls and roofing. For these technological components, respondents' score for gross component based on the values given very low, low, medium, high and very high. The score of housing components were added and sum of the score was taken to compute the index value for housing technologies. Based on the data obtained for each component, the result of housing technology index value across each category indicated in Table 16. It revealed that there is significant mean difference among the adopter categories. The average mean value of housing technological was 0.61 with standard deviation of 0.06. The mean value for very low, low, a medium, high and very high adopter category was 0, 0.35, 0.59, 0.68 and 0.75 respectively. The finding of this study indicated that there is significant variation ($F=44.74$, $P<0.0000$) between adopter categories at 1% significant level.

Table 16: Respondents total score for current adoption of housing technological components

Adoption categories	frequency	%	Mean	SD	F	P
Very low	0	0	0	0		
Low	1	0.91	0.35	0		

Medium	85	77.27	0.59	0.03		
High	23	20.91	0.68	0.06		
Very high	1	0.91	0.75	0		
Total	110	100	0.61	0.06	44.74***	0.0000

Source: own survey (2016) *** Significant at 1% level

4.2.4 Adoption of regular vaccination technological components

Veterinary service is one of the dairy technology components which comprises of were regular vaccination against the prevention measure before occurrence of different bacterial and viral diseases such as anthrax, black leg, and other prevalence diseases. In similar way like other components, adoption score of veterinary technologies was computed by the value of responses (like very low, low, medium, high, very high) across adoption categories and the result of adoption index indicated in Table 17. It revealed that there is significant mean difference among adopter categories. The mean value of adoption of veterinary practices was 0.61 with a standard deviation of 0.06. The mean value for very low, low, medium, high and very high adopter categories was 0, 0.44, 0.61, 0.68 and 0.9 respectively. The result indicated that there is significant mean variation ($F=51.01$, $P<0.0000$) between adopter categories at 1% probability level. The proportion of adopter categories in the adoption of the veterinary service revealed that vaccination against various prevalence disease were 4(3.64%) low, 99(90%) medium, 6 (5.45%) high, and 1(0.91%) very high respectively.

Table 17: Respondents total score for adoption of regular vaccination technology components

Adoption categories	frequency	%	Mean	SD	F	P
Very low	0	0	0	0		
Low	4	3.64	0.44	0.06		

Medium	99	90	0.61	0.37		
High	6	5.45	0.68	0.05		
Very high	1	0.91	0.9	0		
Total	110	100	0.61	0.06	51.01 ***	0.0000

Source: Own survey (2016) ***Significant at 1% level

4.2.5 Adoption of AIS technological components

One of the inputs crucial for dairy enterprises is the availability of inputs like artificial insemination service. Crossbred cows are expensive to buy for smallholder farmers. Availability of AIS is the best way for expansion of improved dairy breeds with low cost. In this study Artificial Insemination Services (AIS) were hypothesized to be positively related to adoption of improved dairy breed and overall dairy adoption. Table 18 shows that AIS were positive and strong influence on adoption of improved dairy breed. The mean value of adoption of AIS were 0.61 with a standard deviation of 0.06. The mean value for very low (0.35), low (0.52), medium (0.62), high (0.75) and very high (0.9) adopter categories. The result indicated that there is significant mean variation ($F=57.77$, $P<0.0000$) between adopter categories at 1% probability level. As to the percentage distribution, the adoption of AIS grouped 1 (0.91%), 9 (8.18%), 97 (88.18%), 2 (1.82%) and 1 (0.91%) of those who have access to artificial insemination were in very low, low, medium, high and very high adoption group respectively. This indicated that access of AIS was at medium level and majority of adopter households used to improve their own improved breed cows.

Table 18: Respondents total score for current AI technology practice components

Adoption categories	frequency	%	Mean	SD	F	P
Very low	1	0.91	0.35	0		
Low	9	8.18	0.52	0.05		

Medium	97	88.18	0.62	0.03		
High	2	1.82	0.75	0		
Very high	1	0.91	0.9	0		
Total	110	100	0.61	0.06	57.77***	0.0000

Source: own survey result (2016) *** significant at 1% level

4.2.6 Current Productivity of local and crossbred cows across sampled households

Current productivity is an important factor in dairy technology adoption. Cross breed and local cows are kept by farmers for milk production and stock replacement. Improvement in milk productivity of crossbred/local cows depends on use of better feeding and application of all recommended technological components. In the study area, the current productivity of cross bred and local cows was assessed and the result is indicated in Table 19. The average milk yield of sampled non-participant households from local cow was 1.49 liters with a standard deviation of 0.41. The current maximum milk gain from this cow was 3 liter/cow/ day. The average milk yield of sampled participant households from improved cow was 7.79 liters with a standard deviation of 2.47. The current maximum milk gain from this cow was 14 liter/cow/day. The result of this study revealed that there was a significant mean difference between local and improved dairy cows in their level of productivity ($F=1195.82$, $P<0.0000$) at 1% probability significant level. However, this level of productivity of improved dairy cows is lower than what the district, regional and even the national extension system expected. In other words, this level of productivity is not sufficient as compared to the optimum productivity that can be achieved by better management of crossbred cows. Extension interventions should be needed based on the current outputs prevailing.

Table 19: Current productivity of crossbred cows across adopter categories (n=110)

Productivity	N	Mean	SD	Min	Max	F	P
Local cow	120	1.49	0.41	0	3	0.99	0.3218
Improved cow	110	7.79	2.47	0	14	1195.82	0.0000***

Total	230
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Source: Own survey (2016) ***Significant at 1% level

4.3. Result of Tobit Econometric Model

Descriptions of the sampled population and test of the existence of association between the dependent and explanatory variables to identify factors affecting adoption of dairy technologies were discussed thoroughly in the previous section. Identification of these factors alone is however not enough to stimulate decision makers unless the relative influence of each factor is known for priority based intervention. In this section, the econometric model (Tobit) was used to see the relative influence of different personal and demographic, economic, institutional, and social variables on adoption and intensity of adoption of dairy technologies.

Multicollinearity was tested using variance inflation factor (VIF); this revealed that no problem of multicollinearity observed because tolerance ($\frac{1}{1-R_i^2}$) greater than 10% among each explanatory variables (the independent variables). The results of the test were indicated in Appendix II.

As shown in Table 20, the Tobit estimate result indicate that farm land size, market distance, and tropical livestock unit have positive and significant effect while sex has negative significant effect. But the rest of explanatory variables had insignificant effect in this study. Statistically, the former three factors are expected to both increases the probability as well as intensity of adoption of Dairy Technologies (DTS) positively and significantly at 5%, 1% , and 1% level of significant respectively while the later was negatively affect at 10% significant level. In other words, as landholding size increases by 0.23, it increases the probability of use of dairy adoption technologies by farm households significantly at 5% level. The possible reason could be as the landholding size increases, the farm households are more in a position to produce animal feed from crop residue and through forage development. As a result it has a positive and significant influence on dairy technology adoption.

Similarly, the total tropical livestock unit increases by 0.04, the probably of use of dairy adoption technologies could be increased significantly at 1% significant level. The positive and

significant of TLU on dairy technology adoption is partly through specialization effect and cash generation for reinvestment in the dairy enterprise.

Regarding effect of market distance as indicated in Table 20, it was affect the probability of farm household purchase or sale of livestock input-output marketing. The finding show that distance to market affects dairy technologies adoption at 1% level of significant. Additionally farmers lack of sustainable milk market due to poor coordination of milk cooperatives and low milk market value chains. This idea was supported by FGD and key informant discussants.

Regarding sex of the households, the analysis revealed that female household head participants were less likely to participation/adoption of dairy technologies by a factor of 0.11 and the result was significant at 10% level. The possible reason could be female households were resource poor and less accessible to extension services so as to participate on technological innovations (dairy technology in this case).

Table 20: Estimated results using Tobit model

Variables	Coef.	Std. Err	p-value
AGE	0.0021493	0.003348	0.522

SEX	-0.1092414	0.064965	0.094
EDULEVEL	-0.0116104	0.057029	0.839
FRMLSZ	0.2277494	0.113261	0.046
LABRAV	0.0495184	0.053918	0.359
MARKDIS	1.088247	0.089111	0.000
EXTCON	0.0251299	0.054263	0.644
TLU	0.0396987	0.009838	0.000
FPACOO	0.0652043	0.059636	0.275
INPUTACC	-0.0669055	0.059878	0.265
_cons	-0.1432414	0.161921	0.377
/sigma	0.2731782	0.019186	

Sample (N) = 230, LR chi2 (10) = 346.38, pseudo R2 = 0.8057, Prob > Chi2 = 0.0000

Log likelihood = -41.7745, Obs. summary: 0 left censored observation, 114 uncensored observations, 116 right censored observation at DTS > = .8

Source own survey result (2016)

4.3.1 Marginal effects of explanatory variables on improved dairy technology adoption

The effect of changes in the explanatory variables on the probability of adoption and intensity of use of improved dairy technologies were computed and the results were summarized below. The results computed indicate that of female household head were negative effects that decrease the probability of adoption and intensity of use of improved dairy technologies. The marginal difference of male household participants was 44.62% higher than female household participants. Relatively better adoption of male households was due to the fact that male headed households have better exposure to any extension activities to use production technologies than female headed households. On the other hand, as opposed to female headed, male headed households are risk averters while the technologies involves with risks. The implication is that male headed households are relatively better in adoption of improved dairy technologies than counterparts. This may be due to many socio-cultural values and norms males have freedom of mobility and participation in different meetings and consequently have greater access to information.

A higher marginal effect was accounted to market distance, being member of agricultural cooperative and availability of labor respectively. Looking into in the column labeled **dy/dx** we see that market distance had positive and higher marginal effect (96.1%) on adoption/participation difference between participants and non-participants households. The possible reason that confirmed by the results and respondents' response were market distance effect has impact on purchasing of inputs. The main problems were unsustainable market for sell of milk and milk products. Hence, the implication of this study could be farm households had not been highly suffered by the market distance because the sampled respondents' residences are around the small town and road sides. The serious challenges of the respondents were poor coordination of milk market value chains among actors.

Similarly, being member of agricultural cooperative resulted in an increase in the probability of adoption and intensity of adoption. Cooperative participant households differ in adoption/participation of dairy technologies by 51.35% with counter parts. The implication of this results could be participation in agricultural cooperatives were positive effect in the majority of participant households because it owning by themselves that provide agricultural inputs and

information in his locality while the non participants were the reverse. Hence, it might be contribute on dairy technologies adoption and intensity of adoption for participants.

Marginal effects on tropical livestock holding could be increase in number of livestock that contribute to increase economic as well as social status of the households. As the result, table 18 below revealed that it was positive effect that adoption and intensity of adoption decision to occur at 5 % significant level. As the table indicated that better number of livestock holding affects the sample respondents' probability of adoption and intensity of use of the improved dairy technologies participant households differ by 14.28% with their counter parts. This means 14.28% of large livestock owner participant households had higher probability of adoption than small number of livestock owners' participant.

Regarding labor availability, the result revealed that availability of labor was positive effect and it increased the probability of adoption and intensity of adoption of dairy technologies. Participant households which had better active labor force increase the probability of participation/adoption by 43% than low labor force non-participants/adopters. This indicated that an additional active labor contributes for adoption/participation of dairy technologies.

Table 21: Marginal Effects of explanatory variables on improved dairy technology adoption

Variables	dy/dx	Means	Std. Err.	P-value
AGE	.0142849	45.3783	.01413	0.312
SEX*	-.4461572	.821739	.15396	0.004
EDULEVEL*	.0142792	.286957	.25633	0.956
FRMLSZ	.6494547	.800087	.51463	0.207
LABRAV*	.4302412	.656522	.25026	0.086
MRKDIS*	.9614397	.456522	.02972	0.000
EXTCON*	.2585664	.66087	.2199	0.240
TLU	.1428291	7.36087	.05059	0.005
FPACOO*	.5134703	.552174	.21107	0.015
INPUTACC*	-.3306161	.586957	.26046	0.204

(*) dy/dx is for discrete change of dummy variable from 0 to 1

$y = \Pr ((RSPCAT) = \text{Respondent Category}) (\text{predict}) = .69948942$

Source: Own survey (2016)

4.4 Result of Econometric analysis of PSM

This section describes econometric analysis which was followed to identify the impact of improved dairy technologies adoption on households' income and asset holdings. It was analyzed and explained that includes the estimation of propensity scores, defining common support region, choosing matching algorithm, testing matching quality, calculating Average Treatment Effect on treated (ATT) and sensitivity analysis.

4.4.1 Estimation of propensity scores

Propensity score matching (PSM) constructs a statistical comparison group that is based on the model of the probability of participating in the treatment, using observed characteristics. Participants are then matched on the basis of this probability, or propensity score, to non-participants. The average treatment effect of the program is then calculated as the mean difference in outcomes across these two groups. The validity of PSM depends on two conditions

- 1) Conditional independence (meaning that unobserved factors do not affect participation) and
- 2) Sizable common support or overlap in propensity scores across the participant and non-participant sample household (Khandker et al., 2010).

The first step in PSM was to determine the propensity score and balancing the property.

Accordingly, in this study ten explanatory variables (Table 22) were identified after iteration to fulfill the criteria of the balancing propensity is satisfied. After balancing the predicted probability values conditional on the observable covariates (the propensity scores) from the binary estimation, matching was done using matching algorithm that was selected based on the data at hand. Even though different approaches were used to match participant and non-participants on the basis of the propensity score choice of matching estimator was decided based on the balancing qualities of the estimators.

In general, this section presents the result of logistic regression, the first step in the propensity score matching (PSM), to estimate propensity score for matching dairy technology participant

households with non-participants. The existence of problem of heteroscedasticity was tested using Breusch –Pagun test. This test resulted in the existence of heteroscedasticity problem as it was significant at 1% probability level (0.0003) suggesting the need for standard error robust. Hence, robust standard error was conducted accordingly.

The logistic regression result in the Table 22 showed that there were different variables that determine households' decision in improved dairy technologies participants at different statistical significant levels. In this study, alternative testing based on logistic regression was taken in identified effects of explanatory variables. Ten selected explanatory variables were hypothesized that determine households' participation adoption of improved dairy technologies in the current promoting program. Among those variables, six of them were found to be significant variables determining household's decision to participate and use of improved dairy technologies either positively or negatively while the rests four variables were not significant in explaining the variations in the dependent variable. Among explained variables by logistic regression model that influence households probability of adoption could be, Sex, Farm land size, Labor availability, Market distance, Tropical livestock unit, Farmers participation in agricultural cooperatives, were variables identified by logistic regression model that influence households probability of participation/ adoption in improved dairy technologies promotion activities.

Looking into output of logistic regression (Table 22), it was found that farm land size, labor availability, market distance, tropical livestock unit and farmers participation in agricultural cooperatives were affect households' probability of adoption and use of improved dairy technologies positively at 10%, 5%, 1%, 1% and 1% statistical significant level respectively. While sex of the household affects it negatively at 10% significant level. In this study, the odds ratio of farm land size indicated that a unit increase in farm land size in hectare, also an increase the probability of participation/adoption and use of improved dairy technologies by 21.97 units. The possible reason for this may be, farmers with less land were expected not to willing to adopt dairy technologies. Hence, there was thinking that the technologies need more land for forage production. In other words, it was found that a unit increase in land size increases households' probability of adoption of improved dairy technologies. The implication of the result that obtained could be households had with more land size holding were more likely to have capacity in expanding dairy production technologies. So land is perhaps the single most important

resource as it is a base for any economic activities especially in the rural and agricultural sector. Hence, the availability of enough amount of arable and/or usable land per household is seen as a potential for food self-sufficiency and investment for further economic progress.

Similarly, the odds ratio of labor availability indicated that a unit increase households' labor increases the probability of households' participation/adoption and use of improved dairy technologies by 7.14. As to the availability of labor, the mere presence of high number of members in the family does not mean that there is enough amount of labor resource. In this study, the implication could be households who had more workable labor force imply that they participate/ adopt this improved dairy technologies in a better manner. A respondent with larger number of workers per unit capital is more likely to be in position to try and continue using a potentially profitable innovation (dairy technologies in this case). Hence, it was assumed that availability of labor in the household affects adoption of dairy technologies positively.

Another factor that hindered households' probability to adopt/participate technologies adoption is market distance effect. It was determining factor for input-output marketing of many research results that influenced households' decision to participate/ adopt technologies negatively. The result of this study indicated that market distance affect household's input-output market positively. As a result, the implication of the result might be market distance was not serious challenge/significant for household input-output marketing rather unsustainable milk and milk market price was serious challenge (milk market) because the sampled households reside along the main road and local small towns. This idea was supported by respondents during key informant and focus group discussion. Hence, it was hypothesized that effect of market distance had positive influence on adoption of dairy technologies in this study.

In addition to this, tropical livestock unit affects households' probability of adoption and use of improved dairy technologies positively and significantly at 1% of significance level. The odds ratio of logistic regression results of tropical livestock unit indicated that, increase in a unit of tropical livestock unit of a household increase the households' probability of participation/adoption and use of improved dairy technologies by 1.97 units. The possible explanation of the result could be households who owned large livestock have the capacity to afford technology purchasing power as well as the confidential to increases the ability to avert or cop up with risks on technologies draw backs.

Similarly, Table 22 of the logistic regression result revealed that Sex of the household influences the households' probability of participation / adoption and use of improved dairy technologies negatively at 10% of level of significance. The odds ratio also indicated that gender difference had its own impact on technology adoptions. The implication of this study were female households had reduces participation of improved dairy technologies by 0.02 units.

With regard to farmers' participation in development cooperatives, the main purposes of these were to provide agricultural input and information to increase production and productivity to their members. As Table 22 indicated that membership in agricultural cooperatives had positive influence on adoption and intensity of use of improved dairy technologies significantly at 5% significance level. The odds ratio in the same table indicated that increase participation of households in agricultural cooperative, increases the probability of adoption and intensity of use of dairy technologies by 12.58units. The possible explanation could be organization of farmers in cooperatives would motivate households directly or indirectly to use improved dairy technologies. This implies the need to strengthen rural cooperatives to enhance adoption of improved dairy technologies adoption were crucial.

As described in Table 22, the Pseudo - R^2 value is large. This pseudo - R^2 value (0.8848) indicates that the allocation of the program fairly random. According to (Caliendo and copeinig, 2008), after matching there should be systematic differences in the distribution of the covariates between both groups and therefore, the pseudo - R^2 should be fairly large. The result, therefore, suggests that improved dairy technology participant households do have diverse characteristics and hence obtaining a good match between both group households become easier.

Table 22: Logit results of respondents improved dairy technology participation

Variables	Coef.	Odds Ratio	Robust Std. Err.	P-value
AGE	.0679574	1.07032	.0622947	0.243
SEX	-3.910844	.0200236	.0427425	0.067
EDULEVEL	.0683323	1.070721	1.254463	0.953
FRMLSZ	3.08964	21.96917	39.64502	0.087

LABRAV	1.966136	7.143025	6.641699	0.034
MRKDIS	.084576	8818.227	18068.63	0.000
EXTCON	1.172769	3.230926	2.994838	0.206
TLU	.6794787	1.972849	.4643767	0.004
FPACOO	2.532198	12.58113	12.5418	0.011
INPUTACC	-1.717243	.1795606	.300425	0.305

Sample size (N) =230 Pseudo R2 =0.8848 Wald chi2 (10) =65.87 Prob >chi² =0.0000, Log likelihood = -18.336346

Source: Own survey result (2016)

The dissemination of propensity score for each household included in improved dairy technologies participant and non-participant groups was computed based on the above participation model to identify the existence of a common support or overlap region ($0 < p(D = 1 | X < 1) < 1$ should be tested). Figure 3 depicts the distribution of improved dairy technology participant and non-participant households were found in the right and left bottom side while most of non-participant households were found in the left bottom side of the distribution. The figure also shows that there is a wide area in which the propensity score of both the technology participant and non-participant households are different.

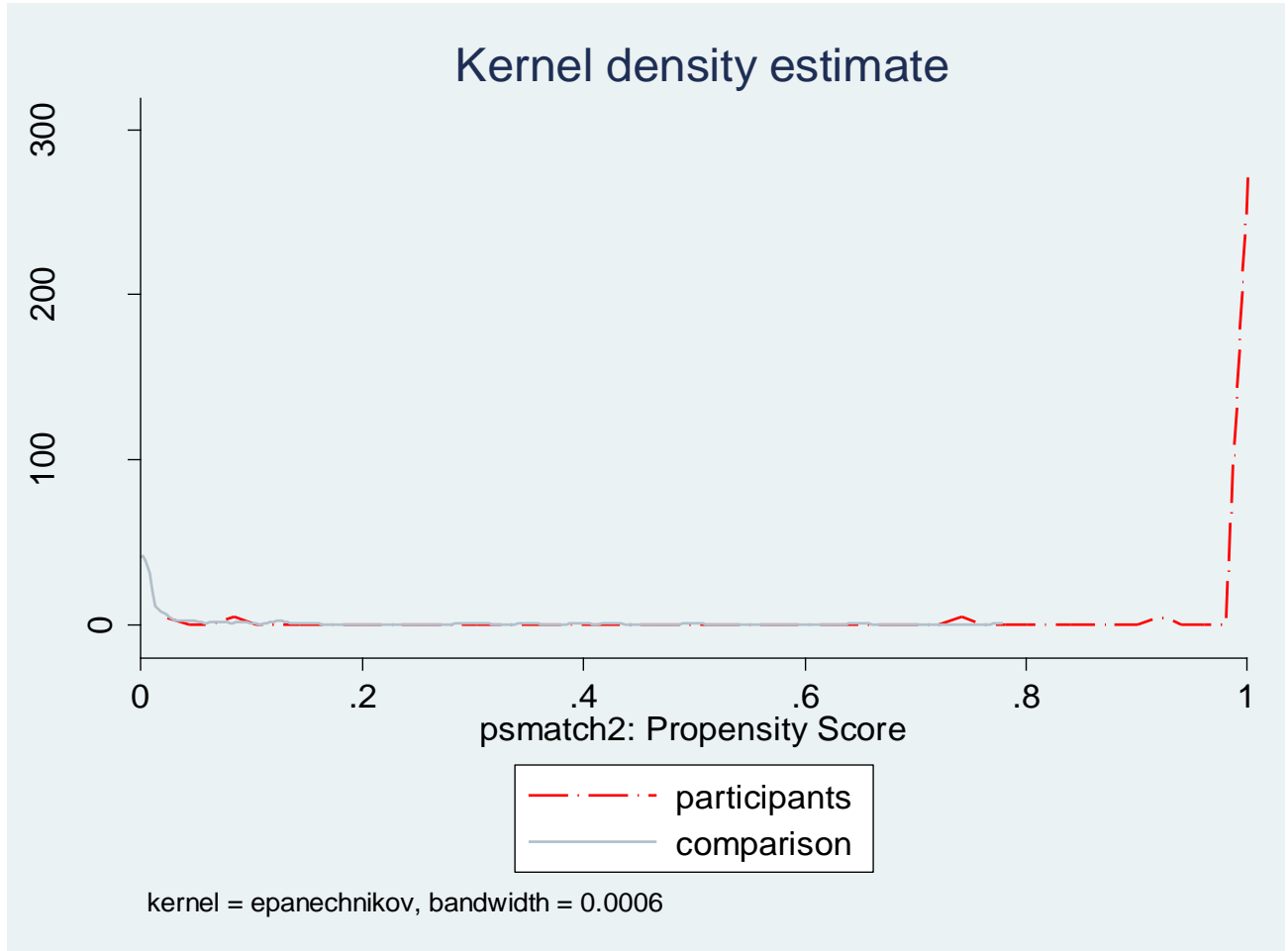


Figure 3: Kernel densities of PS of technology participant and non-participant households

Source: Own survey result (2016)

4.4.2 Matching of technology participant and non-participant households

There are three tasks that should be done before matching between two group households. Estimating propensity score based on identified explanatory variable for all sampled households is the first task, which was done in previous section. Imposing common support condition on the propensity score distribution of households with and without use of dairy technologies are/is the second task. Discarding observations whose propensity score is outside common support region is the final task. Table 23 revealed that the distribution of propensity score for all households. As shown in the same table, the propensity scores vary between 0.0250832 - 1 for dairy technology participants with mean score of 0.95. Whereas the score vary between 2.83e-10 – 0.7785902 for

non-participants household with mean score of 0.05. The common support then lies between 0.0250832 – 0.7785902. This means that household whose propensity score less than minimum (0.0250832) and larger than maximum (0.7785902) are not considered for matching purpose. Based on this procedure, none of the participant and non-participant group was discarded from the study in impact assessment.

Table 23: Distribution of estimated propensity score of households

Group	Observation	Mean	STD	Minimum	Maximum
Total household	230	.4798128	.4775992	2.83e-10	1
Participant	110	.9535803	.168691	.0250832	1
Non-participant	120	.045526	.1233504	2.83e-10	.7785902

Source: Own survey result (2016)

Figure 4 below reveals the distribution of propensity score and common support region. The bottom halves of the histogram shows the propensity score distribution of improved dairy technology non-participant households and the upper halves shows the propensity score distribution of improved dairy participant households. The blue colored (untreated-on support) and the red colored (treated on support) indicates the observations in the technology non-participant group and participant group that have a suitable comparison respectively, whereas the orange colored treated off support indicates the observations in the technology non-participant group that do not have a suitable comparison.

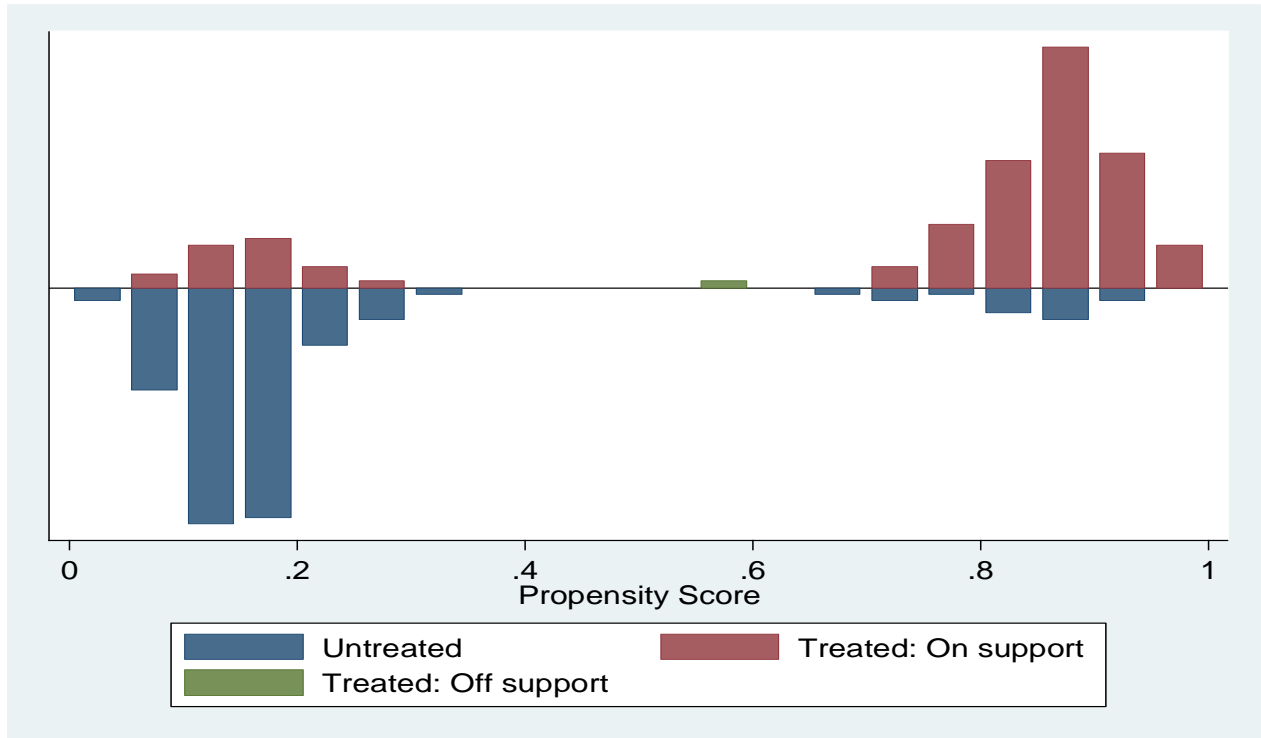


Figure 4: propensity score distribution and common support region for propensity score estimation

Source: Own survey result (2016)

Following identification of common support region, alternative matching estimators (algorithms) were tried via matching technology participant/adopter with non-participant/adopter households in common support or overlap region. The final choice of matching algorithms was guided by three **criteria**: Namely, equal mean test (Balancing test i.e., it considers whether the estimated propensity score adequately balances the characteristics between the treatment and control groups (the assumption $D \perp\!\!\!\perp X \mid P(X)$ is testable)), Pseudo R^2 , and size of matched sample (see Table 24). Matching algorithm which balances all explanatory variables of the groups (result in insignificant mean differences between technology participant and non-participant), bear low pseudo R^2 value and results in large sample size is preferable (Deheja and Wahba, 2002). Based on these criteria and the matching quality indicators, kernel matching with band width (bwidth) of 0.25 resulted in relatively low pseudo R^2 (0.165) was found to be best estimator for this study.

The rest explanatory variables were insignificant. Therefore, impact analysis procedure was followed and discussed by using kernel bwidth of 0.25.

Table 24: Performance criteria of matching algorithms

Matching algorithms	Performance criteria		
	Balancing test*	Pseudo R^2	matched sample size
Nearest Neighbor			
1.Neighbor	6	1.000	126
2.Neighbor	6	1.000	126
3.Neighbor	6	0.650	126
4.Neighbor	6	0.373	126
5.Neighbor	6	0.394	126
Caliper			
0.01	5	1.000	125
0.1	6	1.000	126
0.25	6	1.000	126
0.5	6	1.000	126
Radius			
0.01	6	0.583	126
0.1	6	0.583	126
0.25	6	0.583	126
0.5	6	0.583	126
Kernel			
Bwidth 0.01	5	0.580	125
Bwidth 0.1	6	0.302	126
bwidth 0.25	6	0.165	126
bwidth 0.5	6	0.338	126

Source: Own survey result (2016)

4.4.3 Testing of balance of propensity score and covariates

After selecting best performing matching algorithm which satisfies prior identified performance criteria, balance of propensity score and explanatory variables was checked by the selected matching algorithm (kernel bwidth in this case)

Table 25: Testing of covariance balance using propensity score (evaluation of quality of match)

Covariates	Samples	Mean		% of bias	%reduction	
		Treated	Control		bias	p-value
AGE	Unmatched	45.3	45.45	-1.8		0.890
	Matched	43.571	43.954	-4.7	-155.2	0.923
SEX	Unmatched	.82727	.81667	2.8		0.835
	Matched	.71429	.52943	48.1	-1642.9	0.514
EDULEVEL	Unmatched	.35455	.225	28.7		0.030
	Matched	.14286	.04878	20.9	27.4	0.585
FRMLSZ	Unmatched	.89673	.7115	57.7		0.000
	Matched	.81714	.65972	49.1	15.0	0.150
LABRAV	Unmatched	.85455	.475	87.4		0.000
	Matched	.85714	.61355	56.1	35.8	0.339
MRKDIS	Unmatched	.93636	.01667	469.8		0.000
	Matched	0	.16714	-85.4	81.8	0.294
EXTCON	Unmatched	.85455	.48333	85.5		0.000
	Matched	.71429	.57923	31.1	63.6	0.630
TLU	Unmatched	9.3364	5.55	122.9		0.000
	Matched	9	7.3842	52.5	57.3	0.380
FPACOO	Unmatched	.86364	.26667	150.2		0.000
	Matched	.57143	.5263	11.4	92.4	0.878
INPUTACC	Unmatched	.82727	.36667	105.9		0.000
	Matched	.28571	.52092	-54.1	48.9	0.409

Source: Own survey result (2016)

This figure 5 below indicated that the standardized % bias across covariates (unmatched with matched covariates).

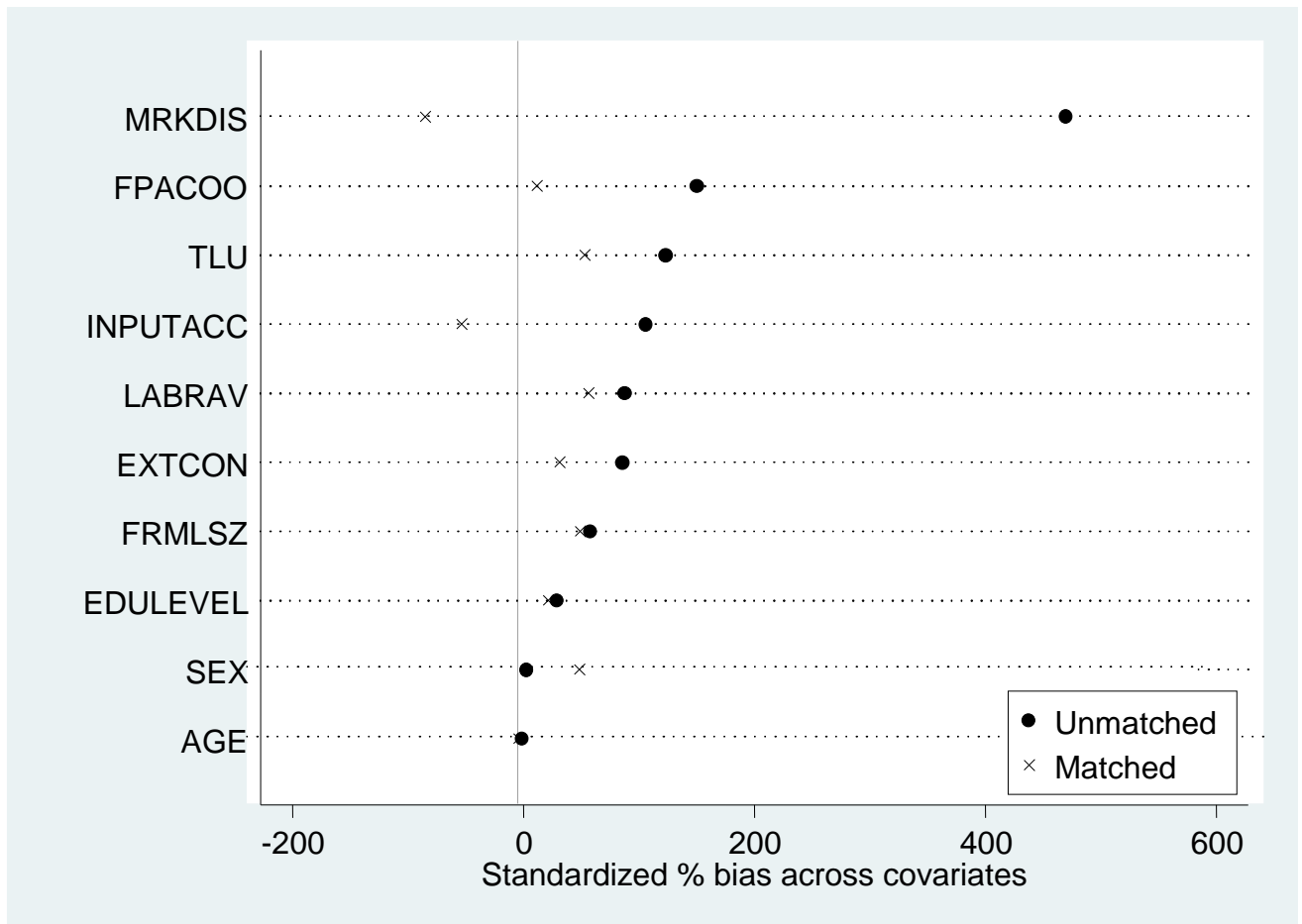


Figure 5: Unmatched and Matched standardized % bias across covariates

Source: Own survey result (2016)

The above table 25 and figure 5 revealed that the standard bias difference between identified explanatory variables before matching was in the range of 1.8 % - 469.8 % in absolute value and p-values in the same table resulted that 89% of the chosen explanatory variable exhibited statistically significant differences at before matching. But after matching, the standardized bias/standard error differences of explanatory variables lied between 4.7 % - 85.4 % in absolute value and all the covariates were balanced which is above the critical level of 20% suggested by (Rosenbaum and Rubin, 1983). In all cases, it was evident that sample differences in the unmatched data significantly exceeded those in the samples of matched cases. It is clear that the

main intention of estimating propensity score is not to get a precise prediction of selection into treatment. Rather, to balance the distribution of relevant variables in both the treatment and control groups (Caliendo and Copeinig, 2008). Therefore, the selected matching algorithm, kernel bwidth (0.25), has created a covariate balance between improved dairy technology participant and non-participant households, which is important to conduct impact analysis in the intervention.

As indicated in table 26, the value of Pseudo- R^2 was very low. This low Pseudo- R^2 value and the insignificant likelihood ratio test indicate that the dairy technology participant and non-participant household, which are important, had the same distribution in the covariates after matching. These results indicate that the matching procedure is able to balance the characteristics in the treated and the matched comparison groups. Hence, these results can be used to assess the impact of dairy technology participation among group of households having similar observed characteristics. This enables to compare observed outcomes for dairy technologies participant with those of non-participant group sharing a common support.

Table 26: Chi-square test for the joint significance of variables

Sample	Ps R2	LR chi2	p>chi2
Unmatched	0.8848	65.87	0.0000
Matched	0.165	2.56	0.979

Source own survey result (2016)

Based on the study results, all of the above tests suggest that the matching algorithm chosen relatively best for the data of this study. Therefore, it was possible to proceed to estimate the average treatment effect on the treated (ATT) for the sampled households.

4.4.4 Impact of improved dairy technology on income and asset holdings

One of the primary objectives of promotion of improved dairy technologies was to improve production and productivities of the rural smallholder farmers as well as commercializing of productive technologies to interested ones. This leads to increase households' income and asset generation for the present and for the future. Here, the dairy technologies impact on the outcome

variables (annual farm income and total asset holding estimated after use of technologies) was evaluated. In this technological promotion intervention impact analysis, the average treatment effect on treated (ATT), calculated using kernel bwidth (0.25) that presented in the Table 27. As income (TOTAFICM) indicator revealed that, average treatment effect (ATT) of dairy technology participant/adopter households got 49.35% more average total annual farm income from dairy technologies and their products per-annum than that of the counterparts (non-participants/adaptors). This difference was statistically significant at 1% level of significance. Similarly, in the same table, the average treatment effect (ATT) of dairy technology participant households had 100% of more chances to earn better asset holdings than non-participant/adaptors households; differences statistically significant at 1% significance level. This indicates that participating on improved dairy technologies has brought significant and positive impact on annual average income and asset holdings on participant households than counterparts. The information obtained from key informant (kebele leader and model farmers) interview that was also support this positive and significant finding.

“Before participating in dairy technologies program, most of the improved dairy technology participant respondents were very poor and have no improvement financially as well as low asset holdings. But after participating and accessing them on it, their living condition has been improved, better saving behavior, the consumption behavior were increased and good health status. Generally, the household status in the way of living and productivity show relatively better increment from time to time than that of the non-participants households in the study area “.

Table 27: ATT Estimation results of household annual income and asset holdings

Intervention	Variables	Treated	Controls	Difference	S.E	T-stat
DTS	TOTAFICM	16905	8562.51759	8342.48241	2298.70407	3.63***
	TASHEVAF	152418.167	0	152418.167	61159.665	2.49***

DTS=Dairy adoption technologies; TOTAFICM=Total annual farm income; TASHEVAF=Total asset holding estimated value after use of technologies

Source: own survey result (2016)

4.4.5. Sensitivity analysis

In this study, sensitivity analysis was carried out on the estimated average treatment effect using alternative matching estimators for all outcome variables, which were mentioned above (ATT section). Kernel matching estimators resulted in statistically significant effects of the program on technology impact analysis of households TOTAFICM and TASHEVAF (which was the lowest Pseudo- $R^2=0.165$)

Table 28: Results of sensitivity analysis using matching algorithm estimators

Outcome Variables	Matching method	Treated	Controls	Difference	S.E.	T-stat
TOTAFICM	N	16905	9567.08333	7337.91667	2709.21964	2.71
	Caliper	16905	11026.6667	5878.33333	4017.49459	1.46
	Radius	16905	7530.275	9374.725	2177.56532	4.31
	Kernel	16905	8562.51759	8342.48241	2298.70407	3.63
TASHEVAF	N	152418.167	0	152418.167	61159.665	2.49
	Caliper	152418.167	0	152418.167	61159.665	2.49
	Radius	152418.167	0	152418.167	61159.665	2.49
	Kernel	152418.167	0	152418.167	152418.167	2.49

Source: Own survey result (2016)

4.5 Constraints/factors affecting adoption of dairy technologies

Focus group discussion with sampled households: In order to complement the quantitative data, qualitative data were collected from Focus Group Discussion (FGD). The focus group discussions were conducted with farmers, district live stock experts and development agents independently. The FGD were conducted in the three sampled KAs. The summarized responses from the three KAs based on points of discussion, such as opportunities, constraints, marketing of dairy products and others.

Regarding the overall dairy technology practices, respondents said that “we have awareness on dairy technology practices and that were acceptable. But, there are constraints which hinder us

from expanding our dairy farming and practicing all of the technological components. The first major problem is lack of input availability (cross bred cows in kind, insufficient AIS, lack of milk market and feed shortage) are the major constraints in the area. In the supply of feed, there is no organization who supplies industrial feed byproducts for farmers at local level. The existing multi-purpose cooperatives did not provide such kind of services except distributing consumption goods and other agricultural inputs such as fertilizers. In order to get industrial feed, we have to travel long distances in towns. We travel individually to purchase feed. After travelling long distance, we purchase from private merchants with an expensive price and again we incurred high transportation cost for the feed we purchased. Purchasing 3-5 quintals of industrial byproduct and transporting costs are more for individual farmer. Our feed marketing system is not in an organized form. If it was in organized form, cost of transportation would have been less. Because of this problem, we are discouraged in using the industrial byproducts and compelled use of improved breeds.

The second issue was the problem of supply of crossbreed heifers in kind and unsustainable of AIS. In this regard they said “the current price of crossbred cow is unaffordable for resource poor farmers; they are expensive, and they are privately owned. But, when crossbred heifers are supplied by research center via district office of agriculture, we are interested to purchasing in reasonable price but from private owners we purchased at high cost. This was the second constraint of response of both adopter and the non adopter groups. They added that, “the number of crossbred heifers ” provided by district were not more than 2-3 in a year time even now totally ignorable. Because of this we are interested to use AIS including synchronization (which is less effective now). This service is provided in the area only by the district AIS technicians at district level. In this regard the main problem is that supply of AIS service is not enough. When cows are ready for insemination, the service is not available. Again, at district office of Agriculture, they are not working in weekends (Saturday and Sunday). As we are farmers, we don’t know the day and time when cows are ready for insemination. We are only trying strictly to follow the cows to know the time when our cows are ready for insemination. When cows are ready, we take them to service area, but the technicians may not be available during that time. The office may be closed or they will say that they don’t have frozen semen. Because of this, we are discouraged. If we want to get the service, we have to stay for 21 days. Therefore, we prefer to use natural mating with local bull. This problem is also discouraging us.”

The third issue was marketing of dairy products. In marketing of dairy products, especially for milk marketing, they said that “we didn’t have sustainable milk market at reasonable price locally and at town level meaning that no market value chain on milk. The local milk cooperatives were not functional and lack of coordination as well as low determination of milk price from their members 6-7 Birr/liters at high discount rate.” Only few farmers remain in dairy cooperatives. The rest are leaving the cooperative and find other alternatives to sell their dairy products. The low price discourages the members to sell to the cooperatives; instead they are selling their milk outside cooperatives to get better price from café and restaurant. In milk marketing, the other problem is the market distance (for purchasing inputs), which is also discouraging. Those farmers who are living near towns were tried to supply to town contract consumers and retailers including tea shops and restaurants. But, farmers who are living at distance are not selling milk; instead they are making butter. They added “We are only selling the morning milk, but during evening we are not able to supply because of shortage of labor and restaurants no need to take it.” So, there is discouraging for using these technologies because no alternative market for milk and milk products.

Another issue raised during FGD was the problem of tick which attacks the teats of milking cows. This was a serious problem in the sampled KAs. Regular vaccination was provided for other diseases and spray for other external parasites. But the tick problem is not treated. The problem is aggravated during dry season when there is shortage of feed. It creates reduction of milk because a cow which is attacked by tick will not allow touching teats for milking.

The other issue raised was about the technology beneficiaries. Which group of community is benefiting from the dairy was raised as one of the discussion point. They said that, “Those farmers who are better or rich farmers are benefiting; the poor farmers are not benefiting. Because, they are not able to purchase crossbred cows. In order to benefit the poor, credit without interest is essential, if it is targeted to benefit the poor farmers.” They concluded the discussion by emphasizing the need for initial capital for dairy technologies.

The discussions with district experts and development agents were conducted by using the same procedures. The professionals also confirmed that all the problems which were raised by farmers during FGD were correct. The woreda veterinary clinic confirmed that in veterinary service, regular vaccinations were provided and awareness of the farmers in using veterinary service

shows improvement from time to time. Currently, the service is delivered by assigning one veterinary technician for 1-2 KAs. As it was discussed by the farmers, the main problem in the area is tick attack, especially for milking cows on the teats. The problem is very severe during the dry season when there is shortage of feed. But, other veterinary services are provided for farmers and they are willing to pay for the service provided. Regarding the AI service, the district experts and development agents confirmed that there is shortage of supply of AIS. In addition to this, farmers AIS provider were trained only for one time.

Regarding shortage of feed they said that, “Even though we are trying to advice farmers to produce different forage crops, there is shortage of selected and improved forage seed, high cost of industrial byproducts. Milk marketing is one of the problems which discourage farmers. Credit is also not provided for resource poor farmers and group base. Because of these problems, those farmers who have better income are benefiting from the dairy technologies. The milk cooperatives also have no functional. In addition to this, they want to purchase milk with low price. They are not becoming competent with the prevailing market prices.”

Table 29 indicated that, some constraints were statistically rated during data analysis. These results was indicated that 79.13 % of the respondent households respond factors include lack of grazing land, occurrence of animal disease, lack of input, lack of capital, low milk price whereas 20.13% respondents include lack of grazing land and lack of input only were the serious factor that affect the rural smallholder farmers to participate/adopt dairy technology in the study area. Based on the responses of the respondent the following factors were summarized.

Table 29: Factors affecting dairy technology adoption

Constraints	Frequency	Percent
1 and 3 only	48	20.87
All of them are constraints	182	79.13
Total	230	100

Factors: 1. Lack of grazing land, 2. Occurrence of animal disease, 3. Lack of input, 4. Lack of capital, 5. Low milk price, 6. 1 and 3 only, 7. all of them are constraints

Source: Own survey result (2016)

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary and conclusion

This study was conducted in Tehuledere district, South Wollo Zone, ANRS that of the potential areas where dairy production as the main components among the extension package provide to farmers by government and other non-governmental organizations. The study assessed and analyzed factors affecting adoption of dairy technologies and their impact on farm household income and asset holdings on the sampled households. Improved dairy technologies (breed, feed, AIS, housing and regular vaccination) and training was provided for rural smallholder farmers in different time in the study area; adoption of this technologies and their impact were unknown to fulfill the information gap for responsible bodies. The sample selection method was probability proportional to size and use of three stage sampling technique. The primary data for this study were collected from 110 dairy technology participants who had at least three year participation and 120 non-participant households who didn't ever accessed this technologies using a structured questionnaire schedule, group discussion and key informant interview. Of which 17.83% (41) households were female.

Descriptive statistics and econometric model were used for analyzing both quantitative and qualitative data using "STATA version 14" software. Additionally, narrations and case studies were incorporated. Factors affecting adoption and its intensity were analyzed using Tobit model whereas impact of technology on households' income and asset holdings was analyzed using Propensity score matching (PSM) model. Before processing Tobit and PSM to assess factors affecting dairy technologies adoption and to calculate the ATT, the resulting raw data passed through different processes of tests such as F (one way ANOVA to analyze current level use of technologies) /t-test, reduction standardized bias, and chi-square test, VIF and pseudo- R^2 and matching quality tests such as matching algorithms. The results of Tobit and descriptive statistics revealed that, dairy technology participant and non-participant households had combination of factors (personal and demographic, economic institutional and social) and other different influencing factors that hinder the probability of adoption and its intensity.

As the descriptive statistics indicates, other things being equal, factors includes lack of grazing land and lack of input were serious influencing factors confirmed by 20.87% sampled households

whereas all influencing factors (lack of grazing land, lack of input, occurrence of animal disease and pest, lack of capital, low milk price) were similar challenges confirmed by 79.13% sampled respondents.

The current status of adoption of dairy technologies were at medium level and the maximum production of local and improved cow were 3 and 14 liters of milk yield /cow/day respectively. But still the production and productivity of both breeds less than their potential

The results of the econometric model indicated that the relative influence of different explanatory variables on adoption and intensity of adoption of dairy technologies. A total of ten explanatory variables in the descriptive analysis were included in the model. Among ten explanatory variables, six of them had shown significant influence on adoption of dairy technologies participation. Accordingly, farmland size, labor availability, effect of market distance, topical livestock unit, and farmers' participation in agricultural cooperatives were found to have positive and significant influence on adoption and intensity of adoption of dairy technologies. Contrary to this, sex of the household, were found to have negative and significant influence with adoption and intensity of adoption/ participation of dairy technologies.

Regarding PSM results on impact analysis, obtaining of a reliable estimate of dairy technologies participation program needs to adequately control for confounding factors. Based on matching performance criteria identified, kernel bwidth (0.25) has produced 110 dairy technology participants and 120 non-dairy technology participant households after none of the group was discarded from the study in impact assessment. Finally, matched comparisons were conducted on these households who share common characteristics in terms of identified independent variables except participating in dairy technologies. The matching result of ATT indicated that dairy technologies had positive and significant impact on participant households' total annual farm income and estimated asset holdings increment in average by 49.35% and 100% respectively than counterparts. From this, it was concluded that, participation in dairy technologies had statistical positive and significant impact on participant households total annual farm income and asset holding after participation on dairy technologies. This result is in agreement with the result of (Mosnier and Mieck, 2010) stated that technology plays a major role in dairy

production because production can be done anywhere as long as traditional constraints are abated by improvements in technologies.

The sensitivity analysis shows that the impact results estimated by this study are as incentive to unobserved selection bias. Therefore, need to attention to major factors that hinder participation of these technologies by livestock development office and intervening organization to increase production and productivity of the sector.

5.2 Recommendations

Based on the findings of this study and the empirical results reveals that participation/adoption of dairy technologies (improved breed, AIS, improved feed, improved housing and veterinary services) associated with increased income and asset holdings' which results improving the smallholder livelihood. Accordingly, the following recommendations were forwarded.

- In this study, there were gender differences in the participation/adoption of dairy technologies negatively and that decreases the probability of participation and use of improved dairy technological innovations. This indicated that male households relatively better in participation of dairy technologies due to many socio-cultural values and norms. This might be male households' freedom to mobility and access to extension services and access to information on innovation than female headed households. Therefore, attention should be given for gender equality for accessing and empowering female households by responsible bodies (women and children affair, and livestock development office).
- As indicated in this study, farm land size holding was an important factor to adopt/participate on dairy technologies positively in this study. Increase in farmland holding that increases the probability to adopt/participate on dairy technologies by 21.97 units. This could be participant households had better land holding and non participant household who had less land that were expected to not willing to participate dairy technologies. The availability of enough arable/usable land per-households was seen as for dairy production self-sufficiency and investment for further economic progress. Hence, there was thinking that the technologies needed more land for forage development and attention should be given land is an important for dairy technology participation by all responsible government and practitioners. Hence, farmers should be aware and

advisable to increase the small land productivity through irrigable forage development by irrigation.

- An additional active labor contributes for participation / adoption of dairy technologies. Increases household labor, increases the probability of households participation and use of improved dairy technologies by 7.14 units. This leads more likely to be in position to try and continue using potentially profitable innovation (dairy technologies in this case). Hence, it was labor intensive and intervening practitioners' in livestock development office assumed that availability of labor in the household could be the focus area for dairy technologies dissemination.
- The effects of market distance were positive and significant for dairy technology participation. The implication of the result might be physical market distance was not serious challenge for households output marketing rather unsustainable milk and its product prices. Dairy developments can only take place when the farmers receive satisfactory price for their milk and protection against price fluctuation. Without sound pricing system, farmers will not improve dairy production system and supply raw milk. These were leads to not participating / adopting of dairy technologies as well. In order to improve the marketing and pricing system, sustainable input-output market value chain could be important. Additionally, market oriented extension should be provided for stakeholders (producer to consumer) done by livestock development office and farmers.
- Tropical livestock unit that were contributes to increase economic and social status of participant households. This indicated that better number of livestock holding affect the sample household respondents positively and has the capacity to afford technology purchasing power as well as the confidential to increase the ability to avert or cope up with the risks of technology draw backs. Hence, livestock owned was crucial and experts need to be focused for dairy technologies participation during technology dissemination.
- Agricultural cooperatives are one of institutional services that help to consolidate the efforts of small scale farmers. They provide a set of production enhancement, input for members to improve the productivity of agricultural development. It provides supporting services such as input, information, training and advice. In the study area, the established agricultural cooperatives are not providing such services even they are lost now. In this study participation of agricultural cooperatives bring positive and significant change on

participant groups than counter parts. Moreover, strengthening of the capacity of agricultural cooperative members and restructuring them should be improved to increase more participation of the non-participants. Therefore, farmers should be organized to get inputs from different agencies. There should be institutional support to organize farmers to supply and accessed them in sustainable manner by cooperative organizers together with bureau of livestock development office and other agencies.

- As indicated in the study, participant households had better annual farm (49.35%) income and asset holdings (100%) from dairy technologies than the non-participants. Hence, dairy technologies participation has brought significant impact on participants and this indicated that there were the gaps of support for those who didn't ever access the technologies. Therefore, the livestock development office work collaboratively with different actors should to maximize the production and productivity of dairy sector by focusing those didn't access.
- As the descriptive statistics indicates , other things being equal, factors lack of grazing land, lack of input, occurrence of animal disease and pest, lack of capital, low milk price, were similar challenges confirmed by 79.13% sampled respondents. Therefore the government, professionals, farmers in the district should be develop sustainable strategy to avert this drawbacks
- The current status of adoption of dairy technologies were at medium level and the maximum production of local and improved cow were 3 and 14 liters of milk yield /cow/day respectively. But still the production and productivity of both breeds less than their potential. Therefore, to increase production and productivity of the sector, introducing of more improved technologies were very important intervention by livestock development office and other concerned bodies in the study area.

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7. APPENDICIES

Appendix I: Conversion factors used to estimate Tropical Livestock Unit (TLU)

Livestock	Conversion factor
Cow	1
Ox	1
Bull	0.60
Heifer	0.75
Calves	0.20
Donkey/Mule	0.70
Horses	1.10
Shoats	0.13
Poultry	0.013

Source: Stock, et al., 1991

Appendix II: Variance Inflation Factor (VIF) of explained variables

Variable definition	variable Symbol	VIF	1/VIF
Market distance effect (km)	MRKDIS	1.95	0.513913
Farmers participation coop (0=no, 1=yes)	FPACOO	1.82	0.548957
Input Access (0=no, 1=yes)	INPUTACC	1.65	0.605895
Tropical Livestock Unit (number)	TLU	1.48	0.674593
Farm land size (ha)	FRMLSZ	1.37	0.731008
Extension contact (number)	EXTCON	1.35	0.738511
Labor Availability (0=no, 1=yes)	LABRAV	1.35	0.742960
Age (number)	AGE	1.24	0.809660
Educational Level (year)	EDULEVEL	1.17	0.851680
Sex (0=female, 1=male)	SEX	1.07	0.930841
Mean	VIF	1.45	

Source: Own survey result (2016)

Appendix III: Case study with successful adopters

Case study 1

Ato Adem hussen is a farmer living in kete kebele administration and he is 46 years old and a well-known model farmer. His educational level is tenth grade and one of the successful adopter of dairy technologies in this kAs. Various discussion points were raised to him to know how he became a better adopter of dairy technologies. Adem began his discussion and said that “Before I started rearing of crossbred cows with additional dairy technologies, I had been engaged intensively in crop production including chat. I experienced that crop production was very tiresome activities and it gave little benefit i.e I lead a hand-to-mouth living compared the life I am leading with dairy production. At that time, I had only four local cows with poor management practices. It gave me low production rate because I had low knowledge and practical performances on it. The daily milk output of the local breed cow was not more than 1-1.5liter/day/cow. He added that, due to low productivity of local cows, “I was communicating with district livestock experts as well as with different NGOs to get advice how to get and manage improved dairy technologies at different time. By accepting that advice, at the beginning, I purchased one crossbred heifer from research center with a price of 2620 birr in the year 1997 E.C. Then I have been broadening the dairy enterprise in recent years with support of other professionals and extension agents.

Currently, I have 4 crossbred cows all are giving milk and as well as selling of milk and other cow products and calves for selling. After rearing crossbreed, I was able to get on average 9 liters/day/cow. The maximum milk yield now is reached 14 liters/day/cow and I supply 48 liters of milk per day for restaurants and cafe”. He added that in improving his livelihood, the income he got from dairy production supports to construct a town house of 100 pieces of corrugated iron sheet with estimated price of 700,000 Birr. “After rearing crossbred, I currently received 14400 Birr /month from the café and restaurants from sale of raw milk. In my local market a crossbred calf, after the age of 9 months costs 15,000 Birr and above. So I sold three of them to neighbors with total price of 60000 Birr of a year old calf and kept the rest 4 original cows and 3 calves for myself. I was also able to send my children to school and now they have completed their secondary high school education. Additionally, he has been earned 100 ETH Birr per day from sale of cow dung. Regarding use of improved dairy technologies, I used to the recommendation of experts because now a days I know what the use of technology offers.”

Issues were raised for him to know what will be his future plan were, “he replied that in the coming future, since the productivity of crop is declining from time to time, I will planned to lied with rearing of modern dairy farming activities and I want to increase the number of cross bred cows to large scale because the demand of milk and other products increasing from time to time. This may be enough for my future living condition and satisfying the town milk demand and supply. They are beneficial to me so that I will stay by rearing cross bred cows with associated improved dairy technologies.”

Case study 2

Aselef Tsegaw is 40 years old and grades eighth female farmer. She has been living in Hitecha kebele administration. The discussion was held by raising issues about the advantages of rearing crossbred cows and use of associated improved dairy technologies. She told that “Crossbred cows and using improved dair technology components are important in my opinion. At the beginning, I had been purchased the crossbred heifer form district that comes from research center with a price of 7500 Birr. The first and the second calf she born was female, and the third one was young bull. A female heifer with an age of 9 month will cost nearly7000- 12000 Birr. But the young bull costs low price compared to female calves and I sold the young bull for my neighboring farmers for ploughing . Currently, I have 3 cows, I am the member of Hitecha milk cooperatives and I provided raw milk for this cooperative. This cooperative boils the raw milk and sold for local consumers. I have been benefited from the cooperative by sharing of money among cooperative members at reasonable price. She added that “In improving my life, I have fulfilled all my house furniture, bed, and TV with the supports of income obtained from selling milk and milk products.” This comes from the use of dairy technologies at different time by supporting different actors like LIVES projects promoting technologies as well as supplying proper training and provision of improved forages seeds. To improve my productivity I used to many technology properly such as AI for breed improvement, industrial by product and forage development, regular vaccination and better housing. Because of this, in near future I want to increase the number of cows and improving it. But, the problem is shortage of input, especially industrial feed and its cot is accelerated from time to time. The price of milk and the price of feed were not comparable with its cost. Because of this problem, I am compelled to still remain with the cows which I have now”.

Case study 3

Ato Beyene eshetu is 52 years old and grade fifth farmer living in Bededo kebele administration. He used improved dairy technology. Based on this, the issues raised to him that he started his discussion by saying; “I had been rearing local cows and I didn’t understand the benefits of improved dairy technologies but I saw later on using this technologies using some neighbor farmers and discuss them. After that I tried to communicate and get some advice from development agents and they advised me to rear cross bred cows and associated dairy technologies. At the beginning, I accepted their advice and purchased one crossbred heifer from district office of agriculture that comes from research centers with a price of 7500 Birr. After that I attended different extension events about improve dairy technologies and their benefit by district office of agriculture and LIVES project. Currently, I have four crossbred cows and obtain 10 liters of milk/day/cow. I sold almost only 10 liters of morning lactating raw milk in the near market of sulula town with cheap price (6-7 Birr / liter). I earned only 1800 Birr – 2100 Birr/ month from four cows. The rest evening and remaining milk was used to butter but my cow is Holstein freesia that produce more milk than butter. So almost 30 liters of raw milk/ day from four cows were wasted or extract few butter.”

He also added that: “ I believed that improving of dairy product market problem by responsible body are crucial and then rearing crossbred cows change my living standard through using improved dairy technologies. The main problem which hindered me from expanding dairy farming is that, there is shortage of feed and lack of dairy product marketing in the area. In order to get industrial feed products, my home is at road side and I travel a distance of 20 km to Dessie town. In the town, I purchase from private merchants. The price of feed is very expensive and incomparable with milk price. This market problem lead to discourage the use of improved dairy technology”

Household Interview Schedule Questionnaire

Part One: General Information

Dear Respondent,

The purpose of this questionnaire is to gather information to write a research paper on “Factor Affecting Adoption of Dairy Technology and their impact on farm household

Income and Asset holdings: The case of Tehuledere District, South Wollo Zone, and Amhara Region”. The Specific Objectives of the Study are: To characterize dairy technology supply and level use by small holder farmers; to identify factors determining adoption and intensity of adoption of dairy Technologies; and to assess the impact of dairy technology adoption on household income and asset holdings. The personal responses of the interviewee would be kept confidential, and there should not be any link between status in the program and response. Therefore, you are kindly requested to give accurate information as much as possible.

Thank you !!!

1. Respondent code: ----2. Kebele name/ code: ---- 3. Name of the village / code: ----
4. Name of enumerator: -----Signature-----
5. Date of interviews: .../.../... 6. Respondent Category: 1) user 0) Non user

Information on Personal and Demographic back grounds of the respondent

1. Age of the HHH-----years 2. Sex of the HHH: 1-Male headed 0-Female headed
3. Education level of the HHH year of schooling: 0- If illiterate 1- literate (.....years)
4. Marital status: (1) Single (2) Married (3) Divorced (4) Widow
5. Religion of the household head: 1-Orthodox 2-Islam 3-Catholic 4. If any-----
6. Family size 1. Male... 2. Female....Tota.....

Information on Experience of dairy farming of HHHs

1. Experience of HHH in traditional dairy farming----years, milk---liters (local)
2. Experience of HHH in improved dairy farming Technologies --years, milk---liters (improved)

Information on land ownership and land Size holdings: 1. Total land holding of HHH in ha--

- 2.1. Total crop land in ha --- 3.Total grazing land in ha---- 4. Improved forage land ha...
- 2.2-Howmuch of the land size do you use irrigated fodder production?(1ha=4 timad)....

Information on off-farm activities of HHHs

- 1 – Did any one of the HH members engaged in off-farm activities? 1-Yes 0-No
- 1.1. If the answer is yes, which types of activities? 1. Vegetable trading, 2.Cattle trading,
3. Grain trading, 4. Petty trade, 6. Other (specify-----)

Information on labor availability of HHHs

1. Do you have enough family labor to perform improved dairy farming? 1) Yes 0) No
- 1.1. If no, how do you solve this shortage? 1- By hiring labor, 2- by indoors management
- 3-by using child labor after schooling 4- by part time work (husband / wife)

Information on Socio- psychological variables HHHs

1. Participation in co- operatives

- 1.1. Are you member of cooperative society? 1) Yes 0) No
- 1.2. What services are you getting being member of the cooperative society /choose more than once/? 1) Credit in cash for Improved crossbred cows purchase 2) Market information
- 3) Provide farm inputs (Fertilizer, chemicals, forage seed, and others) on credit base
- 4) Marketing of dairy products 5) other (specify)-----

2. Social participation.

1. Have you participated in social organization as member or as leader? 1) Yes 0) No
- 1.1. If yes, in which of the following organization are you member or leader?

No	Organization	Non-participant (0)	Member (1)	Committee member (2)	Leader (3)	Frequency of participation in activities		
						Never (0)	Sometimes (1)	Always (2)
1	Religious club							
2	Marketing cooperative							
3	kA leader/council							
4	Saving and credit group							
5	Irrigation association							
6	Women association							
7	Farmer Research Group							
8	District council							

Part two: Information on characterization of dairy technology supply and level use by small holder farmers

1. Do you participate on using improved dairy technologies? 1-Yes 0- No
- 1.1. If yes, what technologies? /Multiple answers are possible/: 1-use of improved dairy breed
2- use of improved feed 3-use of AI services (including estrus synchronization) 4- use of better housing
5-Use of regular vaccination
2. Which one do you think have more exposure to use the dairy technology? 1-Better educated, 2-political members, 3-Religious leader, 4- Model farmer, 5-ordinary farmers
3. In which category do you fall in relation to the use of improved dairy Technology in your community? 1- Poor 2- medium 3-better 4 –rich

Level of Inputs used by smallholder farmers in 2004-2008 E.C

No	Types of Input used	Input used by years /how much????/					Remark
		2004	2005	2006	2007	2008	
1	Improved Breed						
2	Feed (forage, concentrate...)						
3	Vet. Service (Revaccination)						
4	AI (synchronization)						
5	Standardize housing						

4. How do you rate yourself on use of improved dairy technologies in these 5 years?
0-very low 1- low 2-medium 3-high 4-very high
5. Are these technologies important for you and adopt it for future use? 1) Yes 0) No

Part Three: information on factors determining adoption and intensity of adoption of dairy Technologies

Information on Institutional variables /Access to credit, market, and technologies/

1. What is your perception about the importance of credit in dairy development?
1) Least important, 2) less important, 3) important, 4) more important, 5) highly important

No	Access to	Yes (1)	No (0)
1	Credit		
2	Market		
4	Technology/input	Improved breed cows	
		Improved feed	
		Vet. Services/ regular vaccination	
		Standardized housing	
		AI (estrus synchronization)	

2. How far to travel to purchase input (feed) and sell your animal Products? _____Km
 3. Is it not troublesome for your dairy marketing in terms of distance? 1) Yes 0) No
 4. Do you have enough input on improved dairy technologies /breed, improved feed, AIS, vet-services and housing construction material /? 1) Yes 0) No

Information on Contact with extension agent /Extension or service/

1. Did you receive extension advice on dairy technologies during the last 5 years? 1) Yes 0) No
 2- Who provides extension service about improved dairy farming /multiple answers is possible?
 1) DA 2) District experts 3) Local leaders 4) woreda council 5) model farmers 6) NGO
 3- What common place you usually contact with DA's (choose more)? 1) At farm field
 2) At demonstration site 3) At training center/FTC/ 4) At farmer's home 5) At DA's office
 4- How far is the distance of the extension center from your home? ----Km and how many times do you contact with extension agents-----/ current recent month (No, 1, 2, 3, 4)
 5- Is there any other possibility of getting an advice on how to use the dairy farming technologies other than extension agent? 1-Research center 2-University 3-NGO
 5. Participation in different extension events over the last 5 years in dairy farming technologies.

No	Extension Events	Number of times participated per years					Remark
		2004	2005	2006	2007	2008	
1	Training						
2	Field days						
3	Demonstration on tour						
4	NGOs /LIVES/,East Africa project						

Access to mass media: Indicate your access to and frequency of use of the following media on agricultural programs related to dairy technology.

Mass media	Do you have?		How often you use them for attending agricultural programs/obtaining messages				
	1=Yes	0=No	Never(1)	Rarely(2)	Occasionally(3)	Often(4)	Very often(5)
Radio							
Television							
others							

Information of adoption and their intensity level in current situation

Technology/ Input perception

1. What are the qualities of the technologies? 1) Good 0) bad

Practice 1: Adoption of breeds

1. Which animal breed do you normally rear now? 1) Local breeds 0) Crossbreed

2. Do you practice breed improvement with AI services? 1) Yes 0) No

Perceived current efficiency (PCE)

1. Current level of use of breed improvement with AIS (synchronization, bull service, regular AIS)? Rate them on a 5-point scale?

Farmer's rating: 0-very low 1-low 2- medium 3-high 4-very high

Practice2: Adoption of feeding

2.1. Which livestock feed systems to use?1) Free grazing, 2) Zero grazing, 3) Rotational grazing

2.2. What kind of fodder or forage crop you have been grown?

1) Alfalfa, 2) Elephant grass, 3) Tree legumes, 4) Vetch 5) Others-----

2.3. Did you feeding your livestock concentrate feed? 1) Yes 0) No

2.4. Did you feeding forage legume: 1.Not at all, 2.Rarely, 3.Sometimes, 4.Regularly

2.5. If not Q2, 3, 4, why?.....

Perceived current efficiency (PCE)

1. Current level of use of recommended feeding practice, Rate them on a 5-point scale (concentrates, improved forage and standardize crop and hay supplements)?

Farmer's rating: 0-very low 1-low 2- medium 3-high 4-very high

Practice 3: Adoption of housing condition

3.1. Feeding trough (width, depth, smoothness) 1- No 2- Poor 3- Moderate 4- Good

3.2. Floor (Slope, Smoothness) 1- No 2- Poor 3 - Moderate 4 - Good

3.3. Roof and side walls (Ventilation) 1- No 2- Poor 3- Moderate 4- Good

Perceived current efficiency (PCE)

1. Types of dairy Housing (multiple answers are possible): 1-corrugated iron sheet, 2-grass roofed, 3-earth roofed 4-floor cemented 5-Corrugated iron roof with partition

1.1How do you rate current condition of housing on a 5-point scale (feeding trough, gutter, floor, side walls and roofing)?

Farmers rating: 0-very low 1-low 2- medium 3-high 4-very high

2. Perception of technology attributes:

Relative advantage better housing	Rate (Tick one)				
	Very low (0)	Low (1)	Medium(2)	High(3)	Very high (4)
Avoid feed wastage					
Provide comfort and protection					
Convenient for management					
Labor/time saving					
Keeping animals healthy					

Practice 4: Adoption of vet practices

4.1. Regular Vaccination against disease? 1=Not at all 2=< 100% 3 =100%

4.2. Other vet. Activities /deworming, accaricides.../? 1=Not at all 2 =< 100% 3= 100%

Parameters of advantage on vet. services	Rate (Tick one)				
	Very low (0)	Low (1)	Medium (2)	High (3)	Very high (4)
Prevention (refers to vaccination)					
Disease curing					
Productivity (milk yield)					

Perceived current efficiency (PCE)

1. Current use of medical practices is determined, how do you rate it (anthrax, black-leg and other prevalence disease)?

Farmers rating: 0. Very low 1-low 2-medium 3-high - 4-very high

2. Perception of technology attributes

Relative advantage	Rate (Tick one)				
	Very low (0)	Low (1)	Medium (2)	High (3)	Very high (4)
Prevention (refers to vaccination)					
Productivity (milk yield)					

3. Feeding styles: a) Crop residue feeding only b) Crop residue & hay supplementation
c) Concentrates d) Forage/fodder feeding e) Processed/Chopped f) hay and concentrates

5-what are the main serious influencing factors that inhibit use of improved dairy technologies?

1-Grazing land 2-disease 3- lack of inputs 4-lack of capital 5-specify others.....

6) What are other major serious challenges for adoption of dairy technologies?????

6.1.-----

Part four: Information on impact of technology adoption on HHs income and asset holdings

1. Livestock ownership, income and asset holdings in the current years

Types of assets									
assets		quantity		Estimated value in birr		assets		Estimated value in birr	
Livestock assets		Before	After	Before	After	Productive assets		Before	After
Dairy cows	Local					Water pump			
	Cross					Animal cart			
Oxen	Local					Farm instruments			
	Cross					Town house			
						Non-productive assets			
Bulls	Local					Chair			
	Cross					Cups			
Heifers	Local					Mat			
	Cross					Table			
Calves	Local					Bed / Mozbold/			
	Cross					Cooking materials			
						Consumer-durable assets			
shoats						Radio			
Poultry	local					T V			
	improved					Tape Recorder			
Others						Others			

Household farm income

1. Sources & amount of annual income of households in the current year:

No	Sources of income	Amount produced	Total estimated income in birr		Remark
			Before	After	
1	Crop production				
2	Livestock & their products sell				
3	Working on others farm				
4	Renting (pump & others)				
5	Off-farm activities				
6	Sale of wood & charcoal				
7	Remittances				
Total income					

1.1. How much you saved money? At pocket-----birr, At bank account-----birr

2. Type of family house owning (multiple answers are possible): 1-corrugated iron sheet, 2-grass roofed, 3-corgated iron roofed 4-floor cemented, 5-separated from animal housing

3. How many of your family member attending school? 1. Male.....0.Female.....

4. In the past of the year, did any of the family members getting sick? 1- Yes 0-No

4.1. If yes, did the sick person got treatment? 1-Yes 0-No

4.2. Do you afford to pay health expenses every time? 1-Yes 0-No

4.3. If yes, what are your main sources of income to cover the expense?

1- Sell of crop products 2-Sell of livestock & products 3-credit 4- other business

4.4. How do you rate your household health condition in the past three years?

1-poor 2- medium 3-Good 4-very good 5-excellent

No	Impact variables	1. if considerably improved 2. if remain the same, 3. if considerably declined
1	Income	
2	Health status of family members	
3	Productivity	
4	Children schooling	
5	Assets	
5.1	Household assets	
5.2	Farm assets	
5.3	Livestock assets	
6	Farmers social status in the community	
7	Entrepreneurial skill (as the result of training & advice)	
8	Intra-household relationship	

THANK YOU VERY MUCH FOR GIVING GENUINE INFORMATION !!

Part Five: Checklists for key Informants

Please note that your insightful answers are crucial to our efforts in understanding overall factors influencing adoption decision, intensity of adoption of dairy technologies and its impact on household income and asset holdings.

1. Do many people participate in the agricultural extension services?
2. Do farmers participate in dairy technology?
 - 2.1. If yes, in what kinds of technologies? /improved breed, improved feed, better housing, AIS services, vet. Services/
3. What are the constraints for the adoption of dairy technologies?
4. What the community members involved in dairy extension (the rich/poor, female /male HHs, the literate/ illiterate, or other?)
5. What are the roles of women in dairy management?
6. Do you farmers get sufficient extension service and training from GO & NGO?
 - 6.1. Is the dairy technology profitable to farmers after participating in the technology?
7. What are the changes/ improvements/ you observed the impacts on income & asset holding after use of dairy technologies (Income, life style, and consumption pattern)
8. Are there enough input and credit service in the area?
9. What intervention must be used for better implementation of dairy technologies in the future to increase the level of adoption in the area?
10. Please mention all problems associated with livestock production in the area?
11. Describe any social, economic and environmental problems in the district associated with dairy technology adoption?
12. What are the dairy technologies more adopted by the community?
 - 12.1. Are adoption of dairy technologies as high as compared to the extension delivery service provided?
 - 12.2. If your answer is low, explain the reasons?
 - 12.3. What are the problems in the extension system?
13. What potentials are there for dairy technology extension in your area?

THANK YOU VERY MUCH !!

BIOGRAPHY

The author, *Tegege Fentaw Shibeshi*, was born from his father Ato Fentaw Shibeshi and his mother W/ro Yetemegni Mekonon in *South wollo Zone, Ambasel district, Wuchalie town*, 460 km north away from Addis Ababa in Dec 17,1976. He completed his primary education in *Marye primary* and junior school in 1989. He attended his high school education at *Dessie Hotie Comprehensive Secondary school* in 1990- 1991, and *Haik Secondary School*1992 -1993. He then joined the then Agarfa Farmers' Multi-Purpose Training Centre in animal health technician in July 22, 1995 and course leading Diploma in animal health at Alage TVET Collage August, 2004, and then graduated with B.Sc. degree in Agricultural Extension as Mid -career program on February 18, 2010 at Hawassa university.

After his graduation, he worked in *Ambassel and Tehuledere district of Agriculture and Rural Development office* as animal health technician and expert, district administration secretary office head, Technique Transformation Extension Communication Expert and Animal Production Development & Health Process Coordinator for 18 solid years until he joined Hawassa University for his postgraduate study in Rural Development.