ANALYSES OF IMPACT OF IMPROVED DAIRY TECHNOLOGY ADOPTION ON SMALLHOLDER HOUSEHOLD LIVELIHOODS AND MILK VALUE CHAIN IN SELECTED ZONES OF OROMIA AND AMHARA NATIONAL REGIONAL STATES, ETHIOPIA

A Dissertation submitted to the College of Veterinary Medicine and Agriculture, Addis Ababa University in partial fulfillment of the requirement for the degree of Doctor of Philosophy in Animal Production

By

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June, 2014

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Dedication

This dissertation manuscript is dedicated to my late brother, Hawulet Gezie, and my late uncle, Yewogu Abate who passed away during the study period.

STATEMENT OF AUTHOR

First, I declare that this dissertation is my *bona fide* work and that all the reference materials used for this dissertation have been duly acknowledged. This dissertation has been submitted in partial fulfillment of the requirements for doctor of philosophy degree at Addis Ababa University, College of Veterinary Medicine and Agriculture and is deposited at the University/College library to be made available to borrowers under rules of the Library. I earnestly declare that this dissertation is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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BIOGRAPHICAL SKETCH

The author was born in Awabel "woreda", East Gojjam Zone of Amhara National Regional State, in June 1975. He attended his Elementary and Junior Secondary Education at Lumamme Elementary and Junior Secondary School. Then, he joined Gojjam Ber Secondary High School and completed his secondary education in the 1992/93 academic year.

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ACKNOWLEDGMENTS

First and for most, the author would like to thank the Almighty GOD for his indescribable gift of courage and strength in his life.

The author is highly indebted to his major advisor, Dr. Mekonnen Hailemariam, without his encouragement, insight, skilful guidance and professional expertise the completion of this work would have not been possible. His special appreciation also goes to his co-advisor, Dr. Ashenafi Mengestu, for his comments and encouragement at all stages of the study. The author is also very grateful to his co-advisors, Dr. Kidido Michael from ILRI-Kenya and Dr. Emmanuelle GuerneBleich from FAO-Ethiopia, for their kind help, useful comments and cooperation.

The author conveys his deepest thanks to the Ministry of Education of Ethiopia, the German Academic exchange services (DAAD), the Food and Agricultural Organization of the United Nations (FAO), the International Livestock Research Institution (ILRI), SNV- the Netherlands and the Ethiopian Meat and Dairy Technology Institute (EMDTI) for their financial and technical support. The author needs to say thank you to W/o Tigist Endashaw who is a secretary in International Livestock Research Institute - Capacity Development (ILRI-CapDev) Office for her timely financial processing, sisterly approach and encouragement. His thanks also go to W/o Azeb who is the laboratory technician in EMDTI for her kindly approach and support during the milk laboratory analysis. The author also needs to acknowledge his colleagues: Akalu T., Alemu T. and Akelilu M., among others, for sharing their ideas and for their encouragement. The author appreciates the collaboration of the smallholder farmers in the study areas and other individuals, many to name, for their genuine support in the field work.

He also extends his heartfelt gratitude to all members of his family for their everlasting encouragement and support rendered towards his accomplishments.

ABBREVIATIONS

AADPA	Addis Ababa Dairy Producers Association
AAU	Addis Ababa University
ADLI	Agricultural Development-Led Industrialization
ADMY/C	Average Daily Milk Yield per Cow
AELMY	Average Early Lactation Milk Yield
AI	Artificial Insemination
AIMY	Average Initial Milk Yield
ALLMY	Average Late Lactation Milk Yield
AMLMY	Average Mid Lactation Milk Yield
AMYDO	Average Milk Yield at the Day of Observation
AMYL	Average Milk Yield per Lactation
AMYLs	Average Milk Yield per Lactation Stage
ANLC	Average Number of Lactating Cows
CADU	Chilalo Agricultural Development Unit
CC	Coliform Count
CCs	Contingency Coefficients
CSA	Central Statistical Authority
DDE	Dairy Development Enterprises
EARO	Ethiopian Agricultural Research Organization

ABBREVIATIONS (*Continued*)

FAO	Food and Agricultural Organization
HHs	Household Heads
IAR	Institute of Agricultural Research
IE	Impact Evaluation
ILRI	International Livestock Research Institute
NGO	Non-Governmental Organization
PADETES	Participatory Demonstration and Training Extension System
PSM	Propensity Scores Matching
SDDP	Smallholder Dairy Development Project
SPDDPP	Sellale Peasant Dairy Development Pilot Project
TBC	Total Bacterial Count
TLU	Tropical Livestock Unit
TMPADL	Total Milk Production in All Milking Days of One Lactation Length
TMPDO	Total Milk Produced at the Day of Observation
TNLC	Total Number of Lactating Cows
TNTC	Too Numerous to Count
VIF	Variance Inflation Factor
VRBA	Violet Red Bile Agar
WFP	World Food Program

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ABSTRACT

This study was carried out in Amhara and Oromia National Regional States of Ethiopia with the study objectives to describe the milk production and milk utilization patterns of the smallholder farmers, to analyze the raw milk value chain and milk marketing systems, to identify the determinants of raw milk quality at farm level, to identify the determinants of dairy technology adoption and analyze its impact on household livelihoods of smallholder farmers. Totally, 384 randomly selected smallholder farmers from six study sites were included in the study. Data were collected by questionnaire survey, farm observations, group discussions and milk samples were also collected for both microbial and phyico-chemical analysis. Both Statistical Package for Social Science (SPSS version 17.00) and STATA, version 11 software were used for analyses. Pearson correlation, multiple regression, descriptive statistics, analysis of variance (ANOVA) and econometric models such that Heckman two-stage model and propensity score matching (PSM) were also used. About 28% of the interviewed farmers were females that produced a significantly ($P<0.05$) greater average daily milk yield per cow(4.39 liters) than the male headed ones (3.37 liters). In the milk value chain analysis seven main stages (input supply, production, collection, wholesaling, processing, retailing and consumption) were identified. Low milk production (28.4%), need of processing at home (4.9%), unable to pay membership fee (2.3%), lack of awareness (2.1%), loss of trust on cooperatives (1.6%), distance from cooperative center (0.3%) were identified as constraints for smallholder farmers not to be a dairy cooperative members. 74 % of the total milk produced per day was obtained from cooperative members of which 5.2% was utilized directly at farm level and the remains (69.4%) of milk product was transferred indirectly to consumers through the value chain. Milk quality deterioration started at household level and, the microbial load increased through the value chain until it reaches to consumers. There was also a significant difference ($P<0.01$) in all physico-chemical milk quality parameters between the study areas. Dairy technology up-take constraints were financial problem, feed cost and *semen problem for artificial insemination (AI) in Amhara National Regional State and scarcity of crossbred heifers, land shortage and milk market for Oromia National Regional State. Family size, farming experience, availability of extension services, availability of crossbred cows, income from milk and milk products and availability of training in livestock production had positive association with dairy technology adoption and its level of use whereas age of household head and off-farm activity participation had negative association. Introducing and disseminating crossbred cows to smallholder farmers with a continuous follow up used to improve the livelihoods of smallholder farmers and narrow the milk demand – supply gap. Hence, dairy technology input and/or service providers should undertake follow ups to identify possible problems and/or evaluate the use and benefits of the interventions and the concerned public institutions should institute milk quality control and quality based payment to insure milk and milk products quality in the course of production, transportation, processing, marketing and consumption were some of the recommendations forwarded.*

Key words: *Dairy technology, Adoption level, Livelihoods changes, Milk value chain, Milk quality.*

1. INTRODUCTION

Ethiopia has large cattle population estimated at 53.4 million heads out of which 7.5, 0.5, 13.5 and 10.9 million were recognized as being used for milk, beef, draught and breeding purpose, respectively (CSA, 2011). Among the total cattle population, 99.26% (52.99 million) are indigenous, 0.64% (0.34 million) are crossbreds and 0.1% (0.05 million) exotic breeds (CSA, 2011). Cattle play an important socio-economic role in the livelihoods of dairy producers through, among others, exporting live animals and their products. Belachew (2004) as cited by Belete (2006) stated that a total value of 1.764 and 89 million USD was gained by exporting 1,754 tones of live cattle and 21 tones of dairy products in four years (1999-2002), respectively.

However, in spite of the large livestock population, the contribution of the Ethiopian livestock sector in general and the dairy sector in particular is below its potential at both the national and household levels (Berhanu *et al.*, 2007). According to the central statistical agency's estimate (CSA, 2011), the total cow milk production (excluding milk suckled) for the rural sedentary areas of the country during the referenced period is about 4.06 billion liters, average lactation period per cow during the referenced period at country level was estimated to be about six months and average milk yield per cow per day was about 1.85 liters. This low production level of the sector is attributed to inefficient productivity of the livestock as a result of use of traditional methods of production, poor feeding, inferior health care, poor breeds and services and low capital investment in human and fixed assets.

The dairy sector is mainly of subsistent type largely based on indigenous breeds of cattle. Milk production from this system is low to support the demand for the continuously increasing human population, particularly in urban centers (Azage and Alemu, 1998). Ethiopians consume less dairy products than other African countries and far less than the global average. The national-per capita consumption of milk excluding butter was 20 kg/year as compared to 44 kg/year for the African countries and 87 kg/year for the world per capita consumption (FAO, 2009) but the recommended per capita milk consumption is 200 kg/year.

As is common in other African countries (e.g., Kenya and Uganda), the dairy products in Ethiopia are channeled to consumers through both formal and informal dairy marketing systems (Mohammed *et al*., 2004). However, the proportion of total production being marketed through the formal markets remain small (Muriuki and Thorpe, 2001).

In any market system and value chain[1], various actors participate in marketing of commodities and transactions made. These include producers, itinerant/mobile traders, semi-whole sellers, retailers, cooperatives, processors and consumers. The number of actors involved from producer to end consumer varies depending on the nature of the product and the established market chain. Regardless of the number of actors, milk production and milk marketing systems along the value chains in Ethiopia are facing many difficulties including: low and fluctuating output price, high and increasing price of input factors and less infrastructures which discourage the producers from improving the quantity and quality of milk production.

There is also a large demand-supply variation for milk and milk products, especially in urban centers indicating the untapped potential for development of market oriented urban and peri-urban dairy production systems, which play a significant role in minimizing the acute shortage of milk and dairy products in urban centers. Thus, market oriented urban and peri-urban dairy production systems, based on upgraded dairy stock (crossbred dairy cows) and purchased conserved feeds (Staal and Shapiro, 1996) have emerged and dominated in most urban centers. The systems involved the production, processing and marketing of milk and milk products that are channeled to consumers in urban centers (Rey *et al*., 1993; Staal and Shapiro, 1996). But they couldn`t fill the demand-supply gap. In terms of the potential and actual contribution to the national milk production, the role of rural smallholders is immense. A rough ranking which was done by Felleke and Geda (2001) indicated that the volume of milk produced, in decreasing order of importance, was from rural small-scale mixed farms in the highlands, small urban/peri-urban farms in the highlands, pastoral/agro-pastoral producers in the lowlands and large private and state farms.

[1]Value chain describes the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use (Kaplinsky, 2000).

This shows that intensification and commercialization of smallholder farmers will have great role on dairy production. Intensification of smallholder dairy production typically involves the adoption of a combination of improved cattle breeds for milk production and other complementary inputs (*e.g.*, production of improved forages, purchased feeds, disease control measures, and improved record keeping). Previous descriptive studies have suggested that intensification of dairy production in East Africa can have positive impacts on the opportunities and welfare of smallholder farmers, with consequent effects on agricultural development (Leegwater *et al.*, 1991; Nicholson *et al.*, 1999).

The introduction of crossbred heifers and other related dairy technologies in Ethiopia started in the 1930`s by Italians and cattle crossbreeding activities were provided later by the Institute of Agricultural Research (IAR) and Chilalo Agricultural Development Unit (CADU) using Holstein Frisian, Jersey and Simmental Sires that were crossbred with the local Horro, Borana and Arussi dams (EARO, 2001; Lobago, 2007). Since then, governmental and non-governmental organizations have made various efforts to improve the dairy sector by establishing dairy cattle improvement ranches, distributing crossbred F_1 heifers to smallholder farm owners, provision and organization of livestock services (artificial insemination, veterinary and extension services) and creation of dairy co-operatives (to collect and market milk) (EARO, 2001; Kelay, 2002; Lobago, 2007). Several authors reported a number of socioeconomic factors that affect the adoption of dairy technologies by farm households (Birkhaeuser *et al*., 1991; Baidu-Forson, 1999; Rezvanfar, 2007 and Amlaku *et al*., 2012) which include training in basic animal health, extension education, distance from the agricultural development center and educational status among others.

Even though 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 area, the rate of adoption of dairy technologies by farm households varies widely across different agro-ecologies and within the same agro-ecology, based on various technical and non-technical factors. Accordingly, the contribution and benefits of dairy technologies differ among farm households. Moreover, there is a considerable post production milk loss commonly associated with inappropriate production, transport, processing and marketing systems. On the other hand, for policy design and effective management of extension programs, information on the extent of adoption of disseminated technologies, understanding of socio-economic and institutional determinants of adoption of such practices; and information on the efficiency along the milk value chain and impact of dairy technology on the livelihoods of smallholder farmers are very important and would help to come up with workable recommendations to improve the performance of the sector.

Research Questions

1. What types of milk marketing systems do smallholder farmers have access to? What constraints and opportunities does the milk production system face?
2. What are the milk quality problems at different critical points of the value chain?
3. What are the determinants of fresh milk quality at smallholder farm?
4. What are the constraints of dairy technology adoption for smallholder farmers in the study areas?
5. How does dairy technology adoption affect the livelihoods of the smallholder farm households in the study areas?

Research objectives

The main objective was to analyze the impact of dairy technology adoption on livelihoods of smallholder farm households and the milk value chain in selected zones of Oromia and Amhara National Regional States of Ethiopia with the following specific objectives:

1. To describe the milk production and milk utilization patterns of the smallholder farmers;
2. To analyze the raw milk value chain and milk marketing systems;
3. To identify the determinants of fresh milk quality at farm level of the smallholder farmers in order to enhance the maintenance of milk quality;
4. To identify factors influencing adoption of dairy technology; and
5. To analyze its impact on household livelihoods of smallholder farmers.

2. LITERATURE REVIEW

2.1. Importance of the Livestock Sector in Ethiopia

Livestock in Ethiopia perform important functions in the livelihoods of farm owners, pastoralists and agro-pastoralists. Livestock are sources of food (meat and milk), services (transport and traction) cash income, manure (for soil fertility and fuel), and serve as store of wealth and hedge against inflation. The subsector also provides year-round employment for a significant part of the rural population, which would perhaps remain unemployed otherwise (MEDaC 1999; Berhanu *et al*., 2009). Livestock are especially important sources of cash income to the poorer sections of the Ethiopian rural population and women, as is also true in many other developing countries (Delgado *et al*., 1999; Thornton *et al*. 2002; Berhanu *et al*., 2009). Beneficial income diversification investments can arise from cash income generated from livestock (Little *et al*., 2001; Berhanu *et al*., 2009).

The livestock population (in millions) is estimated at 53.4 cattle, 25.51 sheep, 22.79 goats, 2.03 horses, 6.21 donkeys, 0.39 mules, 1.10 camels and 49.29 poultry (CSA, 2011). Among these cattle population 99.26% (52.99 million), 0.64% (0.34 million) and 0.1% (0.05 million) are indigenous, crossbred and pure exotic breed cattle, respectively. In Amhara and Oromia National Regional States, the cattle population is estimated to be 25 .04 % (13.37 million) and 43.00% (22.96 million) of the total cattle population in the country respectively (CSA, 2011). This indicates that livestock production is an important component in local economies at both the national and farm household level, where cattle constitute the main livestock species kept by farm owners (Dehinenet, 2008). Cattle, which are more suitable for intensive production than other dairy species, contribute about 85% of the country's annual milk production, with goats, sheep and camels combined making up the remaining 15% (FAO, 1999). Therefore, the main source of milk in Ethiopia is the cow and smallholder farm owners represent about 85% of the population and are responsible for 98% of total milk production (Tsehay, 2001).

The estimated annual net milk production (exclude milk suckled) from cattle is about 4.06 billion liters, average lactation period per cow during the reference period at country level is estimated to be about six months and average milk yield per cow per day is about 1.85 liters (CSA, 2011). Despite the large livestock population in Ethiopia, the sector's contribution at the micro or the macro level is well below its potential due to various reasons, notably feed shortage and diseases. These problems are compounded by inefficiencies in the input (feed, genetic material and veterinary services) and output (livestock products) marketing, including poor market infrastructure, lack of marketing support services and limited market information (Berhanu *et al*., 2009).

2.2. Dairy Production Systems in Ethiopia

Dairy production is practiced almost all over Ethiopia involving a vast number of small, subsistence and market-oriented farms. Based on climate, land holdings and integration with crop production as criterion, three major dairy production systems are recognized in Ethiopia (Azage and Alemu, 1998; Ketema, 2000; Tsehay, 2001; Yoseph *et al*., 2003; Zegeye, 2003; Dereje *et al*., 2005; Sintayehu *et al*., 2008). Rural system (pastoralism, agro-pastoralism and highland mixed smallholder production system) contributes to 98%, while the peri-urban and urban dairy farms produce only 2% of the total milk production of the country (ketema, 2000; Sintayehu *et al*., 2008).

The rural system is non-market oriented and most of the milk produced in this system is retained for home consumption. The level of milk surplus is determined by the demand for milk by the household and its neighbors, the potential to produce milk in terms of herd size and production season, and access to a nearby market. The surplus is mainly processed using traditional technologies and the processed milk products such as butter, ghee, ayib, and sour milk are usually marketed through the informal market after the households satisfy their needs (Tsehay, 2001; Sintayehu *et al*., 2008). Pastoralists raise about 30% of the indigenous livestock population which serve as the major milk production system for an estimated 10% of the country`s human population living in the lowland areas. Milk production in this system is characterizes by low yield and seasonal availability (Zegeye, 2003; Sintayehu *et al*., 2008).

The highland smallholder milk production is found in the central part of Ethiopia where dairying is nearly always part of the subsistence smallholder mixed crop and livestock farming. Local animals raised in this system generally have low performance with average age at first calving of 53 months, average calving intervals of 25 months and average lactation yield of 524 liters (Zegeye, 2003; Sintayehu *et al*., 2008).

Peri-urban milk production system is developed in areas where the population density is high and agricultural land is shrinking due to urbanization around big cities like Addis Ababa. It possesses animal types ranging from 50% crosses to the high grade Friesian in small to medium-sized farms. The peri-urban milk system includes smallholder and commercial dairy farm owners in the proximity of Addis Ababa and other Regional towns. This sector owns most of the country`s improved dairy stock (Tsehay, 2001; Sintayehu *et al*., 2008). The main source of feed is both home produced or purchased hay; and the primary objective is to get additional cash income from milk sale. This production system is now expanding in the highlands among mixed crop-livestock farm owners such as those found in Selale and Holetta, and serves as the major milk supplier to the urban market ((Gebre Wold *et al*., 2000; Sintayehu *et al*., 2008).

Urban dairy production system includes highly specialized, state or businessmen owned farms, which are mainly concentrated in major cities of the country. These dairy farm owners have no access to grazing land. A number of smallholder and commercial dairy farms are emerging mainly in the urban and peri-urban areas of the capital (Felleke and Geda, 2001; Azage, 2003; Yitaye, 2008) and most Regional towns and *Woreda*s (Ike, 2002; Nigussie, 2006). Smallholder rural dairy farms are also increasing in number in areas where there is market access. According to Azage and Alemu (1998), the urban milk system in Addis Ababa consists of 5167 small, medium and large dairy farms producing 34.65 million liters of milk annually. Of the total urban milk production, 73% is sold, 10% is left for household consumption, 9.4% is fed to calves (excluding the amount directly suckled by the calves) and 7.6% is processed into butter and cottage cheese. In terms of marketing, 71% of the producers sell milk directly to consumers and the rest reaches to the consumers through intermediaries (Tsehay, 2001; Yitaye, 2008).

2.3. Trend and Performance of the Dairy Industry in Ethiopia

The prevailing heat stress, external and internal parasites, infectious disease, poor nutrition and concurrent problems impedes the introduction and use of selected high-producing exotic breeds in most tropical and subtropical countries. Consequently, the most suitable cows for dairy production on these areas are ones with a proportion of genes from the high producing cattle of temperate origin and a proportion well adapted but low producing cattle, in many case a *Bos taurus* X *Bos indicus* cross, often with advantages of heterosis (Albero,1983; Lobago, 2007).

In Ethiopia the crossbreeding of improved European with indigenous zebu cattle breeds was introduced in the 1930`s by Italians. However, wide-scale cattle crossbreeding activities were started later by the Institute of Agricultural Research (IAR) and Chilalo Agricultural Development Unit (CADU) using Holstein Frisian, Jersey, and Simmental Sires that were crossed with the local Horro, Borana, and Arussi dams (EARO, 2001; Lobago et al , 2007). Since then, governmental and non-governmental organizations have made various efforts to improve the dairy sector by establishing dairy cattle improvement ranches and distributing crossbred F_1 heifers to smallholder farm owners (EARO, 2001; Kelay, 2002; Lobago et al, 2007). For example, in 1987 a project known as the Sellale Peasant Dairy Development Pilot Project (SPDDPP) was established and introduced crossbreed dairy cattle and improved management skills in the highlands of Ethiopia. This pilot project was later continued with a new project called the Sellale Smallholder Dairy Development Project (SDDP) which had the same objectives but broader range of activities encompassing other parts of the country (Kelay, 2002; Lobago et al, 2007).

Between 1961 and 1974, milk production increased by 16.6% from 637,400 to 743,100 metric tons with an average annual growth rate of 1.6%. This growth was largely due to the economies of scale in production as well as marketing, subsidies in transport to the formal market, secured land tenure and an active free market for feed and other inputs (Staal and Shapiro, 1996). On a per capita basis, however, milk production declined during this period at an average rate of 0.87% per annum. Processed milk production was stagnated in the early 1960s but expanded significantly in the second half of 1960s and early 1970s (SNV, 2008).

To bridge the gap between supply and demand, dairy imports increased significantly beginning from1978. This was partly due to increased food aid milk powder imports by World Food Program (WFP) and a level of dairy production development that lagged far behind the demand. Imports reached a peak of 314,700 metric tons in 1986 during the drought period (Tsehay, 2001; SNV, 2008). During the period between 1977 and 1989, dairy imports as a percent of total consumption increased from 4.1% to 12.8%. Commercial imports grew rapidly at 24.2% per year (Felleke and Geda, 2001). Further, it was estimated that imported milk powder accounted for 23% of Addis Ababa market.

Post 1991 producer groups such as the Addis Ababa Dairy Producers Association (AADPA) emerged encompassing 90% of all urban dairy producers and a large proportion of peri-urban producers within a radius of 100 km of Addis Ababa (Staal 1996; SNV, 2008). Milk production grew faster in the post reform period, at an annual growth rate of 3%. Per capita milk production stagnated though grew at a positive but insignificant rate. This represents a reversal or termination of the negative trend in the growth of per capita production during the previous two phases. Using rough estimates from the FAO database and available information from Dairy Development Enterprise (DDE) and Felleke and Geda (2001), the contribution of imported milk to total milk consumption declined from 24% in 1985 to less than 1% in 2000. At the same time, the share of government-owned enterprises in total milk production decreased markedly. In contrast, the share of smallholder production in total consumption increased by 30% from 71% to 97% (SNV, 2008).

To sum up, total milk production in Ethiopia increased during the 1961-2000 period at an average annual rate of 1.55% though per capita production declined as a result of the high population growth rate. However, during the last decade production grew at a higher rate of 3%. The increased coverage of extension services (such as better management skills) and increased use of improved inputs (improved breeds and feed) and policy changes promoting dairy production have contributed to faster growth of the sub-sector.

2.4. Milk Marketing Systems in Ethiopia

As is common in other African countries (e.g., Kenya and Uganda), dairy products in Ethiopia are channeled to consumers through both formal and informal dairy marketing systems (Mohammed *et al*., 2004). Until 1991, the formal market and pasteurized milk was exclusively dominated by the DDE (which supplied 12 % of the total fresh milk in the Addis Ababa area (Holloway *et al*., 2000). Unlike the early phases, the formal market appears to be expanding during the last decade with the private sector entering the dairy processing industry. Private businesses have begun collecting, processing, packing, and distributing milk and other dairy products. However, the proportion of total production being marketed through the formal markets remained small (Muriuki and Thorpe, 2001). Formal milk markets are particularly limited to peri-urban areas and to Addis Ababa.

The DDE collects milk for processing from different sources, including large commercial farms and collection centers that receive milk from smallholder producers. The enterprise operates 25 collection centers located around Addis Ababa, 13 of them near *Selale*, 5 near *Holeta* and 7 around *Debre Brehane* (Mohammed *et al*., 2004). The sale price of pasteurized milk changed over time. Until the 1980's, the DDE charged a price of 0.7 birr per liter. The price of milk increased from 1.00 birr in 1985/86 to 1.70 birr in 1990. However, the wide gap between production and sale of milk by DDE during the 1980-1990 reflects the failure of DDE to efficiently market its products; this is because they offer a price of 15 to 25 cents less than that paid by private traders operating in the informal market (Yigezu, 2000).

However, since its inception the enterprise has only utilized its full capacity during the four years period from 1987 to 1990 (Staal and Shapiro, 1996). The reasons for low capacity utilization include management problem, financial difficulties, and unstable and low consumption levels of processed milk in the society due to fasting period that prohibits the Orthodox Christians (about 35- 40 % of the population) from consuming dairy products for almost 200 days every year (Yigezu, 2000).

The informal market involves direct delivery of fresh milk by producers to consumers in the immediate neighborhood and sale to itinerant traders or individuals in nearby towns. In the informal market, milk may pass from producers to consumers directly or it may pass through two or more market agents. The informal system is characterized by no licensing requirement to operate, low cost of operations, high producer price compared to formal market and no regulation of operations. The relative share and growth of the formal and informal market was different. In all cases, the informal (traditional) market has remained dominant in Ethiopia (Tsehay, 2001). The traditional processing and trade of dairy products, especially traditional soured butter, dominate the Ethiopian dairy sector. Of the total milk produced only 5 % is marketed as liquid milk due to underdevelopment of infrastructure in the rural areas.

In the years (1991-2000), promotional efforts have focused on dairy marketing. Milk marketing cooperatives have been established by the Smallholders Dairy Development Program (SDDP) with the support of Finnish International Development Association. These cooperatives buy milk from both members and non-members, process it and sell products to traders and local consumers. The cooperatives also process milk into cream, skim milk, sour milk, butter and cottage cheese. Setting up a new dairy cooperative would clearly reduce the travel time of members, and the actual number of households that would benefit depends on local population densities. It is also important to keep newly emerging milk groups small and geographically limited to ensure proximity and avoid large groups that would tend to increase average travel times (Holloway and Ehui, 2002).

Marketing channels are routes through which products pass as they are moved from the farm to the consumer (Winrock, 1989; Adebaby, 2009). In any marketing system, various actors participate in marketing of commodities and process of transactions made. These include itinerant/mobile traders, semi-wholesalers, retailers, cooperatives and consumers. Itinerant/mobile traders purchase commodities from nearby market points and sell at business site or residences. Retailers are market intermediaries such as super markets, small and large–scale retailers who perform the function of retailing. Semi-wholesalers are important commodity market intermediaries who perform the function of both retailing and whole selling depending on the market conditions.

Cooperatives are common form of collective group of producers. They are milk outlets that are potential catalysts in markets by providing bulking and bargaining services, increase outlet market access and help farmers avoid the hazards of being encumbered with a perishable product with no rural demand. In short, participatory cooperatives are very helpful in overcoming access barriers to assets, information, services, and indeed, to the markets within which smallholders wish to produce high value items (Holloway *et al*., 2000; Adebaby, 2009). Cooperative marketing is based on the premise that a group of producers can achieve better results by combining their efforts and resources than operating separately.

Terms related to marketing outlets, marketing channels, and marketing chains are important to describe milk marketing systems (Sintayehu *et al*, 2008; Adebaby, 2009). Marketing outlet is the final market place to deliver the milk product, where it may pass through various channels and a network (combination) of market channels gives rise to the market chain. Marketing survey in Hawassa, Shashemane and Yergalem depicted that milk producers sold milk through different principal marketing channels (Woldemichael, 2008; Adebaby, 2009). These included:

- Producer → consumer (P-C) channel;
- Producer → Retailer → Consumer;
- Producer → Semi-wholesaler → Retailer →Consumer;
- Producer → Cooperative → Retailer →Consumer;
- Producer → Cooperative →Consumer;

2.5. Milk Consumption in Ethiopia

Ethiopians consume less dairy products than some other African countries and far less than the world consumption. The national average per capita consumption of milk excluding butter was 20kgs/year as compared to 44 kgs/year for the African countries and 87kgs/year for the world per capita consumption (FAO, 2009). The recommended per capita milk consumption is 200 liter/year. On the other hand, they regularly consume other dairy products such as butter, ayib (cottage cheese) and fermented milk. Milk consumption in Ethiopia shows that most consumers prefer purchasing of raw milk because of its natural flavor (high fat content), availability and lower price. Specific upper income market segments prefer and can afford packaged processed milk. Packaging costs alone may add up to 25% of the cost of processed milk depending on the type of packaging used (SNV, 2008).

According to the Central Statistics Agency (2005) only 15.4% of the milk produced is sold in the market where as 54.7% milk produced is consumed at home. The remaining, 29.5% of the milk produced, is converted into butter and cottage cheese or ayib using traditional processing technologies. It is to be expected that these proportions would start to change as collection infrastructures improve around the country. There are differences in the demand for milk between rural and urban population. The demand for milk in rural areas is mainly for fresh whole milk and this demand is partially satisfied by home production and or purchased from neighboring producers. The demand for processed milk in the rural areas, is currently nil and expected not to change significantly in the near future (SNV, 2008).

The potential market for surplus milk which will have to be processed is found in the 7% urban population, i.e. 4 million people. Sixty five percent of this market is formed by Addis Ababa and the surrounding districts. The principal demand will continue to be fluid milk, much of which will be supplied through informal channels. In rural areas, consumption of milk and milk products is heavily influenced by livestock ownership, but in the urban areas, in particular, the principal determinant of consumption levels is income. The growth in demand resulted from rapidly growing population, urbanization, change in life style and consumption behaviors, and some increase in per capita incomes (SNV, 2008). In general, the milk market is characterized by low per capita consumption with inadequate marketing, cooling, bulking, processing infrastructure and market information for traders and dairy industry actors. These limited processing facilities on one hand and its concentration in/ around Addis Ababa on the other hand results in inequitable consumption, as there is no enough milk packaged for non-milk producing areas (SNV, 2008).

2.6. Dairy Value Chain in the Ethiopian Context

Ethiopia has a complex dairy value chain, with both formal and informal marketing channels. Only 5% of the milk produced in Ethiopia is sold in commercial markets (CSA, 2012). The dairy value chain has different actors such as smallholder and commercial producers, small and large processors, services and inputs providers, farmers` organizations and cooperatives.

Dairy producers and downstream actors in the value chains face many challenges in getting milk to market. For the most part, milk collection, chilling and transport are not well organized. Transaction costs are high and up 20-35% of milk is spoiled or otherwise lost (Felleke *et al.,* 2010). Accordingly, Ethiopia`s dairy value chain is thus constrained by low milk productivity at the farm level and inefficient logistics to link producers and processors. However, these limitations generate opportunities for different value chain actors to invest in milk production, collection and processing.

2.6.1. Formal dairy value chain

The formal dairy chain involves seven distinct value adding activities from production of the milk through reaching to the final consumer in the market. These activities include input supply, milk production, raw milk transportation, bulking and cooling/collection/, processing and packing, retailing gathering (bulking) and retail trading/consumers/(Zelalem *et al*., 2011).

2.6.2. Informal dairy value chain

Only 2% of the milk produced in Ethiopia reaches the market through the formal dairy chain. The rest of the milk is consumed at home, processed into traditional products and/or reaches the market via informal marketing channels. The informal liquid milk market involves direct delivery of fresh milk by producers to consumers in the immediate neighborhood and sale to itinerant traders or individuals in nearby towns (Van der en and Abebe, 2010). In the informal market, milk may pass from producers to consumers directly or it may pass through two or more market agents. The informal system is characterized by no licensing requirement to operate, low cost of operations, high producer price compared to the formal market and no regulation of operations (Tsehay, 2001).

The informal (traditional) milk channel has remained dominant in Ethiopia. Moreover this channel provides substantial amounts of milk which goes into traditional dairy processing and then traded especially traditional soured butter. The main milk producers in this channel are sedentary rural smallholders and pastoralists (LOL, 2010). This informal market has one main advantage over its formal counterpart; the informal market is a cash-based market, with producers (farmers) being paid immediately for their goods. Within the formal chain, farmers can wait up to a month to receive payment for their milk. As smallholder farmers are generally facing immediate cash flow needs, the informal market provides an advantage.

2.7. Technology Adoption/Diffusion Theories

The North Central Rural Sociology Sub-committee in Egypt for the study of diffusion of farm practices had developed the traditional well known adoption process which views adoption as a series of stages (Shahin, 2004). According to this committee, individuals do not adopt any innovation immediately after they hear about it. They normally need some time to study the technology before adoption. Such a time might continue for several years before even trying to implement the idea for the first time. The adoption process, as viewed by the committee is composed of five stages which are:

- **Awareness stage**: The individual hears about the existence of the new idea for the first time but lacks information about it.
- **Interest stage:** Out of curiosity and interest, the individual tries to gather more information about the idea.
- **Evaluation stage:** The individual makes a mental judgment taking into consideration both the merits of the new idea and his existing situation and condition. Such an evaluation ends normally in a decision either to try the new idea on a small scale or to reject it.
- **Trial Stage:** Trial means implementation of the new idea or innovation on a small scale.

• **Adoption stage:** After the idea is examined, and its feasibility is tested, the farmer or the individual will try to implement such an idea on a full scale. Implementation on a full scale is conceptualized as adoption.

2.8. Definition of Technology Adoption

New agricultural technology is generally a bundle or package of different technological elements such as improved production and productivity; plus the technical practices and skills needed for their effective use (SAMY, 1998; Shahin, 2004). Any definition of technology encompasses a wide range of phenomena. In the broadest sense, technology is defined as the translation of scientific laws into machines, tools, mechanical devices, instruments, innovation, procedures and techniques to accomplish tangible ends, attain specific needs, or manipulate the environment for practical purposes (Shahin, 2004).

2.9. Agricultural Technologies under Consideration

Before defining impact analysis and discussing its implementation, it is worthwhile to consider the different kinds of agricultural technologies that are likely to be evaluated. Each type of technology has unique limitations that must be kept in mind when setting expectations about what we can learn from impact analysis and the challenges that will arise when implementing evaluations. According to DeJanvry *et al*. (2011), there are four categories of agricultural technologies, namely yield-increasing and cost-saving technologies; risk-mitigating technologies; quality-improving technologies and technologies that alter environmental externalities. Some details of these four technology categories are as indicated here below.

2.9.1. Yield-increasing and cost-saving technologies

DeJanvry *et al*.(2011) states that both yield-increasing and cost-saving technologies are reducing the costs per unit of outputs. Yield-increasing technologies also allow for higher gross output if some inputs (especially land) are limited. Examples of yield-increasing dairy technologies include improved dairy breed and improved feed. Cost saving technologies may also include new dairy technologies that require fewer complementary inputs and cultivation practices that could produce equal results with less effort.

2.9.2. Risk-mitigating technologies

Risk-mitigating technologies help to minimize the risk of very bad outcomes in times of unfavorable environmental conditions, but might not increase yield in times of favorable conditions (DeJanvry *et al*., 2011). It is, therefore, difficult to observe their effects always. Some examples of risk-mitigating technologies and conditions under which their impacts might not be observable are Drought-and disease-resistant cattle breed and Livestock vaccines inoculation.

2.9.3. Quality-improving technologies

These technologies help to increase the quality of outputs in some respect even if yield does not improve. These types of technologies differ from the others in that the main benefits accrue to consumers. DeJanvry *et al*. (2011) states that the impact of quality-improving innovation is difficult to evaluate, in part because the channel of transmission from the availability of the new variety to the manifestation of benefits involves several actors. 'Adoption' by consumers requires that producers have already adopted and produced the variety so that it is available to consumers, and that consumers have chosen to consume it.

2.9.4. Technologies that alter environmental externalities

These technologies diverge from technologies that improve or maintain the quality of the outputs. New cultivation and livestock management techniques may fall into this category, as may fertilizers in that they prevent negative externalities on neighboring property or public resources, for example through groundwater contamination. DeJanvry *et al*. (2011) states that the impacts on public resources can be hard to measure and such impacts could take a long time to manifest. Potential roadblocks to successful impact analysis for these technologies are fairly obvious. Yet, without taking into account these external effects, the social value of the technology can be vastly under-estimated.

2.10. Dairy Technology Uptake and its Determinants

The implementation of new agricultural technologies has become a driving force for management change on smallholder farms. Identifying technologies and management practices could enhance the sustainability of agricultural production, as well as mitigate constraints to their uptake. Economic viability is a fundamental condition for the wide spread uptake of technologies and management practices that will help to achieve the goal of sustainable agriculture in general, and dairy in particular. Studies on the factors that influence uptake of agricultural technologies often focus on household resource endowments, characteristics of the household heads, location of the households, the nature and extent of information provided before uptake, and characteristics of the technology (Feder *et al*., 1985).

The technology diffusion and adoption literature suggests that many different attributes of individuals may influence them to act in different ways. Studies by Baidu-Forson (1999) suggested that adoption behavior of farmers is explained by farmer attributes, farm attributes, infrastructure attributes and perceptions about agricultural technologies. According to Rogers (1995), socioeconomic characteristics, personality values and communication behavior of individuals influence their way of adopting innovations such that some individuals adopt innovations earlier than others.

Numerous studies have examined the influence of socio-economic variables on farmers' adoption decisions of agricultural technologies using either the probit/logit model (Kabede *et al*., 1990, Kaliba *et al.*, 1997) or the ordinary least squares, linear regression model (Rezvanfar, 2007). The linear regression model has a continuous dependent variable, while the probit or logit model involves a binary dependent variable. In these models, the dependent variable is specified as a function of farmer-specific attributes (e.g. gender, age, experience, education, household size, income, extension contact), and farm attributes (e.g. farm size, farm type, location).

High school education is found to be significant and positively related to adoption level. Controlling for other factors, high school education would increase adoption. In other words the more educated the farmer the higher the adoption of livestock technologies. Education makes people to realize the importance and benefits of adopting new technologies. Therefore educated people can be more willing to adopt and apply the new innovations in their farms (Rezvanfar, 2007).

Access to off-farm employment income has a significant positive effect on adoption of livestock technologies. This entails that increased access to off-farm employment income can lead to increased adoption of livestock technologies. One explanation for this result is that off-farm income provides supplemental income to finance technology expenditures for example: purchase of salt block, urea, mineral lick, hay and small tools for dehorning and castration (Rezvanfar, 2007).

As expected the coefficient for training in basic animal health offered by extension staff had a significant positive effect on the adoption rate of livestock technologies. Farmers as individuals are known to gain from access to improved information provided through extension training (Birkhaeuser *et al*., 1991). Similarly, the availability of extension education makes a substantial contribution to motivating adoption or intensity of use of improved technologies (Baidu-Forson, 1999).

The distance from the agricultural developmental center (DADC) has a significant negative influence on the adoption of livestock technologies. An increase in distance causes a decrease in adoption level. The ADC is usually strategically located within the farming areas and it is the place where the local extension worker is stationed. As distance from the ADC increases, livestock technology adoption decreases because this causes transportation cost incurred in obtaining information on technologies and inputs to increase. Farmers are less likely to adopt the livestock technologies as the distance increases from the ADC (Rezvanfar, 2007).

2.11. Technology Impacts to be Considered

"Farm-level restricted profits are the natural place to start when looking for the immediate impacts of a new technology. These represent the expected profitability that drives farmers to adopt a new production technology and provides the channel through which adoption increases producer welfare. Yield is another, apparently simpler, measure of impact for agricultural technologies. While this may be an interesting impact to measure, it does not in itself reveal the extent of the producer's welfare affected by the technology. As Foster and Rosenzweig (2010) cited in DeJanvry *et al*. (2011) stated that adoption can be accompanied by input adjustment by farmers, so that the positive impact of yield increases on profits could be mitigated to some extent by increased expenditures on inputs. On the other hand, a labor-saving innovation might not change yield per hectare but instead give the same amount of output with less work, whether supplied by the farmer or by hired labor. Profits account for both changes in revenues from increased output and changes in expenses from input adjustment, and in so doing they give us a measure of the first-order microeconomic impact of the new technology. It is also important to estimate impacts on household income, expenditure, and poverty because this gives a measure of the extent to which the technology actually affects household welfare" (DeJanvry *et al*., 2011).

3. MATERIALS AND METHODS

3.1. Study Area Description

The study was conducted in three zones and six selected areas from Oromia and Amhara National Regional States of Ethiopia (Fig. 1). The study areas were selected purposively based on the history/extent of dairy development interventions and distribution of dairy cattle. These were among the focal areas for the introduction of dairy technology packages by the Smallholder Dairy Development Project (SDDP) since 1995 (Reijo, 1998) and, hence, many private smallholder farmers owning crossbred cows are found.

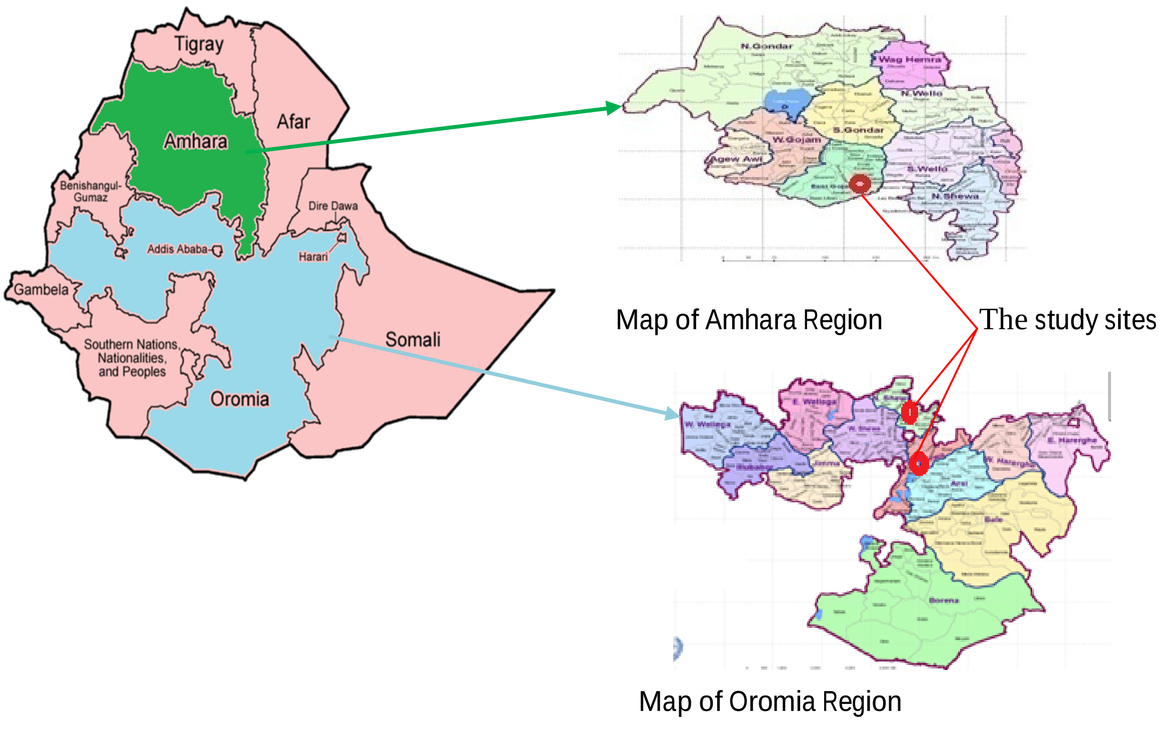

Figure 1: Map of the study areas

3.1.1. An overview of the Oromia National Regional State (ONRS)

The Oromia National Regional State lies in the central part of the country with larger protrusions towards the south and west directions with an area coverage of 353,690 km^2 (OPEDB, 2000). The region has 17 administrative zones and 251 districts with a total population of 27.16 million, of which the economically active population (15-64 years) accounted for 64.5% and the total average household size was estimated at 4.8 people (CSA, 2007). The estimated livestock population and arable land of the region were 41.6 million and 30.7% of the total area respectively (OPEDB, 2000). “Teff” (*Eragrostis tef)*, wheat, maize, barley, sorghum, bean, pea, lentil etc. are some of the widely cultivated crops in the region and cattle, Sheep, Goat, Horse, Donkey, Mule and Chickens are the common livestock species found in the Region (Eshetu, 2008).

3.1.1.1. An overview of North Shewa Zone

The North Shewa Zone of the Oromia National Regional State, which is commonly called Selale, is located 190 km north west of Addis Ababa. It covers 1174500 ha of land from which 40% is crop land, 25% is grazing land, 13% is forest and bush area, 7% is construction area and 15% is unproductive land. Agro ecologically, 42% of the area is highland with an altitude over 2800 meters above sea level , is suitable for crop cultivation and livestock husbandry and the herd structure is characterized by a higher number of cows (Kelay, 2002). This area has two annual rainy seasons: from February-May (short rainy season) and from June-October (long rainy season) (Tittarelli, 1990).The area also has better access to livestock development services (governmental and non-governmental) and milk markets than other rural areas. Because of the above mentioned reasons and the economic capacity of smallholder farmers' dairy production with crossbred dairy cattle was a common practice in the area (kelay, 2002).

3.1.1.2. An overview of the East Shewa Zone

East Shewa zone has an area about 14,050 km^2 that is divided into 11 districts and three administrative towns with estimated population of the zone was about 1,357,522 (economically active age group 15-64 was about 52.4%) and the average family size per household was about 5.2 person (CSA, 2007). The zone has an estimated livestock population of about 5.3 million and arable land of about 44.0% of the total area (OPEDB, 2000). Teff, maize, barley, sorghum, bean, pea, fruits, vegetables etc. are some of the widely cultivated crops in the zone (Eshetu, 2008).

3.1.1.2.1. Ada'a District

Ada'a is one of the 11 districts in East Shoa Zone, located about 45 km South-East of the capital, Addis Ababa and is very close to the other major urban centers like *Adama* and *Mojo*. The district covers an area of 1750 km^2, stretching East of the Bole International Air Port to the North-West of the *Koka* dam. The population in Addis *Ababa, Adama, Mojo* and *Debrezeit* create a large market for most agricultural commodities. There are 27 *kebele* administrations in *Ada'a* district in addition to 9 urban *kebeles* in *Debrezeit* municipality. The total population of *Ada`a* district is 131,273 (CSA, 2007).

The agro ecology of the district is suitable for diverse agricultural production. Crop and livestock production are the major sources of income and livelihoods of the people in the district. The district is nationally known for its best quality teff (*Eragrostis tef)* production, which dominates the agricultural production system, followed by wheat and pulses, especially chickpea (Eshetu, 2008). Production of cattle, sheep, goat, horse, donkey, mule and poultry are a very common practice and there is an existing market oriented production system. Information obtained from the district agricultural office revealed that the total livestock population of the district in 2007 was 291,539 of which both local and crossbred cows accounted 11.68%. The area is certainly the most developed milk shed of the country, providing most of the dairy products available in the market of Addis Ababa, the largest and most diversified market of Ethiopia (Eshetu, 2008).

3.1.2. An overview of the Amhara National Regional State (ANRS)

The ANRS is located in the north-western part of the country which is found between 90-130^0 45"North Latitude and 350-400^{0}30"East longitude. The total area of the region is approximately 170,752 Sq.Km. It has common boundaries with four National Regional States of the country namely Oromia in the South, Afar in the East, Tigray in the North, and Benshangul Gumez in the West. It also shares boundary with the neighboring country, the Sudan, in the west. Ethiopia's largest inland body of water, Lake Tana, which is the source of the Blue Nile river is located in this Region, as well as the Semien Mountains National Park, which includes the highest point in Ethiopia, Ras Dashan.

According to (CSA, 2007), the Amhara National Regional State has 11 zones and 108 districts with a population of 17,214,056 of whom 8,636,875 were men and 8,577,181 women; urban inhabitants number 2,112,220 or 12.27% of the population. With an estimated area of 159,173.66 square kilometers, this region has an estimated density of 108.15 people per square kilometer. For the entire Region 3,953,115 households were counted which results in an average of 4.3 persons to a household, with urban households having on average 3.3 and rural households 4.5 people. In Amhara National Regional State, the livestock population is estimated to be 13.37 million cattle, 8.68 million sheep, 5.18 million goats, 2.24 million donkeys, 0.12 million mules, 0.40 million horses, 0.05 million camels, and 14.05 million poultry (CSA, 2011).

3.1.2.1. An overview of the East Gojjam Zone

East Gojjam is a Zone in the Amhara National Regional State of Ethiopia. East Gojjam is named after the former province of Gojjam. It is bordered on the south by the Oromia National Regional State, on the west by West Gojjam, on the north by south Gondar, and on the east by south Wollo; the bend of the Abay River defines the Zone's northern, eastern and southern boundaries. Its highest point is *Mount Choqa* (also known as Mount Birhan). According to the Central Statistical Agency of Ethiopia (CSA, 2007), this Zone has a total population of 2,152,671 and increase of 26.68% over the 1994 census, of whom 1,066,094 are men and 1,086,577 women. It covers an area of 14,004.47 square kilometers with 213,568 or 9.92% are urban inhabitants. A total of 506,520 households were counted in this Zone, which results in an average of 4.25 persons to a household.

3.1.2.1.1. Dejen District (The Study Area)

The study was conducted in Dejen District, which is 210 km north of Addis Ababa, in East Gojjam Zone. Dejen is bordered on the south by *Abay River*, which separates it from Oromia National Regional State, on the west by *Awabel*, on the North West by *Enarj Enawga*, on the north by *Enemay* and on the East by *Shebel Berenta*. The District has about 25,398 hectares area coverage, which is divided in to three agro-ecological zones namely *dega* (41%) *woyena-dega* (31%) and *kola* (28%). According to the topographical classification, the area also has 49.3%, 38.8% and 11.83% of mountainous, plain, and valley, respectively. The area is situated at latitude of $10^{0}10^{''}$ N and longitude of $38^{0}09^{''}$ E with an altitude of minimum 1080 meters and maximum 2576 meters above sea level (DARDO, 2007). The average minimum and maximum annual temperature is 18^{0}C and 30^{0}C, respectively. The annual mean rainfall is 954.6 mm. The rainfall has bimodal distribution with long and short rainy seasons. Based on CSA (2007), this District has an estimated total population of 103,052 of whom 53,222 were females and 49,830 were males; 9,418 or 9.14% of its population are urban dwellers.

3.2. Study Design

A cross-sectional type of study was carried out to analyze milk value chain, to identify factors that determine the adoption of dairy technologies[2] and to analyze the impact of dairy technologies adoption on the livelihoods[3] of smallholder farmers. A semi-structured survey questionnaire, farm inspection, milk analysis, participatory rural appraisal (PRA) and secondary data sources were used to collect data. Econometrical models were specified and used to analyze different parameters both on dairy technology adoption and its impact on household livelihoods.

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2 For the sake of this study, households which adopted a crossbred heifer were considered as an adopter though the term dairy technology may encompass other components as a package.

3 Livelihoods comprise the capabilities, assets (including both material and social resources) and activities required for a means of living (Carney, 1998).

3.2.1. Sampling Procedures and Sample Size

The study regions were selected purposively based on the intensity of dairy technology adoption, which was delivered by Smallholder Dairy Development Program (SDDP) and distribution of crossbred dairy cattle.

One zone from Amhara National Regional State (East Gojjam Zone) and two zones from Oromia National Regional State (North Showa and East Showa zones) were selected. Cooperative areas (two from each zone) were selected randomly. In total, six cooperative areas namely *Shemeshengo* and *Yetenora* from ANRS and *Godino, Babogaya, Debretsigie* and *Torbenashie* from ONRS were selected. Multistage stratified sampling procedures were used to select farm households. The sampling frame involved those households owning dairy cattle as obtained from district Agriculture and Rural Development Offices. The farm households were categorized into dairy technology adopters and non-adopters based on having at least one crossbred cow or not and the ones having at least one lactating cow at the time of survey constituted sampling units.

Sample size was determined at 95% confidence interval and margin for random error of 5% by using a mathematical model as described by Fox *et al*. (2007).

$N = P\ (100\% - P)/\ (SE)^2$; $SE = MRE/1.96$

Where;

N = Sample size; **P** = Proportion of dairy technology adopter smallholder farmers; **SE** = Standard error; **MRE** = Margin for random error (5%) and 1.96 is tabular value for 95% confidence interval.

Accordingly, the total calculated sample size was 384. Systematic random sampling method was used to identify the study participants and the number of households selected from each cooperative area was proportionate to the size of the farm households of the area (Table 1).

Table 1: Distribution of interviewed household heads in the study areas

Regions	Cooperative areas	HHs in the study areas			Interviewed HHs		
		Non-Adopters	Adopters	Total HHs	Non-Adopters	Adopters	Total interviewed HHs
Oromia	Debretsigie	1078	128	1206	28	47	75
	Torbenashie	940	99	1039	24	36	60
	Godino	888	20	908	23	7	30
	Babogaya	1300	51	1351	34	19	53
Amhara	Shemeshengo	1344	88	1432	35	32	67
	Yetenora	1848	141	1989	48	51	99
	Total	7398	527	7925	192	192	384

3.2.2. Data Collection

3.2.2.1. Secondary data collection

The supplementary or retrospective data about dairy technology adopters and non adopters were gathered from reports and records of *Woreda* and Zonal Agriculture and Rural Development Offices and other relevant institutions in the study areas.

3.2.2.2. Questionnaire survey

Primary data were collected through a face to face interview with contact/sample household heads using a semi-structured questionnaire, which was prepared and pre-tested before its full implementation. The questionnaire was revised as per the outcomes of the test and interview was carried out by trained data collectors. The interviews were conducted after thoroughly explaining the purpose of the interview to the interviewees.

Questionnaire on milk value chain was focusing on input supply (feed production and distribution, milk containers, other physical inputs-labor), technical service provision (AI and health services, financial services), milk production, bulking and cooling, processing and marketing, price of milk per liter, selling place, distance from cooperative center, role of milk cooperatives, milk transport methods and milk utilization at home.

Milk production (average daily milk yield per cow and average milk yield per lactation stages) in the study areas was calculated based on the following mathematical equations.

Average daily milk yield per cow (ADMY/C) is defined as total milk produced on the day of observation (TMPDO) divided by the total number of lactating cows (TNLC).

Mathematically it is represented as; ADMY/C = TMPDO/TNLC………equ.3.1

Average milk yield per lactation (AMYL) is also defined as total milk production in all milking days of one lactation length (TMPADL) divided by the total number of lactating cows (TNLC).

Lactation length means it is the total number of days that a lactating cow could give milk starting from calving up to the first day of dry period which is estimated to be 315 days on average. This lactation length has three stages namely: early lactation stage (7 to 105 days); mid lactation stage (106 up to 210 days) and late lactation stage (211 to 315 days) (Mech *et al*., 2008). The average milk yield in each lactation stage was calculated by using the following formula.

Average Early Lactation Milk Yield (AELMY) = ((Average initial milk yield (AIMY) + Average milk yield at the day of observation (AMYDO))/2)*100…equ.3.2

Average Mid Lactation Milk Yield (AMLMY) = Average milk yield at the day of observation (AMYDO)*100………………………………………….equ.3.3

Average Late Lactation Milk Yield (ALLMY) = Average milk yield at the day of observation (AMYDO)* actual days of milking greater than 200…....equ.3.4

Questionnaire for improved dairy technology adoption focused on socio-economic characteristics (age, sex, household size, experience, and educational background), feed, livestock species composition, land holding, distance from the market center, dairy cooperative membership, training on animal production technologies, management practices (housing, breeding, disease management, recording, etc), constraints to milk production, access to milk market, extension service, credit and market information, constraints of crossbred dairy cows adoption and dairy cattle production. Questionnaire for assessing impacts of dairy technologies adoption focused on availability of food of animal origin for household consumption (AOF), total milk consumed per day at farm level (MCF), total milk sold per annum in liter (MSA), total income from milk and milk products (TIMMP), sending children to school (ASCS), hiring of labor for agricultural activities (AHLAA) and build new or renovate the existing family house (ABNFH).

3.2.2.3. Participatory Rural Appraisal (PRA)

Participatory rural appraisal (PRA) is an approach that involves local communities as active analysts of their own situations whereby they identify, estimate, quantify, compare, rank/score and list resources, constraints and opportunities based on their circumstances (Duguma *et al.*, 2010). This approach used different methods, however, in this study the "before" and "after" proportional piling tool (Catley, 1999) was used and a sample checklist, serving as a guide and consisting of the main points for the PRA interviews, was prepared and then pre-tested and adjusted accordingly prior to full implementation. The time-series approach was used to define the "before" and "after" time frame (Kirsopp- Reed, 1994 and Catley, 1999). The reference time used was the starting time of dairy technology utilization (crossbred cow).

There were a total of six PRA groups and each group had 8-10 members and 32% of the participants were females. All indicators for a particular parameter were written in the local languages on pieces of papers, each paper bearing one indicator. The papers were then placed separately on the ground. Then the informants were asked to divide a pile of beans seed among the indicators according to their prioritization, to score the "before" situation. Throughout the interviews beans seed were used for scoring, as these were/are common in the study areas and "visible" to the informants and easy to handle. "Factor change (FC)" method was used to compute the scores attributed for the "before" and "after" periods. The difference between the scores of the "before" and "after" periods were divided by the "before" value to obtain "Factor Change". "Factor Change" values indicated both the direction and magnitude of the changes.

A literate informant in the group was asked to read out these indicators from time to time to recall as they discuss and score. During the scoring of the "after" situation the informants were free to increase, decrease or leave the "before" pile of beans seed of an indicator, according to their perception for the "after" situation. The informants were also allowed to rearrange the piles until they all arrived at an agreeable result. Besides to this, group informants discussed to identify the major bottlenecks on dairy production and dairy technology uptake and to forward the possible opportunities to mitigate the problems. Onetime farm inspection was also practiced to assess the housing conditions, feeding and milking practices and available records.

3.2.2.4. Milk quality assessment

Collection of milk samples

Milk samples were collected from morning bulk tank milk at farm level before delivery to dairy cooperatives. Approximately 25 – 45 ml milk was collected from each sampling unit (households), as per the procedure described by O'Connor (1995), in to sterile containers and after thorough mixing. A total of 384 samples were taken for physico-chemical analysis that was done at field level and 80 milk samples were randomly taken for bacteriological analysis and somatic cell count. The samples were transported on ice box to the Ethiopian Meat and Dairy Technology Institute's microbiology laboratory, where they were analyzed on the same day.

Examination of milk samples

Physico-chemical characteristics of the milk samples were determined using milk analyzer (LACTOSCANS, LSS001, Bulgaria) at field level to determine milk constituents (fat, solid non-fat, protein, lactose and salt) and physical characteristics(density, temperature, adulteration and freezing point).

Total bacteria count (TBC), total Coliform count (TCC), and somatic cell count (SCC) were conducted following standard procedures cited by Francesconi (2006).

For Bacterial Count, using a sterile-standardized loop, 1 ml of milk sample was diluted with "Peptone Water" progressively to the levels 1/10, 1/100, 1/1000, 1/10000, 1/100000, 1/1000000, and 1/10000000. Dilution levels, 1/100 and 1/1000 were cultured in duplicate at first. Each culture was constituted of 1 ml of the diluted solution poured on a petridish, on which 12-15 ml of "Standard Plate Agar" was added. When the solution in the petridish solidifies, it was put in to incubator at 37°C for 48 hours, after which the number of bacterial colonies grown was counted. When the colonies were found to be too many, compromising the accuracy of counting, the same procedure was repeated using higher dilution levels.

The Coli form Count was the test used to estimates the number of bacteria that originate from manure or a contaminated environment. Milk samples were plated on Violet Red Bile Agar (VRBA) and incubated at 32°C for 48 hours, after which typical coli form colonies were counted.

The corresponding TCC and TBC were computed from duplicate plates containing between 25-250 colonies. Plates containing less than 25 colonies were taken as less than 25 estimated counts and plates containing greater than 250 colonies for all dilutions were recorded as too numerous to count (TNTC). For analysis purpose, only counts in the normal (25-250) were taken directly. When all plates counted less than 25, the nearest count to 25 was taken and when all plates counted greater than 250 colonies for all dilutions, the nearest colony count to

250 was taken APHA (1992). To avoid a fictitious impression of precision and accuracy when computing the counts, only the first two significant digits were reported by rounding up or down to the next number. The following formula was used to calculate the counts.

$$N = \frac{\sum C}{[(1 x n_1) + (0.1 x n_2)]\, d} \qquad \text{……equ 3.5}$$

Where:

N = Number of colonies per ml or g of product; $\sum C$ = Sum of all colonies on all plates counted; n_1 = Number of plates in first dilution counted; n_2 = Number of plates in second dilution counted; d = Dilution from which the first counts were obtained

Somatic Cells Count was conducted following the procedure described by Francesconi (2006). About 0.01 ml milk was spread homogeneously over a microscope slide by using a sterile-standardized loop. Once the milk layer has dried up, Ethanol 96% was added. After waiting for 15 minutes Tolouidin Blue 0.2% was added. The slide was then kept on open air for 5 minutes, after which it was washed with tap running water, dried and then observed by using a microscope at 100 times magnification. Somatic cells in twenty different fields (A) were counted. Given the dimension of the microscope zoom (F; in this case = 0.0346), the somatic cells count (N) is equal to: N= A x 10000 / F.

3.3. Statistical Analyses

The collected data were entered into Micro-soft-Excel and analyzed by SPSS (Statistical Package for Social Science (SPSS), version 17.00, 2006). Descriptive statistics were used to compute mean, standard deviation, frequency, ratio and percentage. Analysis of variance (ANOVA) and Post Hoc (Duncan) were used to determine the statistical difference of milk quality parameters among the different study areas. Pearson correlation and logistic regression were also used. The primary data generated on the determinants of dairy technology adoption and impact assessment were also subjected to an econometric analysis using an appropriate model in STATA, version 11. Multicollinearity and hetroscedasticity of the independent variables were tested using collinearity statistics (tolerance and VIF-variance inflation factors) and Breusch-pagan/Cook-Weisberg, respectively.

The empirical model used for milk quality analysis was:

$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \varepsilon_i.$

Where, Y_i is the dependent variable which is a milk quality parameter, X_1= family size, X_2= farm experience, X_3= parity number of cow, X_4= distance from dairy technology dissemination center, X_5= adulteration, X_6= educational status of households, X_7= feeding system, X_8= breed, β_0= constant(intercept), $\beta_1, \beta_2, \ldots, \beta_8$, = are coefficients ε_i= the error term.

3.4. Econometric Analysis

3.4.1. Theoretical framework

Methodological framework and selection of econometric model depended on the objectives and hypotheses to be tested and verified. In order to identify determinants of dairy technology adoption decision and level of adoption, a Heckman two-stage selection model was used. In selectivity models, the decision to adopt and adoption level can be seen as a sequential two-stage decision making process. In the first-stage, smallholder farmers make a discrete value decision whether or not to adopt the dairy technology. In the second-stage, conditional on their decision to adopt dairy technology, farmers make continuous decision on the intensity of adoption. In the first-stage, standard probit model was used. Prior to actual analysis employing the model, the explanatory variables were checked for being of multicollinearity. This situation occurs when the explanatory variables display little variation and/or high inter-correlation (Maddala, 1992). Heteroskedasticity-robust test was used for exclusion Restrictions condition (Wooldridge, 2002)

Variance Inflation Factor (VIF) for association between the continuous explanatory variables and Contingency Coefficients (CC) for dummy explanatory variables were used to measure multicollinearity. The highest the value of VIF (X_i) the more difficult or collinear the variable X_i is. As a rule of thumb, if the VIF of an explanatory variable greater than 10, there is a multicollinearity problem. Similarly the decision rule for contingency coefficients states that values less than 0.75 mean there is no problem of multicollinearity whereas when the contingency coefficient approaches 1, it indicates that there is a problem of multicollinearity between the discrete variables (Gujarati, 2004; Berhanu, 2012). Hetroscedasticity also tested using Breusch-pagan/Cook-Weisberg in STATA software.

Impact evaluations also rely on econometric and statistical models. There are three main kinds of impact evaluation designs. These are experimental, quasi-experimental and non-experimental which are respectively associated with control groups, comparison groups, and non-participants. Impact Evaluation (IE) rigorously measures the impact that a project has on beneficiaries. It typically does this by comparing outcomes between beneficiaries and a control group (AIEI, 2010). Since the data for this study were obtained from survey, non-experimental impact evaluation design was preferred and analyzed using Propensity Scores Matching (PSM).

Propensity-score matching is a non-experimental method for estimating the average effect of social programs (Rosenbaum and Rubin, 1983; Heckman *et al*., 1998). The method compares average outcomes of participants and non-participants, conditioning on the propensity score value. The parameter of interest is the average treatment effect and has focused on strong identification conditions.

In order to make causal inferences, random selection of subjects and random allocation of the treatment to subjects is required. In observational studies random assignment to treatments is impossible. The primary limitation of an observational study is that there may be random selection of subjects but not random allocation of treatments to subjects. When there is a lack of randomization, casual inferences cannot be made because it is not possible to determine whether the difference in outcome between the treated and control (untreated) subjects is due to the treatment or differences between subjects on other characteristics. Subjects with certain characteristics may be more likely to receive treatment than others.

There were some steps in the estimation of average treatment effect using propensity score matching method. First, the propensity score was estimated using a choice model. To estimate the participation probability, logit model estimated using a maximum likelihood method Etimation (MLE) was used due to the consistency of parameter estimation associated with the assumption that error term v in the equation has a logistic distribution (Ravallion, 2001). In the second step, matching algorithm was selected based on the data at hand after undertaking matching quality test. In the third stage, overlap condition or common support condition was identified. In the fourth stage, the treatment effect was estimated based on the matching estimator selected on the common support region (Owusu and Awudu, 2009).

3.4.2. Analytical model

Generally, there were two hypotheses related to dairy technology adoption (crossbred cows). The first hypothesis was that different socio–economic characteristics may affect both the decision making of dairy technology (crossbred cows) adoption and then intensity of adoption (number of crossbred cows), in this case both dairy technology adoption and intensity of adoption were endogenous. The second hypothesis was that adopting dairy technology has a positive impact on the smallholder livelihoods which was measured by different livelihoods impact indicators (availability of animal origin food for household consumption (AOF), total milk consumed per day at farm level (MCF), total milk sold per annum in liter (MSA), total income from milk and milk products (TIMMP), allow to send children to school (ASCS), allow to hire labor for agricultural activities (AHLAA) and allow to build new or renovate the existing family house (ABNFH). In this case decision making on dairy technology adoption was modeled as a binary exogenous variables.

Variable Definition and Hypotheses

The data were covering information necessary to make farm level indices of social-economic characteristics, milk production, processing and marketing and factors of dairy technology adoption and its impact on the household livelihoods in the study areas. Both continuous and discrete variables were used on economic theories and findings of different empirical studies. Accordingly, in order to investigate the research questions of this study, the following variables were constructed.

Dependent variables: Though a dairy technology transferred as a package, adopting a crossbred heifer/cattle adoption was taken as a proxy for adopters in this study. For the household which adopts dairy technology, the variable takes on the value of one; and value of zero for the household which does not.

Adoption of Crossbred heifer/cattle (ACBC) representing the decision to adopt: Is modeled as a dummy variable that represents the probability of the household adopting crossbred heifer or not. For the household which adopts at least one crossbred heifer, the variable takes the value of one, otherwise zero.

Number of crossbred cattle (NCBC) representing the intensity of adoption: It is the continuous variable which represents the intensity of adoption of dairy technologies (crossbred heifer/cattle).

Impact of Dairy Technology Adoption (IDTA): was a dummy variable representing the probability of the household benefitting from dairy technology or not. Those benefits or impact indicators that were examined included availability of animal origin food for household consumption (AOF), total milk consumed per day at farm level (MCF), total milk sold per annum in liter (MSA), total income from milk and milk products (TIMMP), able to send children to school (ASCS), hires labor for agricultural activities (AHLAA) and builds a new or renovates the existing family house (ABNFH).

Independent (Explanatory) Variables: Independent variables are variables that stand alone and are not changed by the other variables but cause change in the dependent Variable/s. The independent variables used in this study are described as follows.

Sex of the household head (GENDER): This was a dummy variable that took a value of one if the household head was male and zero otherwise. Male farmer heads were expected to adopt dairy technology more than female headed. Male farmers had more access and exposure to get the information about the dairy technology and they were making decision to adopt than what female farmers were doing.

Family size (FS): It is a continuous variable. As dairying was/is labor intensive: dairy production, in general and marketable surplus of dairy products in particular, is a function of labor. Accordingly, household with more family members tended to have more labor and to adopt dairy technology than household with less family members which in turn increased milk production and then milk market participation of the households. Howley *et al*. (2012) showed that farmers with children were much more likely to use dairy technology in a given period.

Distance to Market Center (DMC): Is location of the farm household from the nearest milk market and was measured in kilometer**.** The farthest the market distance the least the dairy technology could be happened because the closer the milk market to farm household, the lesser would be the transportation charges and loss due to spoilage, and better access to market information and facilities. This improved return to labor and capital; increased farm-gate price and incentive to participate in dairy technology adoption.

Distance from Agricultural Development Center (DADC): It is a continuous variable and measured in kilometer. The Agricultural Development Center (ADC) was/ is usually strategically located within the farming areas and it is the place where the local extension worker was/is stationed. As distance from the agricultural development center (DADC) increases, livestock technology adoption decreases because this causes transport cost incurred in obtaining information on technologies and inputs to increase. A study showed that farmers are less likely to adopt the livestock technologies as the distance increases from the ADC (Rezvanfar, 2007).

Education Level of the Household Head (ELHH): It was a dummy variable that took a value of one if the household head was educated and zero otherwise. Education plays an important role in the adoption of innovations/new dairy technologies. Further, education was/is believed to improve the readiness of the household to accept new ideas and innovations, and get updated demand and supply price information which in turn enhances producers' willingness to produce more and increase milk market entry decision and volume of sale. Quddus (2013) reported that adoption of dairy technology is positively associated with the level of farmer's education.

Age of the Household Head (AHH): It is a continuous variable measured in years. AHH also was expected to affect the dairy technology adoption. It was hypothesized that there was/is an indirect relationship between age of household heads and dairy technology adoption. As the age of the household head increased, the probability of adoption decreased because they were/are inactive to participate in the new technology dissemination process, most likely due to being more influenced by culture. The report by Quddus (2013) stated that the probability of adoption decreased with the increase of age of household heads.

Off-farm activity participation (OFAP): It is a dummy variable that took a value of one if the household head participated in an off-farm activity and zero otherwise. OFAP was/is expected to affect dairy technology adoption. A household head farmer who has an access to off-farm employment has a positive effect on adoption of dairy technologies. This entails that increased access to off-farm employment can lead to increased adoption of dairy technologies. One explanation for this result was/is that income from off-farm activities provides supplemental income to finance technology expenditures, for example: purchase of salt block, urea, mineral lick, hay and small tools for dehorning and castration and even to the extent of buying crossbred heifers.

Land holding (LH): It is a continuous variable and measured in hectares. It was hypothesized that there was/is a direct relationship between the size of land held by farm households and dairy technology adoption. Farmers with less land were expected not to be willing to adopt a dairy technology since they were thinking that the technology needs more land for forage production.

Access to credit service (ACS): Access to credit was measured as a dummy variable taking a value of one if the household has access to credit and zero otherwise. This variable was/is expected to influence the dairy technology adoption because of the very high initial investment cost which households may not afford easily. Credit relaxes the financial constraint of the household to invest on dairying. The finding of Muzari *et al.* (2012) stated that the major option for increased adoption of technology is to overcome the income/ capital constraint through increased credit provision.

Access to Dairy Production Extension Service (ADPES). This variable was measured as a dummy variable taking a value of one if the farm household had access to dairy production extension service and zero otherwise. It was/is expected that ADPES affect dairy technology adoption. A household head who had/has access to dairy production extension service was/is more prone for technology adoption than those who had/ has no access. Extension service widens the household's knowledge with regard to the use of improved dairy production technologies which leads to adopt more. The finding of Amelaku *et al*. (2012) revealed that the probability of adopting dairy technology increases by 43% for at least a onetime visit by the extension service per year.

Farming experience: It is a continuous variable measured in years. It refers to the number of years that the smallholder farmer practiced farming activity after the dairy technology transferred to the area. It was hypothesized that there was/is a direct relationship between the farming experience and dairy technology adoption. Farmers with high farming experience were expected to be willing to adopt a dairy technology since they were getting information about the advantages of dairy technology through different ways.

3.4.2.1. Econometric analyses of determinants of dairy technology adoption

Both determinants of dairy technology adoption and intensity of adoption were analyzed by using survey data. The specifications of the empirical models used to identify these determinants followed the selectivity models as widely discussed by Bellemare and Barrett, (2006) and Berihanu (2012). In selectivity models, the decision to dairy technology adoption can be seen as a sequential two-stage decision making process. In the first-stage, smallholder farmers make a discrete decision whether or not to adopt the dairy technology. In the second-stage, conditional on their decision to adopt, smallholder farmers make a continuous decision on the level of adoption.

In the first-stage, the standard probit model was used, which follows random utility model and specified as described by Wooldridge (2002).

$$Y^* = Z'\alpha + \varepsilon_1$$
$$Y = 1 \text{ if } Y^* > 0$$
$$Y = 0 \text{ if } Y^* \leq 0 \text{……………………………………………………………………………..} equ3.6$$

Where,

Y^* = is a latent (unobservable) variable representing farmer`s discrete decision whether to adopt or not

Z' = is a vector of independent variables hypothesized to affect farmer`s decision to adopt dairy technology

α = is a vector of parameters to be estimated which measures the effects of explanatory variables on the farmer`s decision

ε_1 = is normally distributed disturbance with mean (0) and standard deviation of δ_1, and captures all unmeasured variables

Y = is a dependent variable which takes on the value of 1 if the farmers adopt a dairy technology and 0 otherwise.

Since the probit parameter estimate does not show by how much a particular variable increases or decreases the likelihood of adoption of dairy technology, marginal effects of the independent variables on the probability of a smallholder farmer to adopt dairy technology were considered. For continuous independent variables, the marginal effects were calculated by multiplying the coefficient estimate α by the standard probability density function by holding the other independent variables at their mean values. The marginal effects of dummy independent variables were analyzed by comparing the probabilities of that result when the dummy variables take their two different values (1 if adopt dairy and 0 otherwise) while holding all other independent variables at their sample mean values (Wooldridge, 2002).

Finally, the log likelihood function which was maximized to obtain parameter estimates and corresponding marginal effects were given as:

$$Ln\ L\left(\frac{\alpha}{Y}, Z\right) = \sum_{y-1} ln\,(\Phi(Z'\alpha) + \sum_{y-0} ln(1-\Phi(Z'\alpha)) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots equ3.7$$

Conditional on adoption decision, the variables determining intensity of adoption were modeled using the second-stage Heckman selection model (Heckman, 1979). The Heckman selection equation was/is specified as:

$$Z_i^* = W_{i'\alpha} + \varepsilon_2$$
$$Z_i = Z_i^* \text{ if } Z_i^* > 0$$
$$Z_i = 0 \text{ if } Z_i^* \leq 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots equ3.8$$

Where,
Z_i^* = latent variable representing the desired or optimal level of adoption which is observed if $Z_i^* > 0$ and unobserved otherwise

Z_i = is the observed level of adoption

W_i = vector of covariates for unit i for selection equation which is a subset of Z'

α = vector of coefficients for selection equation

ε_2 = random disturbance for unit i for selection equation

One problem with the two equations (3.6 and 3.8) was that the two-stage decision making processes were not separable due to unmeasured farmer variables determining both the discrete and continuous decision thereby leading to the correlation between the errors of the equations. If the two errors were correlated, the estimated parameter values on the variables determining the level of adoption was biased (Wooldridge, 2002). Thus, we were required to specify a model that corrects for selectivity bias while estimating the determinants of the level of adoption. For this purpose, in the first-step, Mills ratio was created using predicted probability values obtained from the first-stage probit regression of the adoption decision. Then, in the second-step, we included the Mills ratio as one of the independent variables in the level of adoption regression. Thus, the level of adoption equation with correction for sample selection bias became:

$$V = W_i\alpha + \lambda\left(\frac{\phi(W_i\alpha)}{\Phi(W_i\alpha)}\right) + \varepsilon_3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots equ3.9$$

Where,

$\phi(.)/\Phi(.)$ = was the Mills ratio

λ = was the coefficient on the Mills ratio

ϕ = denoted standard normal probability density function

Φ = denoted the standard cumulative distribution function

ε_3 = was not correlated with ε_1, ε_2 and other independent variables. Under the null hypothesis no sample selection bias λ was not significantly different from zero.

V = was the level of adoption (number of crossbred cows)

3.4.2.2. Econometric analyses of dairy technology impacts on smallholder livelihoods

Propensity score matching (PSM) 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 nonparticipants. 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: (a) conditional independence (namely, that unobserved factors do not affect participation) and (b) sizable common support or overlap in propensity scores across the participant and nonparticipant samples (Khandker *et al.*, 2010).

The first step in PSM was to determine the propensity score and satisfy the balancing property. It was done using the “pscore” command in Stata. After obtaining the predicted probability values conditional on the observable covariates (the propensity scores) from the binary estimation, matching was done using a matching algorithm that was selected based on the data at hand.

Even though different approaches were used to match adopters and non-adopters on the basis of the propensity score, choice of matching estimator was decided based on the balancing qualities of the estimators. According to Dehejia and Wahba (2002), the final choice of a matching estimator was guided by different criteria such as equal means test referred to as the balancing test, pseudo-R^2 and matched sample size. Balancing test is a test conducted to know whether there is statistically significant difference in mean value of per-treatment characteristics of the two groups of the interviewed household heads and preferred when there is no significant difference. Accordingly, matching estimators were evaluated via matching the adopters and non-adopters households in common support region. Therefore, a matching estimator having balanced (insignificant mean differences in all explanatory variables) mean, bears a low pseudo-R^2 value and also the one that results in large matched sample size was preferred (Alemu, 2010). Then the effect of household’s participation in dairy technology adoption on a given outcome (availability of animal origin food for household consumption, total milk consumed per day at farm level, total milk sold per annum in liter, total income from milk and milk products, allow to send children to school, allow to hire labor for agricultural activities and allow to built new or renovate the existing family house) (Y) was specified as:

$$\tau_i = Y_i(D_i = 1) - Y_i(D_i = 0) \qquad \text{equ3.10}$$

Where τ_i was treatment effect (effect due to adoption of dairy technology), Y_i was the outcome on household head i, D_i whether household head i had got the treatment or not (i.e., a household head adopt dairy technology or not). However, one should note that Y_i (D_i = 1) and Y_i (D_i =0) cannot be observed on the same household head at the same time. Depending on the position of household head in the treatment (adoption), either Y_i (D_i = 1) or Y_i (D_i =0) was unobserved outcome (called counterfactual outcome). Due to this fact, estimating individual treatment effect τ_i was not possible and one had to shift to estimating the average treatment effects of the population than the individual one. Most commonly used average treatment effect estimation was the average treatment effect on the treated (τ_{ATT}), and specified as:

$$\tau_{ATT} = E(\tau|D = 1) = E[Y(1)|D = 1] - E[Y(0)|D = 1] \text{……………………..equ3.11}$$

As the counterfactual mean for those being treated, $E[Y(0)|D = 1]$ was not observed, one had to choose a proper substitute for it in order to estimate the average treatment effect (ATT). One might have thought to use the mean outcome of the untreated individuals, $E[Y(0)|D = 0]$ as a substitute to the counterfactual mean for those being treated, $E[Y(0)|D = 1]$. However, this was not a good idea especially in non-experimental studies. Because, it was most likely that components which determined the treatment decision also determined the outcome variable of interest.

In this particular case, variables that determined household's decision to participate in the dairy technology adoption might have also affected availability of animal origin food for household consumption, total milk consumed per day at farm level, total milk sold per annum in liter, total income from milk and milk products, allow to send children to school, allow to hire labor for agricultural activities and allow to built new or renovate the existing family house. Therefore, the outcomes of individuals from treatment and comparison group would have differed even in the absence of treatment leading to a self-selection bias.

By rearranging, and subtracting $E[Y(0)|D = 0]$ from both sides, one can get the following specification for ATT.

$$E[Y(1)|D=1] - E[Y(0)|D=0] = \tau_{ATT} + E[Y(0)|D=1] - E[Y(0)|D=0] \ldots .equ3.12$$

Both terms in the left hand side are observables and ATT can be identified, if and only if $E[Y(0)|D=1] - E[Y(0)|D=0] = 0$. i.e., when there is no self-selection bias. This condition can be ensured only in social experiments where treatments are assigned to units randomly (i.e., when there is no self-selection bias). In non-experimental studies one has to introduce some identifying assumptions to solve the selection problem. The following were two strong assumptions to solve the selection problem.

1. Conditional Independence Assumption:

Given a set of observable covariates (X) which were not affected by treatment (adoption participation), potential outcomes (household income, number of hired laborers employed; availability of animal source food at house hold level; rate of sending children to school; and to build new or renovate the existing family house) were independent of treatment assignment (independent of how adoption participation decision was made by the household).This assumption implied that the selection was solely based on observable characteristics, and variables that influence treatment assignment (adoption participation decision was made by the household) and potential outcomes (household income, number of hired laborers employed; availability of animal source food at house hold level; rate of sending children to school; and to build new or renovate the existing family house) were simultaneously observed.

2. Common support:

This assumption ruled out perfect predictability of D given X. That was

$$0 < P(D = 1| X) < 1$$

This assumption ensured that persons with the same X values had a positive probability of being both participants and non-participants.

Given the above two assumptions, the PSM estimator of ATT was written as:

$$\tau_{ATT}^{PSM} = E_{P(X)|D=1}\{E[Y(1) \mid D = 1, P(X)] - E[Y(0) \mid D = 0, P(X)]\} \ldots equ3.13$$

Where P(X) was the propensity score computed on the covariates X. Equation (3.13) was explained as; the PSM estimator was the mean difference in outcomes over the common support, appropriately weighted by the propensity score distribution of participants.

4. RESULTS

4.1. Demographic Characteristics of Interviewed Farm Households in the Study Areas

Demographic characteristics of the interviewed farm households are presented in Table 2. As shown, 14.6% of the interviewed household heads were under 31 years of age and 50% were found in the age interval of 31 to 50. Only 35.4 % were greater than 50 years of age. One hundred six (27.6 %) were female household heads of which most (83%) were from Oromia National Regional State. Large majority (98.7%) of the interviewed household heads had basic education and above. Farming experiences also varied among the study areas. Nearly 50% had greater than twenty years farming experience followed by 28.1% which were in 11-20 years farming experience category whereas the remaining 20.8% were less than eleven years farming experience. In the study areas the interviewed household heads had different family size with the overall mean value of 6.1 persons. About 50% of the interviewed household heads had four to six family members followed by 37 % with the family members of greater than six whereas 11.5% of the interviewed household heads had one up to three family members.

4.2. Livestock Ownership

The size and composition of livestock owned by the interviewed household heads is presented in Table 3. The overall average number of livestock owned by the respondent farmers was 10.64 which is equivalent to 5.94 tropical livestock units (TLU). Cattle were the predominant species representing 86.8% of the total TLU followed by donkey (7.4 %). Goat species was representing the smallest proportion of the total livestock composition (0.09 % in TLU).

Table 2: Demographic characteristics of smallholder farmers in Amhara and Oromia National Regional States (N=384)

	Debretsigie	Torbenashie	Godino	Babogaya	Shemeshengo	Yetenora	Total
Age							
≤ 30 yrs	12(21.4)	6(10.7)	11(19.6)	9(16.1)	6(10.7)	12(21.4)	56
31 – 40 yrs	13(17.1)	16(21.1)	5(6.6)	9(11.8)	13(17.1)	20(26.3)	76
41 – 50 yrs	15(12.9)	14(12.1)	6(5.2)	15(12.9)	26(22.4)	40(34.5)	116
≥ 51 yrs	35(25.7)	24(17.6)	8(5.9)	20(14.7)	22(16.2)	27(19.9)	136
Sex of respondents							
Female	23(21.7)	14(13.2)	18(17.0)	33(31.1)	5(4.7)	13(12.3)	106
Male	52(18.7)	46(16.5)	12(4.3)	20(7.2)	62(22.3)	86(30.9)	278
Educational level							
Illiterate	0	0	0	0	2(40)	3(60)	5
Basic education	31(17.8)	34(19.5)	16(9.2)	23(13.2)	27(15.5)	43(24.7)	174
Elementary	14(12.1)	18(15.5)	7(6.0)	15(12.9)	26(22.4)	36(31.0)	116
Junior	8(24.2)	5(15.2)	1(3.0)	8(24.2)	5(15.2)	6(18.2)	33
≥Secondary	22(39.3)	3(5.4)	6(10.7)	7(12.5)	7(12.5)	11(19.6)	56
Farming experience							
≤ 10 years	25(31.2)	12(15.0)	13(16.2)	9(11.2)	7(8.8)	14(17.5)	80
11-20 years	22(20.4)	14(13.0)	12(11.1)	11(10.2)	20(18.5)	29(26.9)	108
≥21 years	28(14.3)	34(17.3)	5(2.6)	33(16.8)	40(20.4)	56(28.6)	196
Family size							
1-3	8(18.2)	9(20.5)	4(9.1)	8(18.2)	5(11.4)	10(22.7)	44
4-6	40(20.2)	22(11.1)	14 (7.1)	18(9.1)	41(20.7)	63(31.8)	198
≥ 7	27(19.0)	29(20.4)	12(8.5)	27(19.0)	21(14.8)	26(18.3)	142

Numbers in the bracket are standard errors

Table 3: Livestock herd size and composition in tropical livestock unit of interviewed household heads (N = 384) in the study areas

Livestock species	Total number of animals	Mean number of animals per HHs	Total TLU	Mean TLU per HHs
Cattle	2445	6.36	1980.5	5.15
Horse	39	.10	31.2	.08
Donkeys	467	1.22	168.1	.44
Sheep	1112	2.90	100.1	.26
Goats	23	0.06	2.1	.01
Total	**4086**	**10.64**	**2282**	**5.94**

4.2.1. Number of lactating cows in the study farms

Totally, there were more than six hundred lactating cows during the study period, of which 56.7 % and 43.3% were local and crossbred cows, respectively. *Debretsigie and Babogaya* owned more crossbred lactating cows per household heads (Table 4).

Table 4: Distribution of breeds and lactating cows in the study areas

Study areas	No. HHs	Local lactating cows	Crossbred lactating cows	Total lactating cows
Debretsigie	75	64(41.3)	91(58.7)	155
Torbenashe	60	79(71.2)	32(28.8)	111
Godhino	30	26(24.3)	09(25.7)	35
Babogaya	53	45(50.0)	45(50.0)	90
Shemshengo	67	53(61.6)	33(38.4)	86
Yetenora	99	77(59.2)	53(40.8)	130
Total	384	344(56.7)	263(43.3)	607

Numbers in bracket are percentages along the rows

4.2.2. Number of lactating cows and average milkyield per cow by major factors influencing technology adoption

Table 5 shows that average daily milk yield per cow was significantly (P<0.05) higher in female headed farms than the male headed ones. Educational level also had a positive significant (P<0.01) effect on both mean number of lactating cows and average daily milk yield per cow. Among the interviewed household heads 40% had greater than six family members which were found also to have a positive significant (P<0.05) correlation with both mean number of lactating cows and average daily milk yield per cow. Family size also has a positive significant (P<0.01) effect on both mean number of lactating cows and average daily milk yield per cow.

4.2.3. Number lactating cows and average daily milkyield per cow by study region and study areas

The average number of lactating cows and average daily milk yield per cow of the Oromia National Region State were significantly (P<0.01) higher than those of the Amhara National Region State (Table 6). There was a significant (P<0.01) variation on both mean number of lactating cows and average day milk yield per cow among different study areas. *Debretsigie, Torbenashie* and *Babogaya* were the study areas with higher number of lactating cows during the study period. Adoption status was also found to have a positive significant (P<0.01) correlation with both mean number of lactating cows and average daily milk yield per cow.

Table 5: Number of lactating cows and average milkyield in selected areas of Amhara and Oromia National Regional States (N=384 smallholders)

Factors	No. of interviewed HHs	Mean number of lactating cows / HHs	ADMY/C
Age		NS	NS
≤ 30 years	56	1.71(.134)	4.80(.697)
31 – 40 years	76	1.59(.105)	3.24(.368)
41 – 50 years	116	1.50(.082)	3.37(.280)
≥ 51 years	136	1.60(.072)	3.64(.311)
Sex of respondent		NS	**
Female	106	1.70(.095)	4.39(.456)
Male	278	1.54(.051)	3.37(.191)
Educational level		***	***
Illiterate	5	1.00(.000)	0.65(.150)
Basic education	174	1.49(.063)	2.67(.203)
Elementary	116	1.59(.067)	3.67(.329)
Junior	33	1.42(.107)	3.76(.588)
Secondary and above	56	2.02(.179)	6.85(.662)
Farm experience		NS	***
≤ 10 years	80	1.66(.094)	4.58(.541)
11-20 years	108	1.65(.095)	3.92(.396)
≥21 years	196	1.52(.061)	3.12(.191)
Family size		**	***
1-3	44	1.27(.105)	2.03(.285)
4-6	198	1.57(.060)	3.73(.297)
≥ 7	142	1.70(.082)	4.04(.269)
Land holding		***	***
≤ 1 ha	122	1.77(.094)	4.34(.370)
1- 2 ha	110	1.40(.073)	2.48(.317)
≥ 2 ha	152	1.57(.066)	3.93(.275)

***: denotes P < 0.01, **: denotes P < 0.05, *: denotes P < 0.1; ADMY/C = Average daily milk yield per cow; NS: not significant

Table 6: Distribution of lactating cows and average daily milkyield per cow in the study areas (N=384 smallholders)

Factors	**No. of interviewed HHs**	**Mean number of lactating cows/ HHs**	**ADMY/C**
Region		***	***
Amhara	166	1.30(.046)	2.55(.180)
Oromia	218	1.79(.069)	4.49(.289)
Total	384	1.58(.046)	3.65(.188)
Study sites		***	***
Debretsigie	75	2.08(.140)	5.27(.445)
Torbenashie	60	1.87(.116)	3.05(.290)
Godino	30	1.16(.065)	4.02(.856)
Babogaya	53	1.72(.136)	5.36(.782)
Shemeshengo	67	1.28(.073)	2.45(.285)
Yetenora	99	1.31(.059)	2.62(.233)
Total	384	1.58(.045)	3.65(.189)
Adoption status		***	***
Non-adopters	192	1.38(.049)	1.48(.871)
adopters	192	1.79(.074)	5.82(.291)
Total	384	1.58(.045)	3.65(.188)

***: denotes P < 0.01; ADMY/c = Average daily milk yield per cow

4.3. Milk Production and Utilization

4.3.1. Milk production

Table 7 illustrates that milk production was affected by different exogenous variables namely: lactation stages (early, mid and late) and breed (local and crossbred). Both average daily milk yield per cow (ADMY/C) and average milk yield per lactation stage (AMYLs) were highest at early lactation stage for both local and crossbreds than at mid and late lactation milk yields (Table 7). Smallholder farmers who owned crossbred cows produced significantly (P<0.01) higher ADMY/C and AMYLs milk yield in all lactation stages than those who owned local breed cows.

Table 7: Milk production at different stages of lactation in the study areas

Milk yield	Lactation stages		
	Early lactation	Mid lactation	Late lactation
ADMY/C	***	***	***
Local breed	2.34(0.12)	1.92(0.13)	0.91(0.05)
Crossbred	11.44(1.02)	6.79(0.27)	4.19 (0.31)
AMYLs	***	***	***
Local breed	216.34(11.5)	192.39(13.1)	44.61(4.5)
Crossbred	1125(100.7)	679.76(42.7)	115.59(11.6)

Figures in bracket are standard errors

Average daily milk yield per cow (ADMY/C) of local and crossbreed cows was significantly (P<0.01) different among the study areas. *Torbenashe* (2.64 litres) and *Debretsegie* (2.49 liters) were the higher average daily milk yield per lactating local cow`s registered in the areas. Whereas *Shemishengo* (1.57 liters) and *Yetenora* (1.69 liters) were the low average daily milk yield per lactating local cow producers. The higher average daily milk yield per lactating crossbred cow was produced from *Babogaya* (12.31), *Godehino* (10.69) and *Debretsegie* (9.13) all from Oromia National Region State whereas *Shemishengo* (5.90 liters) and *Yetenora* (5.80 liters) were the low average daily milk yield producers (Table 8).

Table 8: Average daily milkyield per cow in the study areas

Study areas	ADMY/C	
	Local breed	Crossbred
	***	***
Debretsegie	2.49(0.17)[b]	9.13(0.55)[b]
Torbenashe	2.64(0.15)[b]	6.36(0.75)[a]
Godino	1.71(0.14)[a]	10.69(1.92)[bc]
Babogaya	1.87(0.14)[a]	12.31(0.98)[c]
Shemshengo	1.57(0.10)[a]	5.90(0.44)[a]
Yetenora	1.69(0.09)[a]	5.80(0.34)[a]

***: significant at (P<0.01); Numbers in the barenthesis are standered erorrs; data with the different supscript letters along a column is significantly different; ADMY/C: average daily milk yield per cow.

4.3.2. Milk utilization

Raw milk utilization was assessed using the data obtained through survey questionnaire. Four raw milk utilization categories namely: giving to neighbors, household consumption, processing to milk products and selling as raw milk were cited. The frequency of giving raw milk to neighbors was nil or very minimal in the study areas. In *Torbenashe, Shemishengo* and *Yetenora* areas, the practice of giving milk to neighbors was totally absent. Generally, very small amount of raw milk (0.45% of the total daily milk yield) was given to neighbors.

Raw milk consumption at home was influenced by physical location of the farms, amount of milk produced and market accessibility for fresh milk, among other factors. About 89%, 5.8% and 4.5% of the total daily milk yield was sold, consumed at home as raw milk and processed in to other products, respectively. The proportion of daily milk yield destined to market represented 92.7% in *Debretsegie,* 85% in *Yetenora* and 81% in *Godihino* (Fig.2). When it was observed in Regional wise, the Oromia National Regional State had a good market access to raw milk (87.75% of total raw milk per day was sold). Whereas, in Amhara National Regional State, about 86% was sold but almost all of this was processed at the cooperative level in to butter and other milk products because of weak raw milk market access in the area. Sometimes, even butter and cheese were shared back among producers at a reduced price when there was no buyer for these products.

There was also a significant difference ($P < 0.01$) in milk consumption, processing and selling between smallholder farmers who owned crossbred cows and local cows. Farmers who owned crossbred cows produced, consumed, processed and sold more milk per day than smallholder farms owning local cows (Table 9).

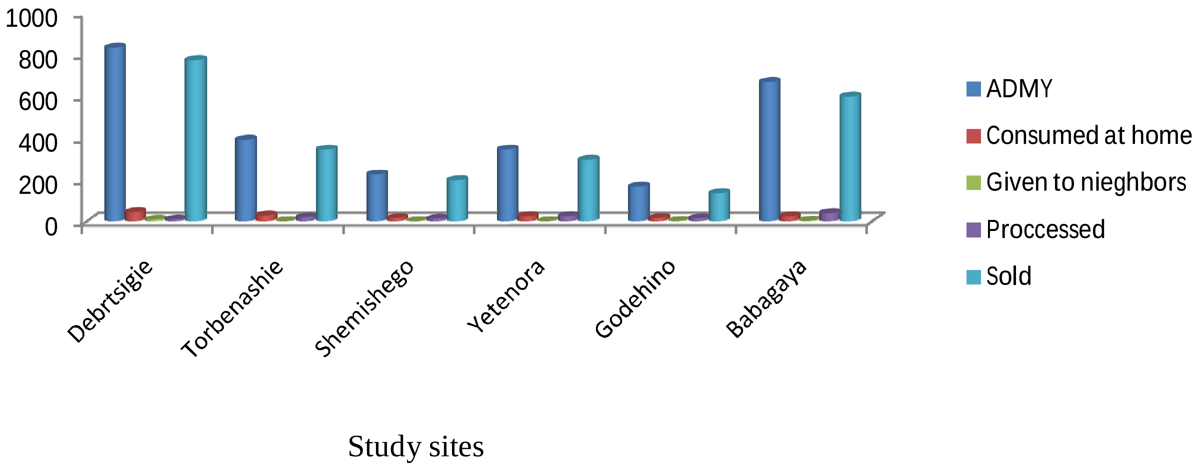

Figure 2: Raw milk utilization status in the study areas

Table 9: Average daily milkyield and milk use categories in smallholder farms owning crossbreed and local cows in the study areas

Breed types	Number of HHs	Average daily milk yield	Consumed at home per day (liter)	Giving to neighbors per day (liter)	Kept for processing (liter)	Sold as liquid milk per day (liter)
		***	***	NS	***	***
Local cows	216	2.55(.309)	0.29(.033)	0.02(.009)	0.42(.052)	1.80(.306)
Crossbred cows	168	12.34(1.064)	0.52(.049)	0.04(.036)	0.16(.048)	11.61(1.05)
Total	384	6.83(.555)	0.40(.029)	0.03(.017)	0.31(.036)	6.10(.550)

***: Significant at (P<0.01); NS: Non Significant; Numbers in the brackets are standered erorrs

4. 4. Milk Marketing

4. 4.1. Milk marketing system and infrastructure

In the study areas, raw milk is marketed through both formal and informal systems. The informal marketing channel practiced both direct and indirect sales to consumers. In direct transactions, producers sold directly to final consumers at the farm level, to their immediate neighborhoods or nearby towns. Producers also sold indirectly to consumers through itinerant traders and catering institutions such as coffee houses, cafeteria, hotels and restaurants. The formal marketing channel which involved in indirect sales of milk to consumers was dominated by the dairy cooperatives which functions as a milk collector, milk quality control or processor and wholesaler. In some areas these dairy cooperatives have milk-collection centers located within the near vicinity of the milk producers. The established marketing channels in the study areas are illustrated in Fig.3 which shows both formal and informal channels

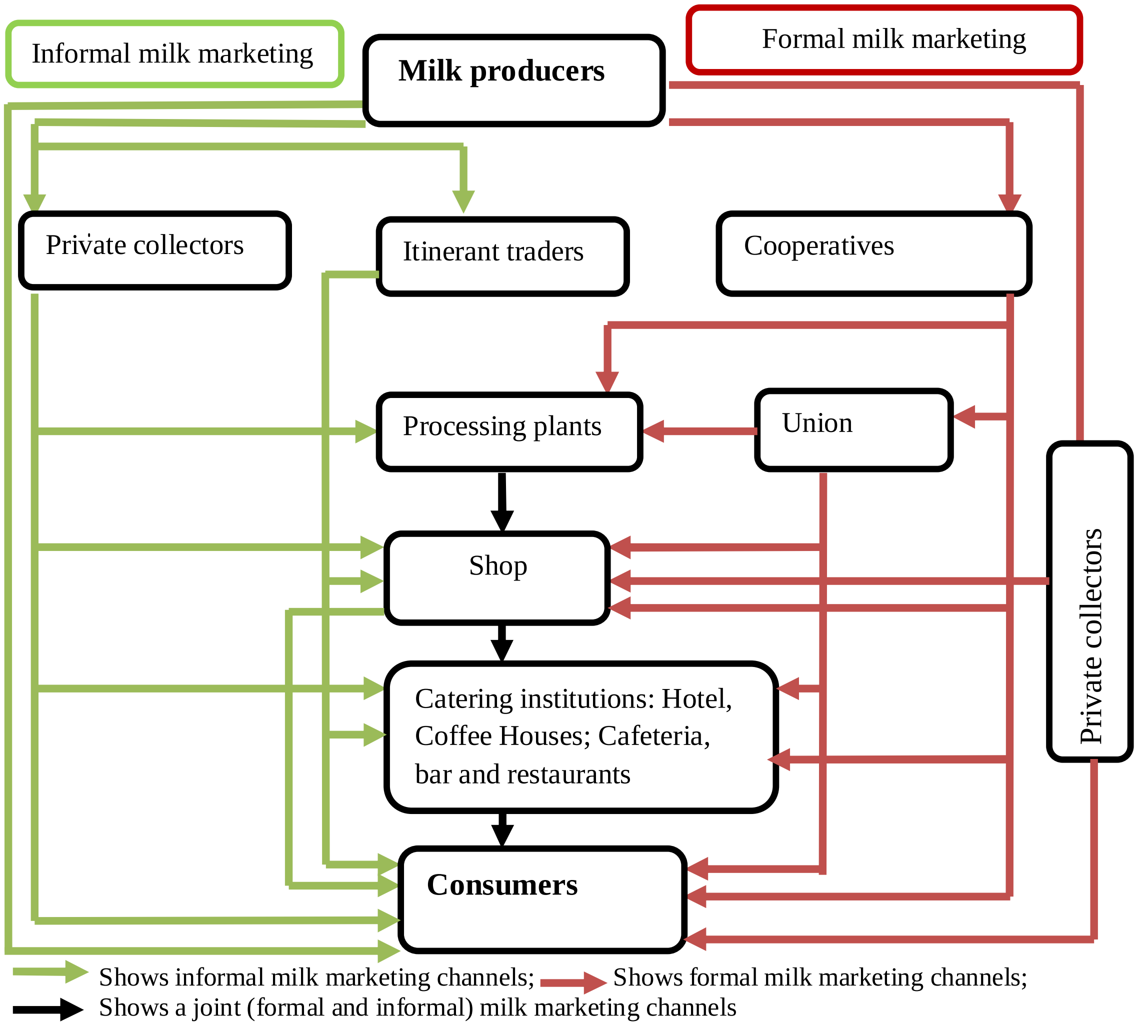

Figure 3: Milk marketing channels in the study areas (Debretsegie and Torbenashe)

Source: compiled by the researcher

In the informal milk marketing system the actors involved were not governed by the rules and regulations of the formal subsystem. The system involved sales of raw milk by producers or by their agents to consumers. It also involved buying of milk from home to home in the rural areas by itinerant traders. Even though marketing of raw milk and milk products through the informal marketing system was highly permissible in areas where dairy cooperatives (formal system) were not being practical, sometimes it was done within the cooperative and caused market competition as well as raw milk price disparity in the areas.

The word “formal” milk marketing system refers the system that passes through the government`s rule and regulations, registered, have license and pay tax. Even though the management system and efficiency is different from place to place, dairy cooperatives were registered, governed by the government`s rules and established to, 1) collect milk, 2) introduce organized milk marketing, 3) pay fair prices for milk producers, 4) supply concentrated feed to the cooperative members, 5) give a dividend or patronage, and 6) ensure the supply of quality milk and milk products to the consumers. This formal milk marketing channel encompassed both the shortest channel (producers - cooperative – consumers) and the longest channel (producers - milk collector - cooperative - union- processors- shop- catering institution -consumers). Even though there is a difference between formal and informal marketing channel systems, both have their own Strengths and Weaknesses (Table 10).

From the total daily milk production in the study areas, 89.2% was destined to market through both formal and informal marketing systems. About 22% of the total milk sold was marketed through the informal channel, which includes private collectors, neighbors and itinerant traders. On the other hand, the organized system, which is called formal market accounts for about 78% of total milk sold per day where co-operatives are the key actors (Fig.4).

Table 10: Strengths and weaknesses of various marketing channels

	Strength	Weakness
Cooperatives	● Provide a permanent market opportunity ● Offer inputs: AI, feed, and extension advice ● Give trainings for milk producers ● Develop confidence on farmers that their cash is safe ● No limit to the volume of milk that a farmer can supply (sometimes) ● Exercise milk quality control ● Develop team work sentiment on the farmers ● Allow farmers to invest on coop. assets ● Collection centers are usually not too far from the producers sites ● Patronage payment for farmers	● Irregular and delayed payments ● Relatively lower prices than informal marketing systems ● Insufficient input supply and low capacity utilization ● Weak management system ● Members shoulder out the cost of any mismanagement risk in the cooperative societies ● Inefficient processing plant operations ● Limited time of milk collection
Private milk collectors	● Provide a market access for places away from cooperative collection centers ● Payment can be negotiated as daily or monthly ● Take the risk of spoilage milk once it is received ● Relatively better prices where competition Exists ● Give true weight price	● No supply of inputs and Services practiced ● The buyers may disappear with the farmers` money ● No milk quality control practices (most of the time) ● The amount and the price of milk may be changed without the knowledge of the farmers ● There is seasonal fluctuations of milk demand
Neighbors	● Milk collection time is flexible since it is near to the farm. ● Collect milk directly from farm ● Price is usually higher and negotiable	● It is not a reliable market ● Cannot take all the milk ● Can delay payments or even refuse to pay
Bars, hotels & restaurants	● Slightly higher prices than cooperatives ● Payment can be negotiated as daily, weekly or monthly basis ● A reliable market relative to middlemen channel system ● Farmers confident for their cash relative to middlemen channel system	● Cannot take all the milk produced by farmers ● No input or service support ● A market is not reliable ● transport cost is there to take milk to the selling area

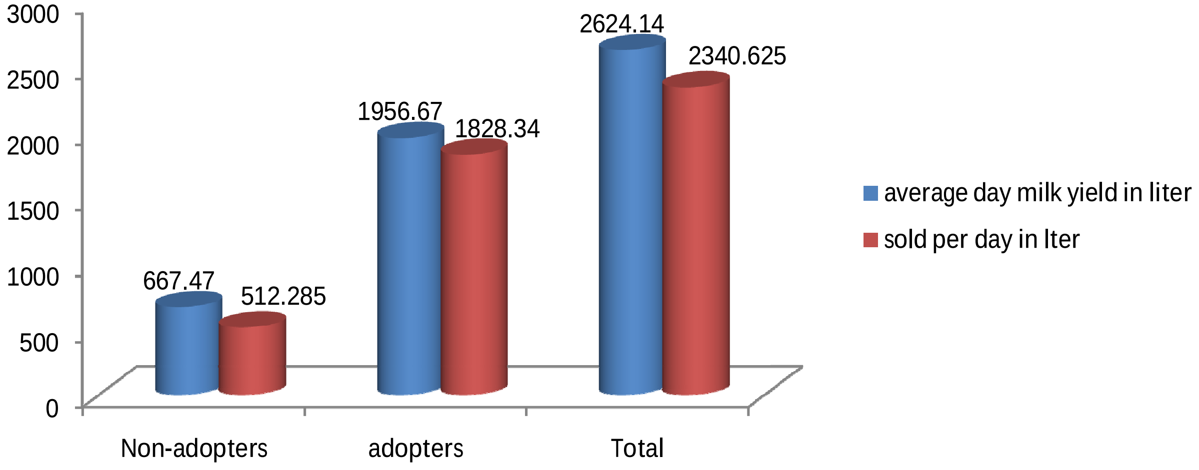

Figure 4: Average daily milk production and sell in the study areas

4. 4.2. Fresh milk price

The price of fresh milk was highly influenced by different exogenous factors such as location, transport access, marketing system, seasonal variation, processors` demand and sometimes by its` quality.

Producers living near the capital city and having a good transport accesses were selling their milk at a relatively good price compared to those living in remote areas. In *Godehino* and *Babogaya*, the average price of milk was 7.50 birr per liter while in *Debretsegie* and *Torbenashe* it was 7.35 birr per liter. On the other hand, the average milk prices in *Yetenora* and *Shemishengo* were 5.90 and 5.80 birr per liter, respectively.

Smallholder farmers selling their milk through private collectors received a little bit higher price per liter of milk than those selling their milk to the cooperatives. The price variation generally ranged from 0.25 - 1.00 birr per liter of milk between private collectors and cooperatives. The price also varied in fasting and non- fasting periods. During the fasting period the consumers demand declined that resulted in a price decrease of an average 0.50 birr per liter. Processors also influenced the price of milk. Processors, diminish the amount of milk they receive from cooperatives when they had problem with their processing machine and/or in times of low market demand. As a result of this, the cooperatives also decreased the amount of milk that they collected or decreased the price per liter of milk they pay for the producers. Cooperatives' buying price also varied with milk fitness for quality test. Cooperatives paid ten cents less than the normal price for milk that developed acidity and processed it to butter and cheese.

4.5. Milk Value Chain

In the milk value chain analysis, a number of relevant issues including but not limited to milk value chain mapping from production to consumption; mode of milk transportation; value chain main stages /core processes/ and value chains actors are presented. As it is shown in figure 5, mapping of the milk value chain included the basic components of value chain such as main stages/core processes/, actors and their activities, flow of products, flow of information and knowledge, value additions at different levels of the value chain, linkages and interactions between value chain actors and business development services.

Fig.5 shows seven main stages (input supply, production, collection, wholesaling, processing, retailing and consumption); main actors and their activities; product flow represented by both broken and solid arrows and business development services.

Input supply: Inputs and services for dairy milk production comprised two broad categories, namely: purchased and non-purchased inputs. The main purchased inputs/services included: feed (supplements), improved forage seeds, crossbreed heifers, milk quality testing and processing materials, Artificial Insemination (AI), veterinary services and milk containers/cans. Therefore, input suppliers provided these different inputs and services which are important for milk production. Non–purchased inputs commonly included family labor, hay, silage and water. Even though it varied from area to area, the major actors that supported the milk producers through supplying inputs and services included USAID, SNV, ILRI-Debreziet branch (before its closure), private animal feed producers, private feed traders, private heifer producers, private milk container traders, developmental agents, AI and animal health service providers (both governmental and private).

Production: The target group for the study was the smallholder farmers which were the largest milk producers. These smallholder farmers were not doing only producing milk but also they managed the farm and delivering the milk to milk collectors, itinerant traders and nearest town consumers. The milk production varied from place to place based on the farmers farming activities, farm size, inputs and services accessibility, technology utilization and milk marketing accessibility.

Collection: Milk collection was/is practiced in both formal (cooperatives, union, licensed traders) and informal marketing (private collectors/ itinerant traders without license) systems. In the place where cooperatives avail, most of the time, milk collecting agents were assigned to the near proximity of the producers in order to minimize milk spoilage and to attract the producers. The milk quality testing was practiced by collectors. In some milk collection points both private and cooperative collectors were competed to buy milk which gave producers better chance to get good price for their milk. Private collectors that operated in non cooperative areas also gave a chance for the producers to get access to milk market.

Wholesaling: Cooperatives, union and licensed private collectors/traders, after collecting milk from smallholder producers bulked the milk and sold it to processors. They were, thus, considered as wholesalers. Milk quality tests were/are also conducted by the wholesalers.

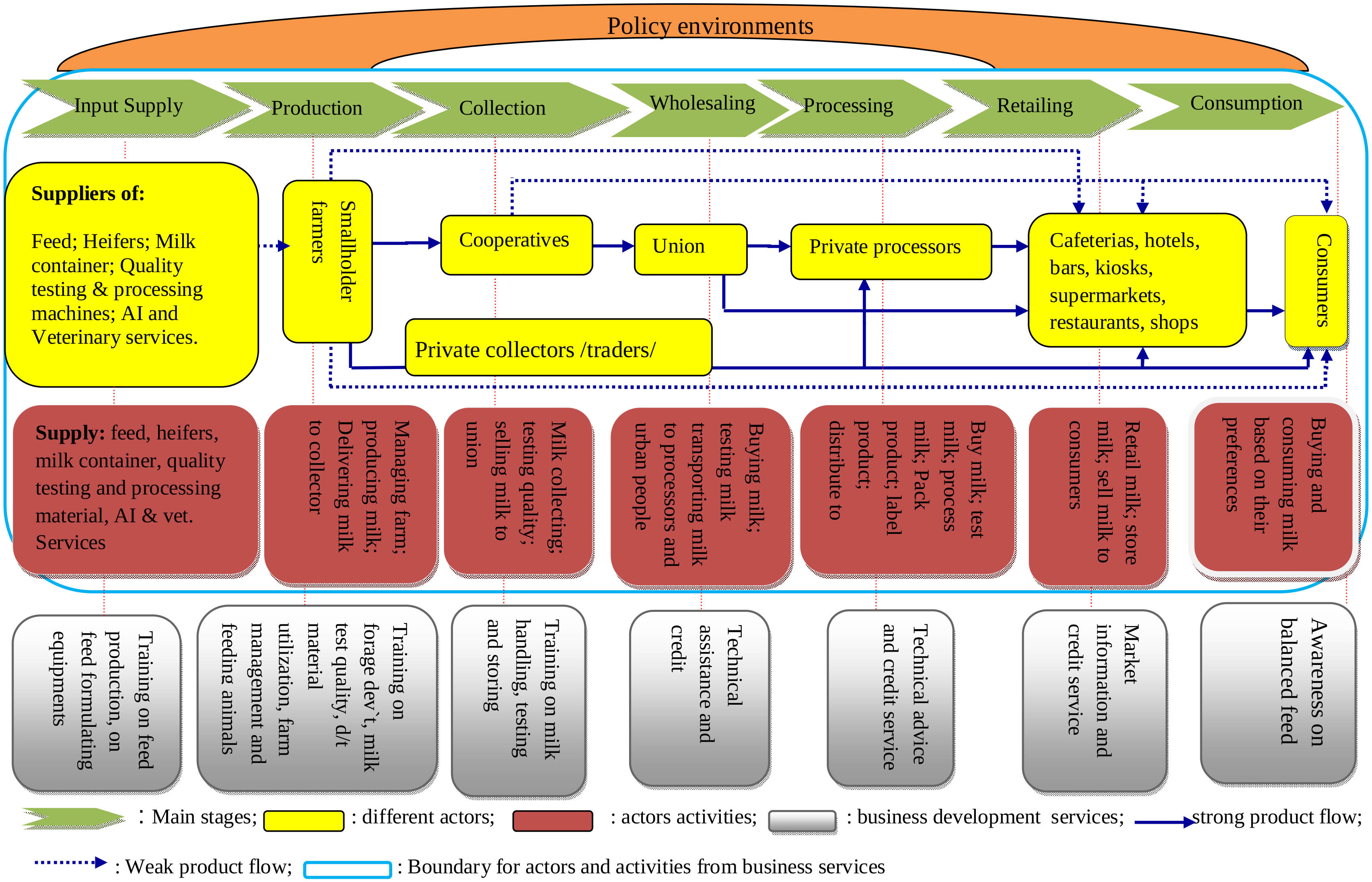

Figure 5: Mapping of the milk value chain in the study areas

Source: Organized by the researcher

Processing: Milk is processed into milk products such as butter, cottage cheese, ghee and skimmed milk. It has been practiced at different levels of the value chain such as at farm, cooperative and private processing plants. At farm level, processing was practiced in a traditional system using clay soil materials. At cooperative level, milk was processed using a simple manual or/and electrical cream separator (*Debretsegie,Yetenora, Shemishengo and Torbenashe cooperatives*) whereas at *Adda`a* dairy cooperative in which *Godehino* and *Babogaya* collecting centers were found the milk was processed by using modern processing plant. *Yetenora and Shemishengo cooperatives* processed milk because there was no fresh milk market in the nearby area but in *Torbenashe* the milk is processed when collected milk turns to have high acidity. Generally, modern milk processing methods were used by cooperatives and processing plants. In the value chain mapping, cooperatives and processing plants activities involved milk testing, buying, storing, processing, labeling products and distributing them to retailers.

Retailing: Is the part of the value chain that sells milk and milk products to consumers. Cafeterias, hotels, bars, restaurants, kiosks, supermarkets and shops were /are retailers that sell milk to the consumers.

Consumption: Milk and milk products were consumed directly by the farm family members and neighbors or peri- urban or urban consumers that buy the products through formal or informal marketing systems. Fresh milk consumption at farm level was not that much practiced because of cultural influences. Therefore, it was processed and utilized in the forms of like butter, cheese, Irgo and whey.

Policy environment: Institutions involved in dairy development activities were the Ministry of Agriculture, the Ethiopian Agricultural Research Organization and Dairy Development Enterprise among others. These institutions provide services like animal health service, extension services and trainings. A new extension system known as the Participatory Demonstration and Training Extension System (PADETES) was developed in 1995 with the objective of bringing Agricultural Development-Led Industrialization (ADLI). However, at the grassroots level there were some gaps on fulfilling the infrastructures and a full implementation of extension services which resulted in the value chain actors did not get many opportunities to discuss with each other about issues affecting the entire value chain. Furthermore, there was no concerned body to assure quality and standards of dairy products in the course of production, transportation, processing, marketing and consumption except a little effort on milk quality testing practiced by different chain actors.

4.5.1. Mapping of flow of products and the volume of product flows

Not all smallholder farmers were registered in dairy cooperatives as members for different reasons such as low milk production (28.4%), processing milk at home (4.9%), unable to pay membership fee (2.3%), lack of awareness (2.1%), loss of trust on cooperatives (1.6%) and distance from cooperative center (0.3%). On top of this some cooperative members started to sell some of their milk to private collectors by reducing from the cooperative because they lost their trust on the cooperative management, they couldn`t get patronage and private collectors give them better price per liter of milk. As it is shown in Fig.6, 74.6% of the total milk produced per day was produced by cooperative member smallholder farmers of which 69.4 % was destined to consumers as fresh milk through cooperative, union and retailers which covered 32.6% and after processing (36.8%) by the cooperatives. The non-cooperative smallholder farmers' milk production represented about 25.4 % of the total volume produced in the study areas and 19.6% of it was sold to the private milk collectors, catering institutions and itinerant traders and the remaining 5.8% was utilized at home.

Fig.7 shows that both income per liter and milk value addition among different actors along the value chain was not uniformly distributed. Income received by the producers per liter of fresh milk was only 43.8% of the amount paid by end user (consumer) while that of the processors was 31.25%. The following mathematical equation was used to determine the percentage share at each stages of the value chain (expressed as a percentage).

$$\textit{Income per liter shared \%} = \left(\frac{\textit{buyer price} - \textit{seller price}}{\textit{End buyer price}}\right) X\ 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{equ4. 1}$$

It is important to note that all the investments (financial, labor cost and opportunity cost) in collectors, wholesalers, processors and retailers was calculated whereas at the farm level the high family labor which was unpaid, utilization of farm produced feed and the considerable time the farmer spends on milk production related activities made the calculation of the investment cost analysis at farm level very difficult. Hence, the value addition calculation was done at collectors and above stages of value chain by using the mathematical formula indicated below.

$$\text{Value addition shared} = \left(\frac{\text{buyer price} - \text{seller price}}{\text{Total sum of value added price}} \right) X\ 100 \ldots\ldots\ldots\ldots\ldots\ldots\text{equ4.2}$$

Accordingly, the processors, retailers, wholesaler and collectors received 55.5%, 22.2%, 21.1% and 1.1% of the value added share in some study areas, respectively.

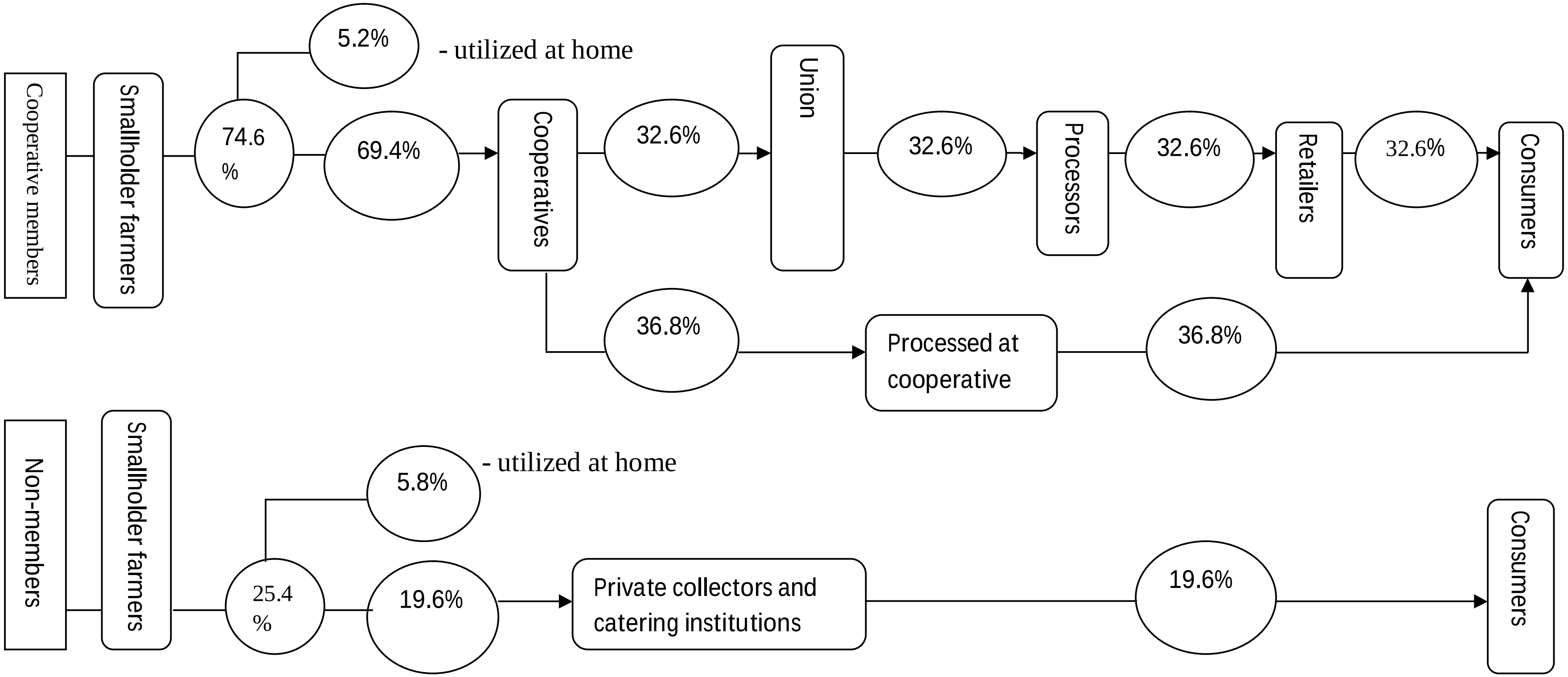

Figure 6: Map of milk product flow and its volume along the value chain in some study areas

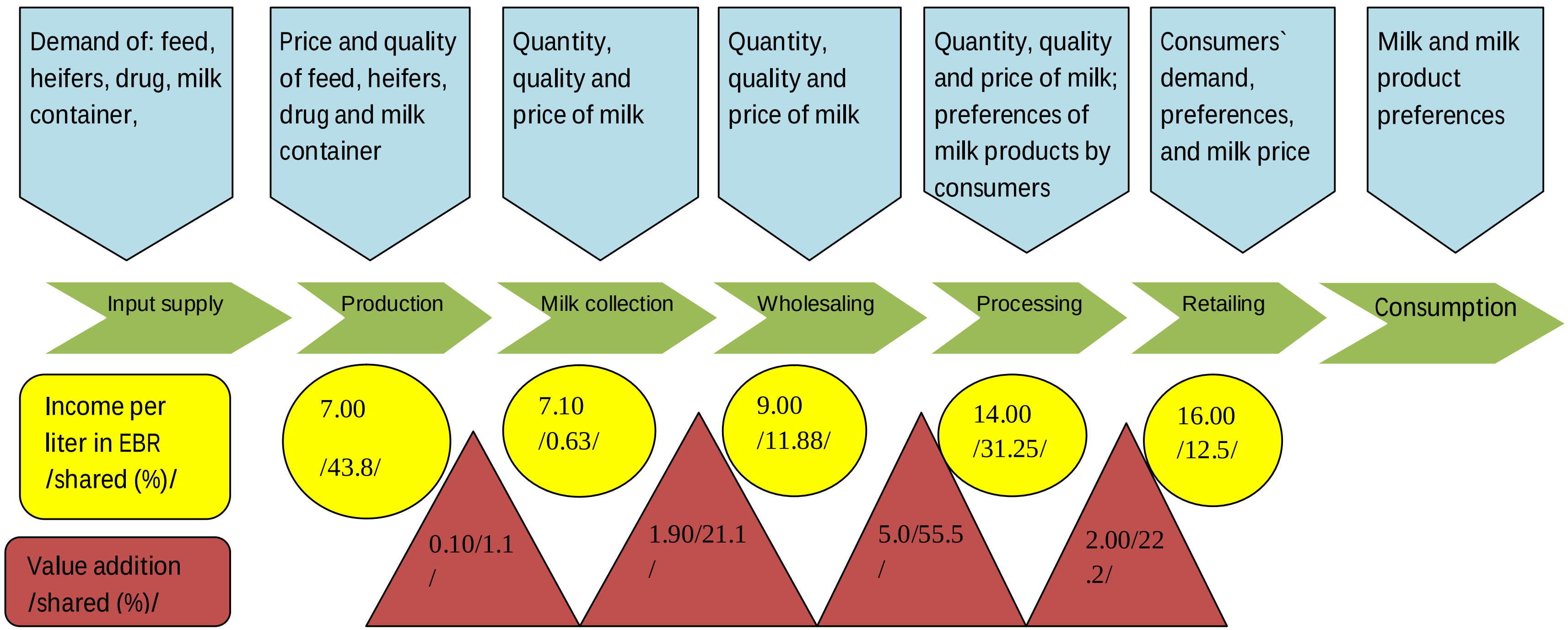

Figure 7: Map of value additions at different levels of the value chain and flow of information and knowledge in the study areas

= information on different core processes; = different stages; = Income per liter in EBR/shared (%)/

= Value addition /shared (%)/

4. 5.2. Mode of transportation

Milk from the area of production was transported by using different transport means. Milk from the producers to the milk collectors transported by using various methods such as people back and cart or donkey. Female family members were the ones doing this job in most cases. Each morning, milk was delivered to collection centers between 6:00am to 8:00am by using mainly plastic containers (Fig. 8).

Figure 8: Milk transporting system from producers to collection centers in the study areas

Vehicles were used to transport milk from collection centers to union, processing plant, shop and urban consumers particularly in Oromia National Regional State (ONRS) (Fig. 9). In the Amhara National Regional State (ANRS) , as there was no fresh milk market accessibility and milk processing plants, milk was processed in to different milk products at farm and cooperative levels.

Figure 9: Milk transporting system from collection centers to processing units and consumers in the study areas

4.5.3. Milk quality at different critical points in the value chain

Milk quality problems started at farm level either of internally from animals or/ and external factors. These external factors included milkers` cleanness and hygiene, milking container cleanness, barn condition and environment, among others. Even if regular animal health check up at farm level was almost inexistent, 81.2 % of the smallholders practiced washing the udder with water (43.2%- using cold water, 37.5% -using hot water and 19.3% using both) and 48.7% used towels to clean the udder before milking. Almost all collectors (cooperatives and private collectors), union and processors used alcohol and lactometers for quality testing.

On the other hand, in almost all the study areas, except *Godihino* and *Babogaya*a, very efficient milk quality testing material called *Lactoscan* (tests nine physico-chemical parameters at a time) which was donated by USAID some five years back was there. But due to lack of technical know-how, the lactoscans were not in use. During the present study the machines were used to test the physico-chemical characteristics of the milk samples and cooperative milk quality responsible persons were also trained and started to use them. However, unavailability of technical backup service providers and reagents needed for daily and weekly washing of the machines in the study areas were major challenges for the long term utilization of the machines.

As it is shown in Figure 10 and 11, Total Bacterial Count (TBC) and Coliform Count (CC) load increased along the value chain. Compared to tests made at farm gate, TBC load increased by 13.5, 23.9 and 42.9 times at collection, union and Addis shop levels, respectively. CC load also increased by 3.5, 6.0 and 12.1 times for the above indicated value chain stages in that order.

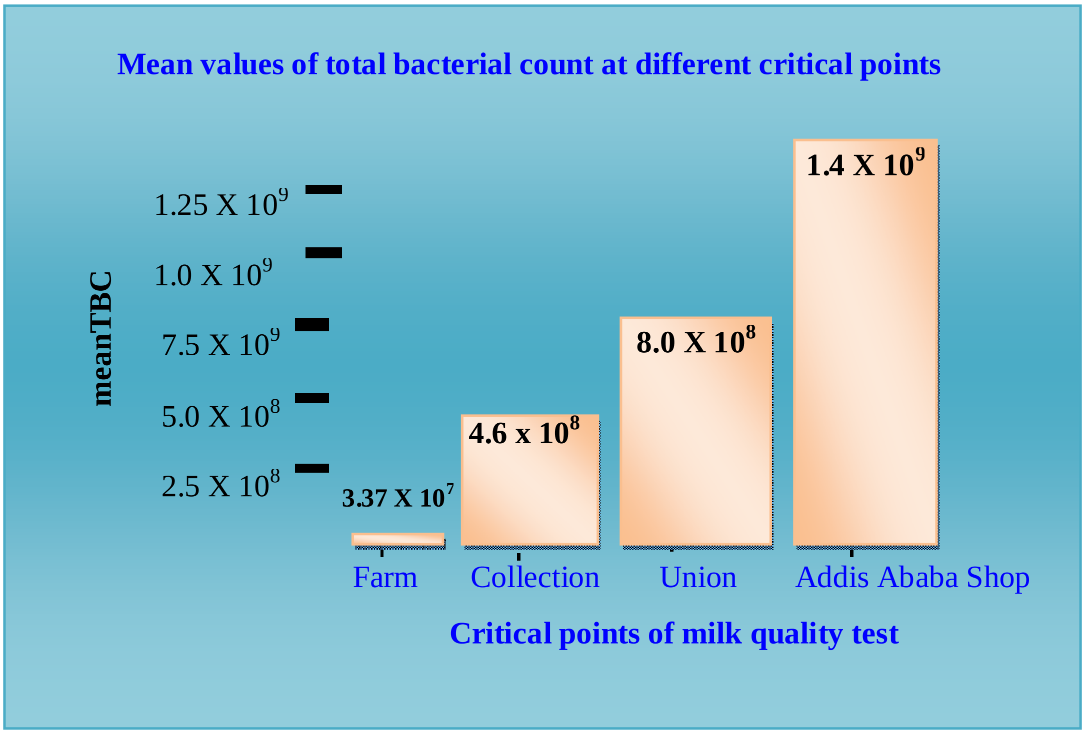

Figure 10: Mean values of total bacterial count at different critical points in the study areas

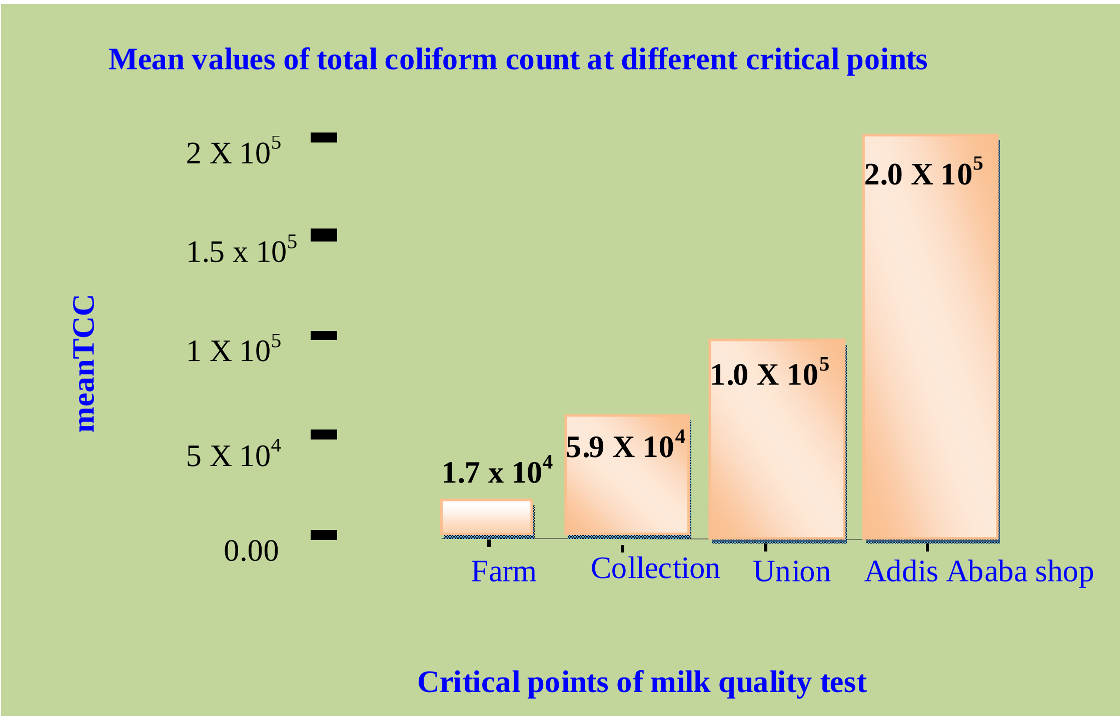

Figure 11: Mean values of total coliform count at different critical points in the study areas

4.6. Determinants of Raw Milk Quality

4.6.1. Physico-chemical quality of the raw milk

Table 11 illustrates physico-chemical properties of milk samples from different study areas. Milk samples from *Yetenora* study site tested highest for fat percentage (5.97 ± 2.36) while that of *Babogaya* was lowest (3.55 ± 1.15).

There was a significant difference (P<0.01) in fat % among the study areas and the overall mean value of the fat in the study area was 5.22%. There was also a significant difference (P<0.01) in solid non-fat (SNF) values between the study areas with the highest percentage (8.88%±0.83) in milk samples from the *Shemeshengo* study area. The table also shows that there was significant difference (P<0.05) in density between study areas. *Babogaya* and *Shemeshengo* samples were significantly differenced (P<0.05) from those of *Debretsegie, Torbenashe* and *Godino*. The mean value of protein percentage was 3.12% ± 0.32. *Godino, Babogaya* and *Shemeshengo values* were significantly different (P<0.01) from those of *Debretsegie*, *Torbenashe* and *Yetenora*. Adulteration of milk was highest in *Debretsegie* milk samples and significantly different (P<0.01) from those of *Shemeshengo* and *Yetenora*. The freezing point of the milk samples was lowest in *Shemeshengo* (-0.587^{0}C) and highest in *Debretsegie* (-0.531^{0}C) with a significant difference (P<0.01).

Table 11: Phyisco-chemical characteristics of cow raw milk in the study areas

Milk quality parameters	Mean values of milk physico-chemical quality parameters across the study areas						
	A_1 (N=75)	A_2 (N=60)	A_3 (N= 30)	A_4 (N=53)	A_5 (N=67)	A_6 (N= 99)	Over all mean (N= 384)
Fat (%)	$4.72(2.13)^{b}$	$5.57(1.87)^{c}$	$4.74(1.94)^{b}$	$3.55(1.15)^{a}$	$5.89(2.03)^{c}$	$5.97(2.36)^{c}$	$5.22(2.17)^{***}$
SNF (%)	$8.16(0.61)^{a}$	$8.27(0.60)^{ab}$	$8.72(0.78)^{cd}$	$8.14(0.41)^{a}$	$8.88(0.83)^{d}$	$8.52(0.71)^{bc}$	$8.44(0.72)^{***}$
Density (%)	$28.04(2.82)^{a}$	$27.78(3.22)^{a}$	$28.07(4.05)^{a}$	$29.55(1.78)^{b}$	$29.53(4.31)^{b}$	$28.91(3.09)^{ab}$	$28.70(3.31)^{**}$
Protein (%)	$2.98(0.22)^{a}$	$3.02(0.22)^{a}$	$3.30(0.28)^{b}$	$3.36(0.13)^{b}$	$3.25(0.36)^{b}$	$3.09(0.37)^{a}$	$3.12(0.32)^{***}$
Adulteration (%)	$2.08(0.48)^{b}$	$1.67(0.53)^{ab}$	$1.57(0.69)^{ab}$	$1.13(0.37)^{ab}$	$0.68(0.31)^{a}$	$0.47(0.24)^{a}$	$1.19(0.17)^{***}$
FP (^{0}C)	$-0.531(.042)^{c}$	$-0.542(.046)^{c}$	$-0.573(.039)^{ab}$	$-0.562(.026)^{b}$	$-0.587(.059)^{a}$	$-0.565(.038)^{b}$	$-0.559(.047)^{***}$

A_1= Debretsegie; A_2= Torbenashe; A_3= Godino; A_4 = Babogaya; A_5= Shemeshengo; A_6= Yetenora; Numbers in bracket are standard deviation; values in the row with different letters have significant difference. SNF= solid Non-Fat; FP= Freezing Point; ***= significant at ($P < 0.01$) and ** = significant at ($P < 0.05$)

4.6.2. Microbial quality of the raw milk

Table 12 reveals the microbial quality of the milk samples. The mean value of total bacterial count per milliliter (TBC/ml) ranged from 4.3x 10^7 to 1.7x10^8 with a significant difference ($P<0.05$) among the study areas. Total coliform count also showed a significant difference ($P<0.01$) between the study areas. The overall mean somatic cell count 5.5 x 10^5 (log10 (45.7)) didn't show significant difference ($P>0.05$). However, somatic cell counts of *Debretsegie* and *Torbenashe* study areas significantly differed ($P<0.05$) from those of the other study areas.

4.6.3. Correlation coefficients between the different milk quality parameters

Table 13 shows correlation coefficients between the different milk quality parameters. Density of raw milk was negatively and significantly correlated with fat content ($P<0.01$) and positively and significantly correlated with solid non-fat ($P<0.01$). Protein content was negatively and significantly correlated with fat content ($P<0.01$). In addition, protein was correlated positively and significantly with both SNF and density ($P<0.01$) whereas lactose was correlated positively and significantly with SNF, density and protein ($P<0.01$). On the other hand adulteration and freezing point were negatively and significantly correlated with SNF ($P<0.01$), density ($P<0.01$), protein ($P<0.01$) and lactose ($P<0.01$) but there was positive and significant correlation between adulteration and freezing point ($P<0.01$).

Table 12: Microbial quality of cow raw milk in the study areas

Sources of Samples	No of Samples Tested	Mean values of milk bacteriological quality of raw milk					
		TBC/ml		TCC/ml		SCC/ml	
		Cfm/ml	Log10	Cfm/ml	Log10	Somatic cells/ml	Log10
A_1	10	$4.3x10^{7}$	$7.6\ (0.72)^{ab}$	$1.0x10^{4}$	$4\ (0.30)^{ab}$	$1.6x10^{6}$	$6.2\ (0.86)^{c}$
A_2	10	$1.6x10^{8}$	$8.2\ (0.81)^{bc}$	$1.2x10^{4}$	$4.1\ (0.86)^{a}$	$3.8x10^{5}$	$5.8\ (0.70)^{c}$
A_3	10	$5.1x10^{7}$	$7.7\ (0.95)^{a}$	$4.1x10^{4}$	$4.6\ (0.75)^{bc}$	$1.5x10^{5}$	$5.2\ (0.83)^{ab}$
A_4	10	$1.7x10^{8}$	$8.2\ (0.62)^{c}$	$5.8x10^{4}$	$4.8\ (0.60)^{c}$	$2.5x10^{5}$	$5.4\ (2.56)^{a}$
A_5	10	$7.5x10^{7}$	$7.9\ (1.10)^{ab}$	$1.6x10^{4}$	$4.2\ (0.68)^{ab}$	$4.0x10^{5}$	$5.6\ (2.25)^{ab}$
A_6	10	$1.4x10^{8}$	$8.1\ (0.60)^{bc}$	$4.5x10^{4}$	$4.7\ (0.30)^{c}$	$5.1x10^{5}$	$5.7\ (0.68)^{ab}$
Total	60	$1.1x10^{8}$	8.0 (0.89)	$3.0x10^{4}$	4.5 (0.71)	$5.5x10^{5}$	4.6 (1.60)
Level of overall significance			***		***		NS

A_1=Debretsegie;A_2=Torbenashe; A_3=Godino; A_4=Babogaya;A_5=Shemeshengo A_6=Yetenora; TBC= Total Bacteria Count; TCC= Total Coli forms Count; SCC= Somatic Cell count; ***= significant at ($P < 0.01$) and ** = significant at ($P < 0.05$); values in the same column with different letters have significant difference.

Table 13: Correlation coefficients between different milk quality parameters in the study areas ;(N= 384)

Variable	Fat	SNF	Density	Protein	Lactose	Adult	FP
Fat	1	-.072	-.603(**)	-.188(**)	-.099	-.129(*)	-.116(*)
SNF		1	.663(**)	.866(**)	.877(**)	-.142(**)	-.567(**)
Density			1	.582(**)	.753(**)	-.049	-.309(**)
Protein				1	.746(**)	-.109(*)	-.500(**)
Lactose					1	-.179(**)	-.672(**)
Adult						1	.590(**)
FP							1

** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed); SNF= Solid Non Fat; FP= Freezing Point; Adult = Adulteration

The results of the regression analysis, using 8 variables in the model, are presented in Table 14. The coefficients of determination (adjusted R-squares) indicate the variation of the overall raw milk quality in the study areas. Hence, the results in Table 14 show the important factors influencing raw milk quality in the study areas. All the coefficients have the expected signs. Only those coefficients associated with statistically significant variables at 10-percent level or lower are presented.

The effect of breed (dummy variable denoted by 1 for local breed and 0 for crossbred) was found to have positive significant (P<0.01) effect on fat and protein percentages and on the total Coliform count, but negative significant (P<0.01) effect on freezing point. Milk from local breed cows had 0.74, 0.10 and 0.57 percent higher fat percentage, protein percentage and total Coliform count, respectively, than crossbred cows. The feeding system (dummy variable denoted by 1 for stall feeding and 0 for grazing) had also significant negative (P<0.01) influence on protein percentage and positive influence on freezing point of raw milk. Feeding system had also significant (P<0.1) association with somatic cell count of raw milk. Milk from farms which practice stall feeding had an increased somatic cell count and freezing point by 0.87 and 0.007 percents, respectively, than farms practicing grazing system. However, in a stall feeding farms, 0.1 lower protein percentage was recorded.

Education level (dummy variable denoted by 1 for formal education and 0 for informal education) showed a negative significant ($P<0.1$) effect on somatic cell count. The result reveled that formal education can reduce somatic cell count by 0.74 percent than milk from household heads with informal education.

Adulteration milk had a positive significant effect on freezing point ($P<0.01$) and total coliform count ($P<0.1$), but negative significant ($P<0.05$) effect on protein percentage. By taking other factors constant, increase of a unit of water addition in raw milk caused increases in freezing point and total coliform count by 0.005 and 0.03 rates, respectively, and protein percentage decreases by 0.009 rate.

Distance from dairy technology dissemination center had positive significant ($P<0.05$) effect on protein percentage and negative significant ($P<0.01$) effect on freezing point. Increasing a unit distance caused protein to increase by 0.008 rate and freezing point to decrease by 0.001. The coefficients of parity had negative and positive significant ($P<0.01$) effects on fat and protein percentages, respectively.

Table 14: Multiple regression analysis of effects of independent variables on raw milk quality

Independent variables	Dependent variables				
	Fat%	Protein%	FP	TCClog10	SCClog10
	β	β	β	β	β
Intercept	7.61(0.42)[a]	3.05(.06)	-0.56(0.01)	3.20(0.46)	6.13(1.00)
FS	-0.07(0.04)*	.006(000)	.001(.001)	0.005(.04)	-0.09(.08)
FE	0.016(0.01)*	.001(.001)	000(000)	0.01(0.01)	-0.03(.02)
PNC	-1.15(0.08)***	0.04(0.01)***	.002(.002)	.11(0.09)	-0.25(0.19)
DDTDC	-0.002(0.023)	.008(.004)**	-0.001(0.0)***	.003(0.02)	.005(.04)
WaAd	-0.02(0.02)	-.009(.004)**	.005(0.001)***	.03(0.02)*	.005(0.03)
Education[b]	0.01(0.18)	.01(.028)	.005(0.004)	.12(0.21)	-.74(.44)*
FeSys[b]	-0.2(0.20)	-0.10(0.03)***	.007(.004)**	.25(0.23)	.87(.48)*
Breed[b]	0.74(0.22)***	0.10(0.03)***	-.01(.004)***	.57(.24)**	-.73(0.51)
R- square	***0.428***	***0.142***	***0.322***	***0.219***	***0.317***
	F (9, 374) = 28.79, P= 000	***F(9,374) = 6.25, P = 000***	***F(9,374)= 17.81, P= 000***	***F(9,50)= 1.41, P= 0.204***	***F(9,50)= 2.29,P=.0.027***

***: denotes P < 0.01, **: denotes P < 0.05, *: denotes P < 0.1[a] = numbers in the brackets are standard errors, [b]= shows the dummy explanatory variables, β = unsaturated regression coefficient, FP = freezing point, TCC= Total Coli forms Count; SCC= Somatic Cell count, FS = family size, FE = farming experience, PNC = parity number of cow, DDTDC = distance from dairy technology dissemination center, WaAd = water addition, FeSys = feeding system.

4.7. Animal Health, and Milk Production and Utilization Issues

This section summarizes results obtained through group discussions focusing on the diseases status, veterinary services, milk production and its utilization, milk use categories and income of smallholder farmers in the "before" and "after" situations of the study areas. It also addressed both dairy production and dairy technology up-take constraints.

4.7.1. Disease status before and after starting use of modern veterinary services

A total of 14 disease problems were identified as major constraints in both Amhara and Oromia National Regional States. For the "before" situation, Pasteurellosis , Foot and Mouth Disease (FMD) and Blackleg in Amhara National Regional State (ANRS) and Anthrax, Blackleg and Foot and Mouth Disease (FMD) in Oromia National Regional State (ONRS) were ranked first to third positions as major disease problems (Table 15). With the exception of FMD in Amhara National Regional State, the importance of all the top ranked disease problems showed considerable decline in the "after" situation. On the other hand Mastitis, Respiratory problems and Milk fever conditions were ranked as considerably worsened in the "after" situations compare to the "before" ones. For other disease problems the rates of increment or decrement varied as shown in Table 15.

Table 15: Disease status in "before" and "after" starting use of modern animal health services

Common Name	Local Name	Amhara Region (*No of Groups= 2)		Oromia Region (*No of Groups= 4)	
		Before/ After	FC	Before / After	FC
Rabies	Yebd wusha beshita	-	-	40/57	0.425
FMD	Tifer awulik	177/236	0.33	248/161	-0.35
Mastitis	Yetute beshita	68/176	1.59	201/294	0.46
Black Leg	Worchiga	172/94	-0.45	360/156	-0.57
Anthrax	Kurba/simoter	91/116	0.27	511/244	-0.52
Milk fever	-	-	-	19/306	15.11
Lumpy Skin Disease	Gurbereb	128/30	-0.77	70/24	-0.66
Respiratory Problem	-	11/185	15.82	135/215	0.59
Pasteurellosis	Enkert/Litium	266/53	-0.80	32/35	0.09
Diarrhea	Tekimat	-	-	81/112	0.38
Brucellosis	Chigafi	-	-	64/38	-0.41
Bloating	Hode menifat	136/97	-0.29	61/96	0.57
Ext. Parasite	-	20/33	0.65	87/105	0.21
Int. Parasite	-	-	-	27/9	-0.67

*: Each group had 8 to 10 members; Factor Change (FC) = (after – before)/ before

4.7.2. Uses of different animal health services in the "before" and "after" technology transfer situations

Four types of animal health services, namely traditional animal treatment, religious healing, government veterinary service and private veterinary service were identified as being practiced both in the "before" and "after" situations. Traditional animal treatment and religious healing were highly performed than governmental and private modern animal health services in the "before" situation in all the study areas. On the other hand, in the "after" situation, governmental and private modern animal health services were highly practiced. Even if it varied from place to place, governmental and private modern animal health services use was increased by up to five and two folds, respectively in the "after" situation (Table 16).

Table 16: Use of different types of animal health services in the "before" and "after" the dairy technology introduction into the areas

Area of the study	Animal health services							
	Traditional animal treatment		Religious healing		Modern animal health service use			
					Government service		Private service	
	Before/ After	FC	Before/ After	FC	Before/ After	FC	Before/ After	FC
Babogaya	48/31	-0.35	15/10	-0.33	24/40	0.67	10/28	1.8
Yetenora	135/33	-0.76	58/8	-0.86	22/60	1.73	-/-	-
Shemishengo	128/40	-0.69	63/16	-0.75	15/90	5	-/-	-
DebreTsegie	69/31	-0.55	35/6	-0.83	36/85	1.36	7/14	1
Torbenashe	81/24	-0.70	21/4	-0.81	40/98	1.45	3/8	1.67
Godiho	92/39	-0.58	29/9	-0.69	18/100	4.56	-/-	-

Factor Change (FC) = (after – before)/ before

4.7.3. Milk production and utilization in the "before" and "after" technology transfer situations in the study areas

Based on group discussion results, milk production was very small in the "before" situation and increased by two to five folds in the "after" situation. However, the rate of change of production varied from place to place with highest increases in *Yetenora* and *Shemishengo* (Table 17).

Table 17: Average milk production per cow per day in the *"before" and "after"* situations in the study areas

Area of the study	Groups of informants (N=6)	
	Milk production in the area	
	Before/ After	FC
Babogaya	3/10	2.33
Yetenora	1.5/10	5.67
Shemishengo	1/6	5
DebreTsegie	3.5/13	2.71
Torbenashe	3/11	2.67
Godiho	2/8	3

The discussion groups identified that fresh milk and milk products consumption at household level varied in the "before" and "after" situations. Fresh milk consumption increased up to nine times in the "after" situation compared to the "before" whereas other milk product consumption decreased in the "after" situation than in the "before" ones (Table 18).

Table 18: Milk use categories at home in the study areas

Area of the study	Milk consumption at home											
	Fresh milk		Cheese		Buttermilk		Yoghurt		Butter		Whey	
	Before/ After	FC	Before/ After	FC	Before/ After	FC	Before/ After	FC	Before/ After	FC	Before/ After	FC
Babogaya	*13/20*	*0.54*	*40/20*	*-0.5*	*30/15*	*-0.5*	*10/7*	*-0.3*	*23/12*	*-0.48*	*11/5*	*-0.55*
Yetenora	10/18	0.8	30/15	-0.5	20/13	-0.35	8/6	-0.25	21/14	-0.33	9/6	-0.33
Shemishengo	5/15	2	21/7	-0.67	16/8	-0.5	4/3	-0.25	16/9	-0.44	5/4	-0.2
DebreTsegie	3/16	4.33	20/17	-0.15	18/12	-0.33	10/5	-0.5	20/11	-0.45	7/4	-0.43
Torbenashe	2/20	9	18/15	-0.17	16/12	-0.25	9/5	-0.44	23/10	-0.57	10/3	-0.7
Godiho	8/21	1.63	31/25	-0.19	40/23	-0.43	20/11	-0.45	35/24	-0.31	18/8	-0.56

Factor Change (FC) = (after – before)/ before

The groups` discussions also identified six types of milk use categories for the "before" and "after" situation (Table 19). Milk for processing, family consumption and giving neighbors were the leading categories whereas milk for sell was the least category in the "before" situation in both Regions. Inversely, milk for sell became the leading category which was increased sixteen times and four times than in the "before" situation in Amhara and Oromia National Regional States, respectively. The increase in the "after" situation in both Regions was due to milk production increment (more than two times), establishment of dairy cooperatives (market access), high demand of cash income and increment of milk price than in the previous (Table 19).

Table 19: Different milk utilization in the *"before" and "after"* situations in the study areas

Indicators	Groups of informants (N=6)			
	Amhara National Regional State		Oromia National Regional State	
	Scores "before"/ "after"	FC	Scores "before"/ "after"	FC
Milk production	37/124	2.35	122/267	1.19
Milk for family consumption	140/34	-0.76	249/65	-0.74
Milk for gusts	95/48	-0.49	110/36	-0.67
Milk for neighbors	127/55	-0.57	134/42	-0.67
Milk for sale	20/340	16	121/624	4.16
Milk for processing	185/55	-0.70	225/28	-0.88
Milk for cosmetics	101/43	-0.57	99/41	-0.59

Factor Change (FC) = (after – before)/ before

The discussion groups also identified that the income of smallholder farmers in the "before" and "after" situations. House hold income from cow per day was lower in the "before" situation in all study areas than in the "after" situation. The maximum income of the household in the "before" situation was 3.5 birr per day per cow which increased by twenty one times and reached at seventy eight birr in the "after" situation. The house hold income increment rate was higher in *Yetenora* and *Shemishenego* which accounted about sixty five and fifty nine times than in the "before" situation (Table 20).

Table 20: Average household income per cow per day in the *"before" and "after"* situations in the study areas

Area of the study	Groups of informants (N=6)	
	Average income in ETB	
	Before/ After	FC
Babogaya	3/60	19
Yetenora	0.75/50	65.67
Shemishengo	0.5/30	59
DebreTsegie	3.5/78	21.29
Torbenashe	3/66	32.85
Godiho	2/48	23

ETB= Ethiopian birr; Factor Change (FC) = (after – before)/ before

As per groups discussions, twelve general dairy production and seven dairy technology up-take constraints were identified and ranked. In Amhara National Regional State (ANRS), Management of dairy animals, land security, milk quality and lack of training were ranked from 1st to 4th positions in that order (Table 21). In Oromia National Regional State (ONRS), lack of training, animal disease prevalence and land scarcity were the constraints ranked 1st to

3th positions. There were also some differences in the ranking of other constraints between the two Regions (Table 21).

Table 22 illustrates dairy technology up-take constraints identified by both ANRS and ANRS discussion groups. While the identified constraints remained the same in the two regions, there were disparities in the rankings. Among the seven identified dairy technology up-take constraints, financial problem for ANRS and scarcity of crossbred heifers, for ONRS were the top ranked ones (Table 22)

Table 21: Ranking of constraints of dairy production by discussion groups in Amhara and Oromia National Regional States

Constraints	TNG =2; TNP= 17		TNG=4; TNP= 35	
	Amhara (%)	Rank	Oromia (%)	Rank
Milk market problem	12	11	14	11
Poor AI service	47	7	29	9
Veterinary service	53	6	37	8
Cost of feed	35	9	43	5
Concentrate feed	29	10	40	7
Training problem	76	4	83	1
Land scarcity	94	2	66	3
Milk quality	94	2	43	5
Animal disease	41	8	71	2
Lack of attention from Gov.	76	4	51	4
Mang`t problem	100	1	23	10
Union / coop management.	-	12	14	11

TNG = Total number of Groups; TNP = Total number of participants

Table 22: Ranking of constraints of dairy technology up-take by discussion groups in Amhara and Oromia National Regional States

Constraints	TNG =2; TNP= 17		TNG=4; TNP= 35	
	Amhara (%)	Rank	Oromia (%)	Rank
Finance scarcity	71	1	37	4
Milk market problem	12	7	60	3
Land scarcity	24	6	66	2
Feed scarcity	36	5	14	7
Feed cost	65	2	26	5
Crossbred heifer scarcity	59	4	71	1
Semen problem for AI	65	2	17	6

TNG = Total number of Groups; TNP = Total number of participants

4.8. Determinants of Dairy Technology Adoption

The characteristics of the households and other exogenous variables are described in Table 23. The average household age was 46 years and the mean number of family members was 6. The proportion of male-headed households was 72% and the mean value of cattle in the study area was 5.13 in TLU. However, the mean number of crossbred cows was 0.99.

Seventy percent of the interviewed household heads said that there was crossbred availability in their proximity. The majority of the interviewed household heads (94%) also indicated availability of animal health services in the study areas. Availability of training on livestock in the study areas was indicated by only 38% of the interviewed household heads. 30% of the households were participated in the off farm activities and the average farming experience of the households was 22.6 years.

Table 23: Definition of variables and their descriptive statistics

Variable definition	Symbol	Mean (STD)
Gender of the household head(0= female, 1= male)	GENDER	0.72(.45)
Age of the household head (years)	AHH	45.87(12.25)
Family size (number)	FS	6.10(2.27)
Educational status (0 = non-educated, 1= educated)	ELHH	0.53(.50)
Farming experience (Years)	FE	22.61(11.58)
Total land holding (hector)	LH	1.76(1.20)
Total income from milk and milk products per year (Birr)	TIMMP	15748 (2178)
Off-farm activity participation(0 = not accessible, 1 = accessible)	OFAP	0.30 (.46)
Distance from Agricultural Development Center (kms)	DADC	4.83(3.66)
Are extension services on livestock available? (0 = no, 1= yes)	ADPES	0.66(.48)
Availability of veterinarian /animal health services? (0 = no, 1= yes)	AVS	0.94(.24)
Availability training services on livestock? (0 = no, 1= yes)	ATL	0.38(.49)
Have you used saving service institutions? (0 = no, 1= yes)	USS	0.47(.50)
Have you used credit service institutions? (0 = no, 1= yes)	UCS	0.34(.48)
Is crossbred cattle availably?(0 = no, 1= yes)	CBCA	0.70(.46)
Adoption of crossbred cattle(0 = no, 1= yes)	ACBC	0.50(.50)
Number crossbred cows	NCBC	0.99(1.35)
Total cattle in TLU(Tropical Livestock Unit)	TCTLU	5.13(2.63)

Before running the Heckman two stage models, the exogenous variables were checked for existence of multicollinearity and hetroscedasticity problem. A technique of Variance Inflation Factor (VIF) and Breusch-Pagan / Cook-Weisberg test were used to detect the problem of multicollinearity and hetroscedasticity among exogenous variables, respectively. Accordingly, the VIF (Xi) result showed that the data had no serious problem of multicollinearity (Table 24). This was because, for all exogenous variables, the values of VIF were less than 10. Therefore, all the exogenous variables were included in the model. On top of this, the hetroscedasticity test P-value was 0.9744 which was insignificant implying that there was no problem of hetroscedasticity.

Table 24: Variance Inflation Factor (VIF) for explanatory variables

Variables` symbols	VIF	1/VIF
FE	3.43	0.29
AHH	3.10	0.32
TCTLU	1.84	0.54
LH	1.75	0.57
TIMMP	1.58	0.63
UCS	1.51	0.66
CBCA	1.40	0.72
ELHH	1.38	0.72
USS	1.35	0.74
FS	1.30	0.77
DADC	1.30	0.77
OFAP	1.29	0.77
ADPES	1.28	0.79
GENDER	1.24	0.80
ATL	1.19	0.84
AVS	1.14	0.88
Mean VIF	1.63	

Probit model estimation of the determinants of dairy technology adoption and the values of marginal effects which were evaluated in first-stage Heckman selection at the means of all other independent variables are shown in Table 25. The probit model estimation gave a Pseudo-R^2 of 0.46 which implied that the variables included in the model were able to explain about 46 percent of the probability of farm households' decisions to adopt or not to adopt dairy technology. The Log-likelihood Ratio (LR) was also found to be significant at the 1% level (Table 25). This means that all the explanatory variables included in the model jointly influenced farmers' probability of adoption of dairy technologies. The model results also gave a predicted probability of adoption of 0.62. This means that there was about 62 percent probability that farm households in the areas were willing to adopt dairy technologies. Given the above mentioned goodness of fit measures, it was concluded that the probit model employed was reliable and appropriate.

Table 25: First-stage Heckman estimation results of determinants of probability of dairy technology adoption

Symbol	Coefficient	Marginal effect (dy/dx)	P> /Z/
Constant	-3.435(.691)	-	0.000***
GENDER	0.228(.218)	0.088(.085)	0.297
AHH	-0.034(.015)	-0.013(.006)	0.033**
FS	0.083(.044)	0.032(.017)	0.056*
ELHH	0.063(.191)	0.024(.073)	0.743
FE	0.043(.018)	0.016(.007)	0.014**
LH	-0.012(.133)	-0.004(.051)	0.930
TIMMP	0.00008(.00002)	0.00003(5.42e-06)	0.000***
OFAP	-0.510(.203)	-0.196(.077)	0.013**
DADC	-0.0001(.026)	-0.00005(.010)	0.996
ADPES	0.784(.193)	0.301(.072)	0.000***
AVS	0.846(.497)	0.327(.176)	0.089*
ATL	0.741(.184)	0.269(.065)	0.000***
USS	0.565(.189)	0.212(.069)	0.003***
UCS	0.044(.227)	0.017(.086)	0.847
CBCA	0.679(.187)	0.262(.073)	0.000***
TCTLU	0.026(.049)	0.010(.019)	0.595

Number of observations = 384, Wald chi^2 (16) = 124.25, Log pseudo likelihood = -142. 66, Pseudo R^2 = 0.46, Prob> Chi^2 = 0.0000, Observed probability =0.50, Predicted probability = 0.62. Numbers in brackets are robust standard errors. ***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively.
Source: Compiled by the researcher

Age of household head was negatively and significantly ($P<0.05$) associated with farmer`s likelihood to adopt dairy technology. As household head`s age increased by a year, the probability that household adopts dairy technology decreased by $1.3x10^{-2}$ %. Both family size and farming experience had positive and significant association with farmer`s likelihood to adopt dairy technology at less than 10% and 5% significance levels, respectively. When the family member increased by one, the probability that household adopts dairy technology increased by $3.2x10^{-2}$ % and as household head`s farm experience increased by a year, the probability that household adopts dairy technology increased by $1.6x10^{-2}$ %. Total income from milk and milk products, availability of dairy production extension services, availability of training on livestock, utilization of saving institutions and crossbred cow availability were also positively and significantly associated with farmer`s likelihood to adopt dairy technology at less than 1% significance level.

Availability of dairy production extension services was positively associated with farmer`s likelihood to adopt dairy technology. This indicated that good availability of dairy production extension services increased the probability of adopting dairy technology by 30.1%. Similarly, utilization of saving institutions and crossbred cow availability were positively associated with farmer`s likelihood to adopt dairy technology. These indicated that utilization of saving institutions and crossbred cow availability increased the probability of adopting dairy technology by 21.2% and 26.2%, respectively. On contrary to prior expectation, off-farm activity participation was negatively associated and statistically significant with farmer`s likelihood to adopt dairy technology. This indicated that off-farm activity participation decreased the probability of adopting dairy technology by 19.6%.

Results of second-stage Heckman selection estimation for the level of participation are shown in Table 26. The coefficient of Mills ratio (Lambda) in the Heckman two-stage estimation was significant at the probability of less than 1%. This indicated sample selection bias, existence of some unobservable farmer characteristics determining farmer`s likelihood to adopt dairy technology and thus affecting the intensity of adoption. The overall joint goodness of fit for the Heckman selection model parameter estimates was assessed based on the log likelihood ratio test. The null hypothesis for the log likelihood ratio test was that all coefficients are jointly zero. The model chi-square tests applying appropriate degrees of freedom indicate that the overall goodness of fit for the Heckman selection model was statistically significant at a probability of less than 1%. This shows that jointly the independent variables included in the selection model regression explained the intensity of adoption.

Age of household head and participation in an off-farm activity were negatively related and statistically significant ($P< 0.05$) with the intensity of dairy technology adoption. This indicates that holding other exogenous variables constant, an increase in household head age by a year resulted in $3.5x10^{-2}$ decreases in the intensity of dairy technology adoption. Similarly, as the off-farm activity participation increased by a unit results in 45.1×10^{-2} decreased in the intensity of dairy technology adoption. On the other hand, both farming experience, total income from milk and milk products, availability of dairy production extension service, availability of training on livestock, utilization of saving services and crossbred cow availability were correlated positively and statistically significant ($P<0.01$) with the intensity of adoption.

Regarding to farming experience, considering other exogenous variables constant, as it increased by a year, intensity of dairy technology adoption increased by 4.5×10^{-1}. Holding other exogenous variables constant, as total income from milk and milk products increased by one birr per annum resulted in $8.0 x10^{-5}$ increase in the intensity of dairy technology adoption. Holding other explanatory variables constant, utilization of saving services and availability of crossbred cow resulted in $58.7 x10^{-2}$ and $66.2 x10^{-2}$ increase in intensity of dairy technology adoption, respectively. Availability of veterinary service was also positively related and statistically significant ($P< 0.05$) with the intensity of dairy technology adoption. This implied that taking other independent variables constant, availability of veterinary service resulted in 82.7×10^{-2} increase in intensity of dairy technology adoption.

Table 26: Results of second-stage Heckman selection estimation of determinants of intensity of dairy technology adoption

Symbol	Coefficient	P> /Z/
Constant	-3.304(.699)	0.000**
GENDER	0.278(.211)	0.188
AHH	-0.035(.014)	0.012**
FS	0.049(.042)	0.247
ELHH	0.042(.198)	0.834
FE	0.045(.016)	0.005***
LH	0.005(.092)	0.957
TIMMP	0.00008(.00001)	0.000***
OFAP	-0.451(.222)	0.042**
DADC	-0.016(.028)	0.580
ADPES	0.834(.215)	0.000***
AVS	0.827(.413)	0.045**
ATL	0.711(.185)	0.000***
USS	0.587(.197)	0.003***
UCS	-0.019(.227)	0.934
CBCA	0.662(.227)	0.004***
TCTLU	0.038(.047)	0.414
LAMBDA	0.239(.046)	0.000***

Number of observations = 384, Wald chi^2 (16) = 1884.78, Prob >chi^2 = 0.000, Rho = 1.000, Sigma = 0.23936308, Censored observations = 195, Uncensored observations = 189. Numbers in bracket show Heckman two- stage Robust standard error. *** and ** indicate statistical significance at 1% and 5%, respectively.
Source: Compiled by Researcher

4.9 . Impact of Dairy Technology on Smallholder Farmers Livelihoods

The balanced propensity scores and then a best fit matching estimator to the data were used. Lastly, based on those propensity scores estimated and matching estimator selected, matching between adopters and non-adopters was done to find out the average treatment effect on the treated (ATT) for intended outcome variables.

4.9.1. Propensity score estimation

Prior to estimate propensity scores, the explanatory variables were checked for existence of multicollinearity and hetroscedasticity problem with appropriate technique as it is indicated in the method section. However it was done in the previous chapter (4.8.1) and indicated in Table 24. The first step in PSM was to determine the propensity score and satisfy the balancing property and it was done using the “pscore” command in Stata. Accordingly, twelve explanatory variables (Table 27) were identified after iteration to fulfill the criteria of “the balancing propensity is satisfied”.

Table 27: Propensity score estimation

variable	coefficient	Std. Err.	Z-value
GENDER	-0.018	0.180	-0.10
AHH	-0.0004	0.007	-0.06
FS	0.068	0.037	1.84*
ELHH	0.201	0.172	1.17
DADC	-0.080	0.022	-3.58***
ADPES	0.705	0.180	3.91***
AVS	0.018	0.330	0.05
ATL	0.800	0.162	4.90***
USS	0.723	0.171	4.22***
UCS	0.035	0.194	0.18
CBCA	0.761	0.187	4.08***
TCTLU	0.100	0.034	2.91***
constant	-2.277	0.532	-4.28***
Number of observation	384		
LR $chi^2(12)$	161.62		
Prob > chi^2	0.000		
Pseudo R^2	0.3036		
Log likelihood	-185.35625		

*** and * indicate statistical significance at 1% and 10%, respectively.

4.9.2. Choice of matching algorithm

Matching estimators were evaluated via matching the adopters and non-adopters households in common support region. Hence, based on the matching quality indicators, kernel matching with band width of 0.5 resulted in relatively low pseudo-R^2 with best balancing test (all explanatory variables insignificant) and large matched sample size as compared to other alternative matching estimators as indicated in Table 28. Then it was selected as a best fit matching estimator for this study.

Table 28: Performance measure of matching estimators at the study areas

Matching estimator	Performance Criteria		
	Balancing test	**Pseoudi-R^2**	**Matched sample size**
Nearest Neighbor (NN)			
NN(1)	5	0.239	330
NN(2)	5	0.236	330
NN(3)	5	0.222	330
NN(4)	5	0.215	330
NN(5)	5	0.211	330
Radius caliper			
0.01	5	0.164	279
0.25	5	0.239	330
0.50	5	0.239	330
Kernel matching(KM)			
Band width 0.1	5	0.191	330
Band width 0.25	5	0.127	330
Band width 0.5	5	0.008	330

NN= Nearest Neighbor

4.9.3. Testing of covariates` balance for adopters and non-adopters

The next task after choosing the best performing matching algorithm was to check the balancing of covariates by comparing the before and after matching algorithm significant differences using the selected matching algorithm. The balancing powers of the estimations were ascertained by considering different test methods such as the reduction in the mean standardized bias between the matched and unmatched households and equality of means using t-test. The mean standardized biases before and after matching are shown in the fifth column while the total bias reductions are reported in the sixth column of Table 29. In the present matching algorithm, the standardized bias difference in before matching is in the range of 3.2% and 70.6% in absolute value and t-values in the same table show that 75% of chosen variables exhibited statistically significant differences at before matching. After matching, the standardized bias differences for almost all covariates lied between 0.1% and 37.8% and all of the covariates were balanced. In all cases, it was evident that sample differences in the unmatched data significantly exceeded those in the samples of matched cases. Hence, the process of matching created a high degree of covariate balance between the treatment and control samples that were ready to be used in the estimation procedure.

Table 29: Testing of covariates` balance for adopters and non-adopters

Variables	Unmatched	Mean		% bias	% reduction	T- test	
	Matched	Treated	Control		/bias/	T	P>/t/
GENDER	Unmatched	0.739	0.708	7.0		0.68	0.495
	Matched	0.712	0.729	-3.8	45.5	-0.00	0.996
AHH	Unmatched	46.068	45.672	3.2		0.32	0.752
	Matched	45.552	45.961	-3.3	-3.3	-0.38	0.703
FS	Unmatched	6.542	5.667	39.3		3.85***	0.000
	Matched	6.239	5.919	14.4	63.3	-0.25	0.806
ELHH	Unmatched	0.630	0.438	39.3		3.85***	0.000
	Matched	0.619	0.523	19.7	49.7	0.03	0.980
DADC	Unmatched	4.239	5.428	-32.9		-3.22***	0.001
	Matched	4.476	4.696	-6.1	81.5	0.29	0.773
ADPES	Unmatched	0.786	0.536	54.6		5.35***	0.000
	Matched	0.748	0.686	13.8	74.8	-0.33	0.741
AVS	Unmatched	0.948	0.927	8.6		0.84	0.400
	Matched	0.945	0.945	-0.1	98.3	-0.26	0.794
ATL	Unmatched	0.542	0.219	70.4		6.89***	0.000
	Matched	0.496	0.401	20.8	70.4	-0.64	0.526
USS	Unmatched	0.641	0.307	70.6		6.92***	0.000
	Matched	0.601	0.423	37.8	46.5	-0.50	0.616
UCS	Unmatched	0.406	0.281	26.5		2.59**	0.010
	Matched	0.393	0.409	-3.6	86.4	-0.40	0.692
CBCA	Unmatched	0.844	0.547	68.0		6.66***	0.000
	Matched	0.816	0.746	16.0	76.4	-0.79	0.432
TCTLU	Unmatched	5.715	4.544	45.6		4.46***	0.000
	Matched	5.157	5.102	2.1	95.3	-0.56	0.577

% reduction /bias/= ((unmatched % bias – /matched % bias/)/ unmatched % bias)*100

4.9.4. Estimating the average treatment effect of the treated (ATT) with the matched sample and calculating standard errors

Here, the dairy technology`s impact on the outcome variables (total income from milk and milk products; availability of animal origin food for household consumption; able to send children to school; allow to hire labor for agricultural activities; allow to build new or renovate the existing family house; total milk consumed per day at farm level; total milk sold per annum in liter) were evaluated whether there was a significant impact on adopter households or not, with the pre-intervention differences controlled (Table 30 and 31).

Table 30 shows the estimates of average treatment effect (ATT) of dairy technology on production indicators such as total milk consumed per day at farm level (MCF), total milk sold per annum in liter (MSA) and availability of animal origin food for household consumption (AOF). As the result shows, the total milk consumed per day at farm level was 42% ((difference value/ treated value) * 100), which is significantly ($P<0.01$) higher in dairy technology adopter households than control groups (non-adopters). As it is also indicated in the same table, on average, the dairy technology adopter household sold 1674 liters more milk per annum than the non-adopters and this result is statistically significant ($P<0.01$). Regarding to the availability of animal origin food for household consumption, it is 20% more practiced in adopters than non-adopters and it is statistically significant ($P<0.05$).

Table 30: Estimates of average treatment effect (ATT) on production indicators

Intervention	Variables	Treated (Adopters)	Control (Non-adopters)	Difference	S.E.[b]	T- stat
ACBC	**MCF**	0.53117	0.30806	0.22310	0. 08293	3.03***
	MSA	3092.88	1418.37	1674.51	541.859	4.80***
	AOF	0.78528	0.62550	0.15977	0.08450	2.84**

ACBC = adoption of crossbred cow**; AOF** = availability of animal origin food for household consumption; **MCF** = total milk consumed per day at farm level; **MSA** = total milk sold per annum in liter. *** and ** means significant at 1% and 5% probability levels, respectively; [b] The bootstrapped SE is obtained after 100 replications.

As it is indicated in Table 31, total income from milk and milk products (TIMMP), able sending children to school (ASCS), hire labor for agricultural activities (AHLAA) and able to build new and/or renovate the existing family house (ABNFH) were taken as income indicators.

Total income from milk and milk products showed that on the average, treated households (adopters) got 73% more income from milk and milk products per annum than the controls (non-adopters) and this difference was statistically significant (P<0.01). The average treatment effect of the dairy technology on sending children to school is also shown in the same table and it reveals that dairy technology adopter households got 32% more opportunity to send children to school than non-adopter households and the result was statistically significant (P<0.01). Adopter households had also 50% and 40% more chances than non-adopters on hiring labor for agricultural activities and build new or renovate the existing family house, respectively; differences statistically significant at (P<0.01).

Table 31: Estimates of average treatment effect (ATT) on income indicators

Intervention	**Variables**	**Treated (Adopters)**	**Control (Non-adopters)**	**Difference**	**S.E.**[b]	**T- stat**
ACBC	**TIMMP**	24158.45	6501.47	17656.98	2512.73	8.29***
	ASCS	0.66258	0.45054	0.21203	0. 10326	3.57***
	AHLAA	0.36196	0.18231	0.17966	0. 07888	3.47***
	ABNFH	0.46626	0.27982	0.18644	0. 11200	3.42***

ACBC = adoption of crossbred cow**; TIMMP** = total income from milk and milk products; **ASCS** = allow to send children to school; **AHLAA** = allow to hire labor for agricultural activities; **ABNFH =** allow to built new or renovate the existing family house. *** means significant at 1% probability level; [b] The bootstrapped SE is obtained after 100 replications.

5. DISCUSSION

The overall mean value of family size in the study areas (6.10 person per household) was comparable to what was reported by Getnet (1999) (5-7 persons per household) and lower than the finding of (Kelay, 2002) (7.54 person per household) for *Selale*. The mean number of lactating cows and average daily milk yield per cow, which were positively and significantly affected by family size, were also in agreement with the reports made by kelay (2002). The later stated that households with larger family size were encouraged to own more lactating cows and were able to manage the herd properly since they had a relatively large family labor force. About 98.7% of the households were literate at least at basic education level in this study but this value was higher than the report of Eshetu (2008) for *Ada`a woreda* in Ethiopia (89.3%). Educational level of the household heads had also positive significant ($P<0.01$) effect on both mean number of lactating cows and average daily milk yield per cow. It could be said that households with higher education level were more likely to manage, feed properly and protect animals from disease which resulted in owning of large number of lactating cows and producing larger volume of daily milk yield.

The finding, nearly 28% of the farms were female headed was slightly higher than the result reported by Mekonnen *et al.* (2010) for *Dejen* district. These female headed households produced a significantly ($P<0.05$) greater average daily milk yield per cow than the male headed ones. Nearly 49% of household heads had less than twenty years farming experience in this study and this result is in agreement with the findings of (Kelay, 2002) (51.5%) for *Selale* area. Average daily milk yield per cow was affected significantly ($P<0.01$) by farming experience. Households with longer farming experiences, due to the wealth of knowhow they acquired through practices and trainings, managed and fed their animals properly which resulted in producing higher volume of daily milk yield per cow.

The mean total livestock holding per household in these study areas was 5.94 TLU which was considerably lower than what was reported by Gashaw (1992) (10.6TLU) for *Selale* area and Solomon (1996) (11TLU) for the central highlands of Ethiopia. Most of the livestock herd was cattle (87%) and this was in agreement with the finding of Tefere (2007) for *Sululita* district (85%). The number of lactating cows and average daily milk yield per cow of the Oromia National Region State were significantly (P<0.01) higher than those of the Amhara National Region State. This may be due to the proximity of the area to the capital city. The areas near to the capital city have a better access for crossbred heifers market, concentrated feed, animal health services and fresh milk market which might be an incentive to the farmers to have relatively high number of lactating cows and higher milk production per cow than those from the remote areas (Amhara National Region State).

In this study, both average daily milk yield per cow (2.34 liter for local and 11.44 liter for crossbreds) and average milk yield per lactation stage (216.34 liter for local and 1125 liter for crossbreds) at the early lactation stage for both local and crossbreds were greater than those of mid and late lactation stages. These values were different from the findings of Addisu *et al.* (2011) (2.1 liter and 7.9 liter of average daily milk yield per cow and 296 liter and 1803 liter milk yield per lactation stage, respectively, for local and crossbred cows in Amhara National Regional State). However, both studies showed that smallholder farmers who owned lactating crossbred cows produced considerably higher milk yield in all lactation stages than those who owned lactating local breed cows.

Fresh milk consumption at home was influenced by physical location of the farms, amount of milk produced and market accessibility for fresh milk among other factors, and about 89%, 5.7% and 4.5% of the total daily milk yield was sold, consumed at home as fresh milk and processed in to other products, respectively. The percentage of fresh milk consumed and processed per day in this study was considerably lower than the report of Lemma *et al.(* 2005) (83.3% and 16.7%, respectively). This difference might be due to difference in the areas where the two studies took place, which might also be influenced by culture and the accessibility of fresh milk market. Ahmed *et al.* (2004) stated that the consumption of milk and milk products vary geographically between the highlands, the low lands and level of urbanization.

In all the six study areas, farmers practiced both formal and informal marketing systems to sell their milk. About 89.2% of milk produced in the study areas (2624.14 liters per day) was destined to market through both formal and informal marketing systems. 22% of the total milk sold was marketed through the informal channel, which includes private collectors, neighbors and itinerant traders. On the other hand, the organized system, which is called formal market accounts for about 78 % of total milk sold per day where co-operatives are the key actors. This result was considerably higher than the report of Negash *et al. (*2012 liter) (28.4%) for Mid Rift Valley of Ethiopia. The present study was done in the places where fresh milk market was/is relatively good through cooperative and other private milk collectors.

During the study period not all respondents were registered in dairy cooperatives. Reasons mentioned were low milk production (28.4%), need for processing at home (4.9%), inability to pay membership fee (2.3%), lack of awareness (2.1%), loss of trust on cooperatives (1.6%) and distance from cooperative center (0.3%). These reasons corroborate with the ones reported by Spielman *et al*.(2008); farmers did not join the cooperatives because; (i)they didn‘t know if the cooperatives could benefit them, (ii)some people were not being accepted into the cooperative while (iii) others preferred to wait and see if the cooperatives could benefit so that they could join, (iv) feared to invest in the cooperatives because they were not sure if they could get back their money,(v) had issues of trust in the organization,(vi) lacked awareness about the cooperatives, (vii) some reported not having land in the area where the cooperative was located and lastly (viii) some farmers reported that they did not have money to meet membership requirements.

Both income per liter and milk value added distribution among different actors along the value chain was not uniformly distributed. The income received by the producers per liter of fresh milk was equal to 43.8% of the total income of the whole milk value chain while the processors received 31.25%. On the other hand, the processors, retailers, wholesaler and collectors received 55%, 22.2%, 21.1% and 1.1 % value addition shared, respectively. This result was in agreement with the findings of Nga *et al*. (2011) which stated that value added seems distributed unequally among actors along the chain and the farmers, who spend most of the investment, received only one fifth the total value added of the whole chain.

The overall mean fat content of 5.22% in the study areas was higher than what was reported by Francesconi (2006) for cooperative smallholders in Ethiopia (4% fat). Results from analysis of variance (ANOVA) showed that milk samples from remote districts (*Yetenora* and *shemeshengo* in Amhara National Regional State) had significantly ($P<0.01$) higher fat content than the study sites situated closer to the capital city (*Babogaya* and *Debretsige*). This might be due to less utilization of crossbred cows and feeding staffs almost entirely composed of roughages in the remote areas. Local breeds are known to test higher fat percentage than cross or pure exotic breeds (Mesfin and Getachew, 2007) and feeding staffs with low fiber content have depressive effect on fat percentage (Onetti *et al*. 2001). The protein content of 3.12% observed in the present study is, however, comparable to the report by Francesconi (2006).

The TBC as well as TCC results showed significant differences ($P<0.01$) between the study areas, reflecting variability in hygienic conditions of milk handling in different locations. Milk samples from *Debretsegie* had least counts both for TBC and TCC while milk samples from *Babogaya* site had highest values for TBC and TCC. On the other hand *Debretsegie* milk samples tested highest for SCC. What can be speculated is that at *Debretsegie* study site, dairy cows were managed poorly as can be seen from high SCC indicating mastitis problem, but milk handling practices was relatively good; least contamination was observed. The high bacteria count in *Babogaya* and *Torbenashe* may be due to poor animal health management as well as poor hygienic conditions in milk handling. The overall mean total bacteria count (TBC) in the present study (8.0 $\log_{10}$ cfu/ml) is higher than what was reported by Asaminew and Eyassu (2010) (7.58 $\log_{10}$) but lower than the report of Francesconi (2006) (8.78 $\log_{10}$ cfu/ml) and it was highly greater than the minimum quality standard value set for the country (2×10^6(6.30 $\log_{10}$)), ES (2009). The overall mean coliform count (4.5 $\log_{10}$ cfu/ml) was, however, similar to the reports of Asaminew and Eyassu (2010) (4.49 $\log_{10}$ cfu/ml).

Adulteration had positive significant ($P<0.01$) association with freezing point. This result is in line with what was reported by Kurwijila (2006). The later stated that adulteration lowers the specific gravity and increases the freezing point of milk. Adulteration also increased total coli form count with the rate of 0.03%. Therefore, milk adulteration might, at least partly, explain the difference in milk bacterial count between the different study areas. Both physico-chemical and microbial quality of the milk could be affected by different explanatory variables. Breed had a positive significant (P<0.01) effect on fat and protein percentage of fresh cow milk. Local breed cows` fresh milk has greater fat and protein content with 0.74 and 0.1% respectively, higher than crossbred cow but it has 0.01% lower freezing point. This result is in agreement with the finding of Fikirneh *et al.*(2012), which stated that local Arsi zebu cows (5.87 ± 0.25%) were observed to have high fat percent than crossbred cows (5.02 ± 0.25%). Protein content of the milk was increased by 0.04% when the parity number of the cow increased by one but the fat content was decreased by 1.15% and the overall mean value of protein (3.12 %) in the study area was slightly lower than Ethiopian standard value (3.20%), ES (2009).

Stall fed herds produced milk with 0.1% less protein content and 0.89% increased somatic cell count compared to free grazing animals. The increased risk of mastitis (higher somatic cell count) in stall fed cows was also reported by FRELICH and ŠLACHTA (2011). Education also has a positive significant (P<0.1) association with somatic cell count. Education, by improving access to information, might have a role to play in influencing udder health.

The group discussion findings on disease status that showed mastitis, milk fever and respiratory problems become high in the “after” situation than in the “before” situation of dairy technology transfer might be from intensification dairy farming. Traditional animal treatment and religious healing were highly performed than governmental and private modern animal health services in the “before” situation in all study areas. On the other hand, in the “after” situation governmental and private modern animal health services highly practiced with different rates. This finding was in line with the report of Dehinenet (2008) who stated that smallholder farmers also become aware of veterinary services and they leave the religious healing and other traditional treatment methods and then shifted to the modern animal health treatment after certain dairy technologies practiced in *Dejen* district.

The groups` discussions results that showed changes of about 2.35 and 1.19 times more milk production in the “after” situation of dairy technology transfer in Amhara and Oromia National Regional States, respectively was comparable with the report of Dehinenet (2008) that even gave a five times increase in the “after” situation than in the “before” situation. Fresh milk consumption increased up to nine times in the “after” situation than in the “before” whereas other milk product consumption decreased in the “after” situation than in the “before”. This is also in line with report of Tolera (2007) that described the most important uses of milk in the “before” situation as milk for butter making, milk for children, milk for home consumption and milk for cheese making, in the decreasing order; for the “after” period, milk for sell was given the highest score which was almost 6 fold compared to the “before” situation.

Milk for processing, family consumption and giving neighbors were the leading categories in the “before” situation in both Regions. Inversely, milk for sell became the leading category which was increased sixteen times and four times in the “after” technology transfer than in the “before” situation of Amhara and Oromia National Regional States respectively. Selling of milk increased in the “after” situation in both Regions was due to milk production increment (more than two times), establishment of dairy cooperatives (market access), and high demand of cash income and increment of milk price than in the previous. This idea is in agreement with the report of Dehinenet (2008) that stated gradual increment of milk and butter prices as well as the need of farmers for more cash income, which resulted in the shifting of milk utilization from household and children consumption to the market products.

The probability of dairy technology adoption and its intensity associated negatively and significantly ($P<0.05$) with age of household heads. This finding is in line with Quddus (2013) report which stated that the probability of adoption decreased with the increase of age of household heads. It could be hypothesized that more educated and younger farmers are more ready to try the dairy technology whereas older farmers may be more conservative to participate in the new technology dissemination process and practices. But both family size and farming experience had positive and significant association with the probability of dairy technology adoption. This finding is also in line with the same author Quddus (2013) which stated that Adoption of dairy technology is positively associated with level of farmer’s education and farming experience; household income and earning members.

Household with large family size could have a high probability of dairy technology adoption which is similar with the finding of Howley *et al.* (2012). As per the later, farmers with children were much more likely to use AI in a given period. This justifies that dairy technology needs more labor, hence having more family size could alleviate labor scarcity that constitute one of the limitations for technology uptake. The probability of dairy technology adoption and level of use increased with the increase of farmer`s farming experience. Practices and experiences lead the farmers to have a better knowhow to handle technologies and understand their benefits easily.

Availability of dairy production extension services was positively associated with farmer`s probability of dairy technology adoption and use level. This result is in agreement with the finding of Amelaku *et al.* (2012). The later reported that the probability of adopting dairy technology increases by 43% for at least a onetime visit by the extension service per year. This implies that farmers that have access to extension services could get good information about the technologies that result in a high probability of adoption.

Availability of crossbred cows and accessibility of saving institutions were also positively associated with farmer`s likelihood to adopt dairy technology and level of adoption. As the technology is available in the areas the probability of adopting the technology increases. This is because it reduces the transport cost and farmers may learn more about the technology by observing which initiate them to adopt. This is consistent with the report of Akudugu *et al.* (2012). As per the later, the availability of modern agricultural production technologies to end users, and the capacities of end users to adopt and utilize these technologies are critical. Having access to formal (bank and microfinance) and informal (Iquib) saving institutions create a good opportunity for farmers to have an asset and to purchase different agricultural technologies including crossbred cows. On contrary to prior expectation, off-farm activity participation is negatively associated and statistically significant with both farmer`s likelihood to adopt dairy technology and level of adoption. This result is in line with the finding of (Howley *et al.*, 2012) stated that off-farm job much less likely to adopt AI. This could be due to time constraints of the individual farmer to adopt the dairy technology.

Total income from milk and milk products and availability of training on livestock production are positively and significantly ($P<0.01$) correlated with the intensity of adoption of dairy technologies. Getting high income from milk empowered farmers economically and triggered them to get more dairy technologies. Muzari *et al.* (2012) stated that the major option for increased adoption of technology is to overcome the income/ capital constraint through increased credit provision. The availability of livestock training also increases the level of dairy technology adoption through creating awareness on the advantages of the technology and then improving the farm management skill. Therefore, farmers in the areas of training availability could adopt more and owned more dairy technology than non-training areas` farmers. This is in agreement with Quddus (2013) report that indicated more knowledge on improved technologies through training, availability of reliable and continuous technical assistance, availability and low price of concentrate feeds, increased and timely provision of medicine, increasing AI facilities, providing pure breed and strengthening extension services as the main suggestions from farmers.

Total milk consumed per day at farm level in dairy technology adopter households 42% higher than control groups (non-adopters) and the dairy technology adopter household selling 1674 liters more milk per annum than the non-adopters were the outputs of adopter smallholder farmers use of improved dairy breeds and improved techniques in feeding, breeding and animal health. Mosnier and Wiek (2010) also 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 technology.

Propensity score matching analysis also showed that adopter smallholder farmers, on an average, could get 73% more income from milk production than the non-adopter smallholder farmers. Positive relationship exists between the productivity of a herd and the income received by the farmer per cow. With more productive milking herds, farmers produced more milk and received more income from selling. This result is in line with the finding of Medola (2007) which stated what farmers gain from new agricultural technology has a direct influence on the poor households by raising their income while indirectly raising employment and wage rates on landless laborers.

6. CONCLUSSION AND RECOMMENDATIONS

Smallholder dairy farming is an important economic activity in the study areas. Cattle were the predominant species representing 86.8% of the total TLU. Average number of cattle herd size per household was 6.36 of which 56.7 % and 43.3% were local and crossbred cows, respectively. Female headed farms produced higher average milk yield per cow than the male headed ones and it was significantly varied between the different study areas both for local and crossbred cows. Milk yield was also influenced by household head's education level, farming experience, family size, land holding and/or cooperative membership. The average number of lactating cows and average daily milk yield per cow of the Oromia National Region State were higher than those of the Amhara National Regional State. Milk production per lactation, for crossbred animals, was four times higher than for local breeds and regardless of the breed, both average daily milk yield per cow and average milk yield per lactation stage were greater at the early lactation than at mid and late lactation stages.

Fresh milk consumption at home was influenced by physical location of the farms, amount of milk produced and market accessibility for fresh milk, among other factors. Selling raw milk represented more than 86% of the daily milk production which was marketed through both informal and formal systems (mostly cooperative members). Smallholder farmers registered in dairy cooperatives were 6.6% of the total. Low milk production, need for milk processing at home, inability to pay membership fee, lack of awareness, loss of trust on cooperatives and distance from cooperative center were identified as determinants for not joining cooperatives.

The price of fresh milk was highly influenced by different exogenous factors such as location, transport access, marketing system, seasonal variation and processors` demand. Remote and less transport accessed areas have less fresh milk price. It also decreased with the decreases of processors` fresh milk demand and during the fasting period. Input supply, production, collection, wholesaling, processing, retailing and consumption were identified as main stages of the milk value chain in the study areas. Milk was transported using people back and cart or donkey from producer to cooperative and/or collection centers and female family members were the ones doing this job in most cases.

Milk quality problems started at farm level either of internally from animals and/or external factors. Milkers` cleanness and hygiene, milking container cleanness, barn condition and environment were some of the external factors which affected the quality of milk by creating favorable condition for coliform bacteria production. On the other hand, regular animal health check up at farm level was almost inexistent. Total bacterial count (TBC) load and coliform count (CC) load increased at different critical points of the milk value chain as compared to at farm gate.

Total bacterial count (TBC), total coli form count (TCC) and somatic cell count (SCC) test results illustrated that the quality of milk in the study areas was poor as compared with the established standard of raw milk quality in Ethiopia. TBC and TCC increased at different critical points along the milk value chain. Significant difference in milk quality was also observed among the study sites and between the different critical points of the value chain. Adulteration that was commonly observed in areas that are near to the capital city or that have access to fresh milk market strongly affected the quality of fresh milk.

Introduction of crossbred cows allowed to considerably decreasing the incidence of a number of animal diseases such as Pasteurellosis, Bloating, Foot and Mouth Disease (FMD), Anthrax, Brucellosis, Internal Parasite, Blackleg and Lumpy Skin Disease (LSD). Mastitis, Milk fever and Respiratory Problem, however, become more prevalent in the post technology introduction period.

The probability of crossbred cows adoption and its level of use were found to be influenced by family size, farming experience, availability of dairy production extension services, availability of crossbred cows, accessibility of saving institutions, total income from milk and milk products, availability of training on livestock, age of household head and off-farm activity participation. Introducing and disseminating appropriate dairy technologies to smallholder farmers with a continuous follow up could improve livelihoods of smallholder farmers, narrow the milk demand – supply gap and have a good public health implication nation wise. Accordingly, the following recommendations are forwarded.

- Introducing different dairy technologies (crossbred cows, milk quality testing materials and processing machine) should be supported with a continuous training or technical backup on how to manage and utilize the technologies.
- Dairy technology input and/or service providers should undertake follow ups to identify problems and/or evaluate the use and benefits of the interventions.
- A sustainable supply of crossbred heifers/cows at a reasonable cost and supported with continuous training or technical backup will be of great help to smallholder farmers.
- The concerned public institutions should institute milk quality control and quality based payment to insure milk and milk products quality in the course of production, transportation, processing, marketing and consumption.
- Further microbial work on bacterial isolation should be done in order to implement a proper intervention on raw milk quality.
- Availing regular platforms/forums for milk value chain actors to communicate and discuss between them might help to narrow gaps in fulfilling the infrastructure needs and delivering inputs and services.
- There should be technical support and awareness creation by extension workers for smallholder milk producers to have a strong direct linkage with consumers for fresh milk marketing in order to shorten the chain length and minimize quality deterioration.
- A small to medium milk processing plant at the union level will help to minimize the milk price fluctuation and maximize a sustainable income of the smallholder farmers.
- Ethiopian dairy cooperatives should be transformed into dairy business hub that enables farmers to access both services and inputs in their vicinities.
- Further study, wider coverage, that assesses cost-benefit aspects of dairy technology (crossbred cows) adoption, should be sought.

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8. APPENDICES

Appendix A: Appendix Tables

Appendix Table 1: TLU conversion factors for different species of livestock

Types of animals	Indigenous bred		Crossbred	
	Live weight	TLU	Live weight	TLU
Cow	250	1.00	380	1.5
Heifres	125	0.5	150	0.6
Oxen/young bulls	250	1.0	300	1.2
Calves	50	0.2	50	0.2
Sheep and Goats	22	0.1		
Horse and Mules	200	0.8		
Donkeys	90	0.4		

Source:(Varviko,1991)

Appendix Table 2: Average daily milkyield and milk use categories in smallholder farms owning crossbreed and local cows

Parameters	breeds	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
average daily milk yield	local	216	2.54926	4.541764	.309028	1.94015	3.15837	.25	59.50
	crossbred	168	1.23423E1	13.791664	1.064050	10.24154	14.44298	1.00	80.00
	Total	384	6.83370	10.871050	.554761	5.74294	7.92446	.25	80.00
Consumed within the household per day (lt)	local	216	.29762	.486330	.033091	.23239	.36284	.00	4.00
	crossbred	168	.52232	.646750	.049898	.42381	.62083	.00	3.00
	Total	384	.39592	.572377	.029209	.33849	.45335	.00	4.00
Giving for neighbors per day (lt)	local	216	.0223	.12554	.00854	.0055	.0392	.00	1.00
	crossbred	168	.0417	.46884	.03617	-.0297	.1131	.00	6.00
	Total	384	.0308	.32370	.01652	-.0017	.0633	.00	6.00
Kept for processing to other products (lt)	local	216	.4220	.75750	.05154	.3204	.5236	.00	4.00
	crossbred	168	.1637	.62686	.04836	.0682	.2592	.00	5.00
	Total	384	.3090	.71409	.03644	.2374	.3807	.00	5.00
Sold as liquid milk per day (lt)	local	216	1.8027	4.50088	.30625	1.1990	2.4063	.00	57.50
	crossbred	168	11.6146	13.64792	1.05296	9.5358	13.6934	1.00	80.00
	Total	384	6.0954	10.78628	.55044	5.0131	7.1776	.00	80.00

Appendix Table 3: Raw milk utilization status in the study areas

Parameters	Areas	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
average daily milk yield	Debre Tsigie	72	1.15625E1	12.368730	1.457669	8.65599	14.46901	.50	59.50
	Torbenashe	61	6.40984	7.545699	.966128	4.47729	8.34238	.50	42.00
	godino	32	5.17625	7.633265	1.349383	2.42416	7.92834	.25	32.00
	Babogaya	53	1.25755E1	20.447199	2.808639	6.93953	18.21142	.25	80.00
	Shemshengo	67	3.34701	3.780922	.461913	2.42478	4.26925	.25	16.50
	Yetnora	99	3.47727	3.362854	.337980	2.80656	4.14798	.25	16.50
	Total	384	6.83370	10.871050	.554761	5.74294	7.92446	.25	80.00
Consumed within the household per day (lt)	Debre Tsigie	72	.61111	.746929	.088026	.43559	.78663	.00	3.00
	Torbenashe	61	.46311	.637109	.081574	.29994	.62629	.00	2.00
	godino	32	.48938	.472781	.083577	.31892	.65983	.00	2.00
	Babogaya	53	.45047	.713174	.097962	.25390	.64705	.00	4.00
	Shemshengo	67	.22761	.321959	.039334	.14908	.30614	.00	1.00
	Yetnora	99	.25253	.368559	.037042	.17902	.32603	.00	1.50
	Total	384	.39592	.572377	.029209	.33849	.45335	.00	4.00
Giving for neighbors per day (lt)	Debre Tsigie	72	.1111	.72297	.08520	-.0588	.2810	.00	6.00
	Torbenashe	61	.0000	.00000	.00000	.0000	.0000	.00	.00
	godino	32	.0412	.16232	.02869	-.0173	.0998	.00	.66
	Babogaya	53	.0472	.17024	.02338	.0002	.0941	.00	.75
	Shemshengo	67	.0000	.00000	.00000	.0000	.0000	.00	.00
	Yetnora	99	.0000	.00000	.00000	.0000	.0000	.00	.00
	Total	384	.0308	.32370	.01652	-.0017	.0633	.00	6.00

Appendix Table3 (*Continued*---)

Kept for processing to other products (lt)	Debre Tsigie	72	.1181	.52065	.06136	-.0043	.2404	.00	3.00
	Torbenashe	61	.3115	.90330	.11566	.0801	.5428	.00	5.00
	godino	32	.4425	.67685	.11965	.1985	.6865	.00	2.50
	Babogaya	53	.7453	1.08363	.14885	.4466	1.0440	.00	4.00
	Shemshengo	67	.1903	.35911	.04387	.1027	.2779	.00	1.00
	Yetnora	99	.2500	.54163	.05444	.1420	.3580	.00	4.00
	Total	384	.3090	.71409	.03644	.2374	.3807	.00	5.00
Sold as liquid milk per day (lt)	Debre Tsigie	72	10.7222	12.08534	1.42427	7.8823	13.5621	.00	57.50
	Torbenashe	61	5.6352	7.35804	.94210	3.7508	7.5197	.00	41.00
	godino	32	4.2344	7.48554	1.32327	1.5355	6.9332	.00	30.00
	Babogaya	53	11.2948	20.70804	2.84447	5.5870	17.0027	.00	80.00
	Shemshengo	67	2.9291	3.86951	.47274	1.9853	3.8730	.00	16.50
	Yetnora	99	2.9747	3.47522	.34927	2.2816	3.6679	.00	16.50
	Total	384	6.0954	10.78628	.55044	5.0131	7.1776	.00	80.00

Appendix Table 4: Analysis of marginal effects

Number of obs = 384
Wald chi2(16) = 124.25
Prob > chi2 = 0.0000
Log pseudolikelihood = -142.66297
Pseudo R2 = 0.4640

ACBC	dF/dx	Robust Std. Err.	z	P>|z|	x-bar	[95%	C.I.]
GENDER*	.0879801	.08496	1.04	0.297	.723958	-.078538	.254499
AHH	-.0128937	.0060513	-2.13	0.033	45.8698	-.024754	-.001033
FS	.0318318	.0168664	1.91	0.056	6.10417	-.001226	.064889
ELHH*	.0239657	.0732891	0.33	0.743	.533854	-.119678	.16761
FE	.0164136	.0067825	2.45	0.014	22.6068	.00312	.029707
LH	-.004419	.0506673	-0.09	0.930	1.76353	-.103725	.094887
TIMMp	.0000314	5.42e-06	5.00	0.000	15748.1	.000021	.000042
OFAP*	-.1959173	.0772263	-2.50	0.013	.302083	-.347278	-.044557
DDTAC	-.0000527	.0100942	-0.01	0.996	4.8337	-.019837	.019732
ADPES*	.3007413	.0717338	4.06	0.000	.661458	.160146	.441337
AVS*	.3267433	.1759073	1.70	0.089	.9375	-.018029	.671515
ATL*	.2693064	.0652545	4.03	0.000	.380208	.14141	.397203
USS*	.2121545	.0686828	2.99	0.003	.473958	.077539	.34677
UCS*	.0166632	.0863561	0.19	0.847	.34375	-.152592	.185918
CBCA*	.2621909	.072529	3.63	0.000	.695313	.120037	.404345
TCTLU	.0099362	.0186999	0.53	0.595	5.12943	-.026715	.046587
obs. P	.5						
pred. P	.6163623	(at x-bar)					

(*) dF/dx is for discrete change of dummy variable from 0 to 1
z and P>|z| correspond to the test of the underlying coefficient being 0

Appendix Table 5: Average treatment effect (ATT) estimation results

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
AAOFHC	Unmatched	.786458333	.630208333	.15625	.045819325	3.41
	ATT	.785276074	.625504035	.159772039	.056246674	2.84
	ATU	.622754491	.831880615	.209126124	.	.
	ATE			.184748197	.	.
consumedperday	Unmatched	.58375	.352630208	.231119792	.064900066	3.56
	ATT	.531165644	.308064381	.223101263	.073623616	3.03
	ATU	.35002994	.408738884	.058708944	.	.
	ATE			.139908786	.	.
SR_8_2a1	Unmatched	3459.24219	831.375	2627.86719	321.853435	8.16
	ATT	3092.88037	1418.37061	1674.50976	348.912719	4.80
	ATU	954.305389	2399.78051	1445.47512	.	.
	ATE			1558.60435	.	.
TIHHp	Unmatched	25693.0443	5803.15365	19889.8906	1980.52441	10.04
	ATT	24158.454	6501.47377	17656.9802	2130.86455	8.29
	ATU	6292.47006	19113.8577	12821.3877	.	.
	ATE			15209.8773	.	.
ASCT	Unmatched	.692708333	.359375	.333333333	.048164645	6.92
	ATT	.662576687	.45054359	.212033097	.059398363	3.57
	ATU	.389221557	.588510593	.199289037	.	.
	ATE			.20558383	.	.
AHLAA	Unmatched	.390625	.208333333	.182291667	.045992324	3.97
	ATT	.36196319	.182305265	.179657925	.051832368	3.47
	ATU	.167664671	.33144701	.163782339	.	.
	ATE			.171623916	.	.
ABMFH	Unmatched	.526041667	.171875	.354166667	.045283043	7.82
	ATT	.466257669	.279817606	.186440063	.054487649	3.42
	ATU	.19760479	.440257628	.242652837	.	.
	ATE			.214887133	.	.

Appendix B: Survey questionnaire format for household head interview

Date of interview ______/_____/_____ Code No______ District___________
Kebele__________ Village_______________Time interview started:____________Time interview ended:_____________

Instruction: - First explain the purpose of interview to the households

- Use pencils only, encircle the numbers for closed questions and write the responses precisely for open questions.

SECTION 1. Household head profile

1.1. Name______________Sex ____Age: ____ (years)

1.2. Family size____; No of female______; No of male_____; No of children under 12______

1.3. Level of education (write “X”)

Basic education___; Elementary (1-6) ___; Junior (7-8) ___; Secondary school and above__

1.4. Marital status: 1. Married_____ 2. Single_____

SECTION 2. General farm information

2.1. Land assets

Parcel* ID	Land used pattern	Parcel Description /Name	Size of this parcel	Unit of land (Code)	Tenure system (Code)	If parcel **is *owned,*** who owns (Code**)**
1	Total land area					
2	Land used for crop cultivation					
3	Land used for forage development					
4	Land used for grazing					
5	Land used for homestead					
5	If others specify					

UNIT OF LAND	**TENURE SYSTEM**	**IF OWNED, NAME ON TITLE/CERTIFICATE:**
1= acre 2=ha 3=sqm^2 4= other, specify conversion in metric system	1= Title deed 2= Owned but not titled 3= Public land 4= Rented-in/ sharecropped 5=Other (specify)	1= Male 2= Female 3= Joint 4=Other relative 5= Other

**parcel is one contiguous plot of land. One parcel can contain more than one plot.*

2.2. Number of animals on the farm:

Livestock species		Number owned by male	Number owned by female	Number owned jointly	Number owned by the household (total)
Cattle					
Cow	local				
	cross				
Oxen/bull	local				
	cross				
Heifers	local				
	cross				
Calves	local				
	cross				
Sheep/goats					
Horses					
Donkeys/mules					
poultry					

2.3. Feed resources and feeding systems

2.3.1. What are the major cattle feeding systems you use?

	Feeding scheme	Tick appropriate
1	Free grazing	
2	Rotational grazing	
3	Stall-feeding	
4	Others, specify!	

2.3.2. What types of feeds do you use? (Tick)

No.	Feed sources	Tick appropriately	Quantity bought (kg) in the last 12 months	Total Amount paid (Birr)
1	Crop residues(straw)			
2	Hay			
3	Green grass			
4	Forage			
5	Beer preparation residues (Atela)			
6	Areki (ethanol) residues			
7	Oil seed cakes			
8	Wheat bran			
9	Wheat middling			
10	Molasses			
11	Silage			
12	Mineral blocks			
13	Chemical treated straw			
	Others (please specify)			

2.3.3. What is the source of water used for cattle? (Encircle)

Water sources	For Cattle	Place of watering animals	For dairy equipment sanitation
1.Tap/ Pipe			
2. Rain			
3. Wells			
4. Pond			
5. River			

2.3.4. How frequent the animals are watered? (Encircle)

1. Free access 2. Once a day 3. Twice a day 4. Three times a day 5. Others__________

2.4. Animal barn condition

No.	Types of animals	Types of housing					
		Open with enclosure	Traditional hut	In proved hut	Separate (dairy) barn	In family house	Other specify
1	Calves						
2	Local cows						
3	Crossbred cows						
4	Bulls						

2.5. What are the main purposes of keeping cattle?

1. Milk 2. Traction 3. Manure 4. Meat production 5. Others specify

2.6. Indicate source of income from livestock production for in last 12 months**!**

2.6.1. Have you sold any livestock and /or livestock products in last 12 months?

1.Yes 2. No

2.6.1.1. If **Yes** for the above question, please provide the information on the livestock you sold and revenue obtained during the same period?

No.	Livestock Species	Unit	Amount sold	Unit price	Reason of selling
1	Oxen/ Bulls	Number			
2	Cows	Number			
3	Heifers	Number			
4	Calves(<one year)	Number			
5	Sheep	Number			
6	Goat	Number			
7	Poultry	Number			
8	Horse	Number			
9	Donkey/mule	Number			
10	Others specify				

2.6.1.2. If say **Yes** for the above question 8.1.1, please provide the information on the livestock products you sold and revenue obtained during the same period?

No.	livestock product types	Unit	Amount sold	Unit price	Reason of selling
1	Fresh milk	Liters			
2	Sour milk	Liters			
3	Butter	Kilo			
4	Egg	Number			
5	cheese	kg			
6	Honey	kg			
7	Others specify				

2.7. In the past 5 years, is the cash income from dairy production increasing or decreasing at household level?

1. Increasing 2. Decreasing 3. It varies 4. I do not know 5. Others (specify)______

2.8. During the past 5 years, is your living conditions improved or deteriorated?

1. Improved 2. Deteriorated 3. No change 4. I do not know 5. Other (specify)____

SECTION 3: Income Generated from Agricultural Production other than Dairy

3.1.In the last 12 months, have you harvest crop production? 1. Yes 2. No (if no go to next page)

3.2.If yes for the above question, please fill the following table?

No	Type of crops	Unit of measurement	Cultivated area (ha)	Total amount produced	Amount consumed	Amount sold	Average price/unit
1	Maize	Kilo					
2	Sorghum	Kilo					
3	Wheat	Kilo					
4	Barely	Kilo					
5	Beans	kilo					
6	Teff	Kilo					
7	Chickpea	Kilo					
8	Peans	kilo					
9	Mango	Number					
10	Eucalypt us tree	Number					
11	Chat	Killo					
12	others						

SECTION 4: Income from Non-Farm Activities

4.1. Did you work in non-agricultural activity during the last 12 months? 1. Yes 2. No

4.2. If your answer is yes for the above question, please fill the following table below

Income Source	Did anyone in the household earn income from source in last 12 months? (1 = yes, 2= no)	Total HH income in last 12 months from this source.	Rank of Source	Who mainly earns/ controls this source? (code)
Trading in livestock and livestock products (not own produce)				
Trading in agricultural products (excluding livestock!) (not own produce)				
Formal salaried employment (non-farming e.g. civil servant, private sector employee, labourer, domestic work in other home)				
Business – Trade or services (non-agricultural)				
Working on other farms (including herding)				
Sale of products of natural resources (forest and sea/rivers products)				
Pensions				
Rent out land/ sharecropping (cash value of share crop or rent)				
Remittances				
Others specify				

4.3. Distance to nearest market or trading centre (km) _______

SECTION 5. Information Sources for Improved Agricultural Practices

5.1. Do you listen to agricultural programmes on radio? 1. Yes 2. No

5.2. If you say yes, how frequently? 1. Once per week 2. Less than once per week

5.3. Do you watch agricultural programmes on TV? 1. Yes 2. No

5.4. If you say yes, how frequently? 1. Once per week 2. Less than once per week

SECTION 6: Access to and use of services

Type of services	Is the service available?	Have you used this service in the last 12 months?	Who requested/ received this service? (code)
Extension visits			
• Livestock			
• Crop			
• Others, specify			
Animal health services			
• Veterinarian			
• Others, specify			
Training			
• Livestock			
• Crop			
• Others, specify			
Information other than extension and training)			
• Market			
• Weather			
• Others, specify			
Financial services			
• Savings			
• Credit			
• Health insurance			
• Domestic/home insurance			
• Crop insurance			
• Livestock insurance			
Electricity			
• National grid			
• Solar			
Piped water (available and working)			
WHO MAKES THE DECISION TO USE THE SERVICE/ WHO USED THE SERVICE			
1 =household male 2 = household female 3 = joint household (male & female) in HH		4 = non-household member 5 = other, specify	

SECTION 7: Technology Adoption

7.1. Do you use any dairy technology? 1. Yes 2. No

7.1.1. If your answer is yes, which technologies do you use?

Type of Technology/ Input	Is the technology available? 1=yes; 2 = no	Have you used this technology in the last 12 months? 1=yes; 2 = no	Who mainly makes the decision to use it? (code)	When do you start to use in year?
Crossbred heifer				
Improved forage seed				
Animal health				
Preventive methods (incl. vaccination)				
Curative (treatment)				
Breeding				
Natural service(bull)				
AI				
Supplemental feeding				
Commercial feed				
Minerals				
Improved dairy barn				
WHO MAKES THE DE CISION TO USE THE SERVICE/ WHO USED THE SERVICE				
1 =household male 2 = household female 3 = joint household (male & female) in HH		4 = non-household member 5 = other, specify		

7.1.2. If you are adopter, what are the advantages of dairy technology adoption?

	Advantages obtained from dairy technologies	Tick"√"
1	Increase in household income	
2	Availability of food of animal origin for household consumption improved	
3	Allowed to send children to school	
4	Allowed to hire labor for agricultural activities	
5	Allowed to build new or renovate the existing family house	
6	Other benefits (please specify)	

7.1.3. If you use crossbred cows, how do you get it? (Encircle)

1. Buying 2. Crossing local cow by exotic bull 3. By using AI 4. Others (please specify)

7.1.4. If you use bull, what is its source? (Encircle)

1. Private 2. Communal deliver by government 3. Once own 4. Others (please specify)

7.1.5. If you use AI, what is its source? (Encircle) 1. Private 2. Governmental

7.1.6. What are the major problems for adopting dairy technology?

1) 3) 5)

2) 4) 6)

7.1.7. What should be done to see increased dairy technology utilization?

1) 3) 5)

2) 4) 6)

SECTION 8: Milk Value Chain

8.1. Materials used for milk processing

8.1.1. Do you use the water to clean the udder of the cows before milking? 1. Yes 2. No

8.1.2. If yes, which water do you use? 1. Cold 2. Hot 3. No

8.1.3. Do you use cleaning material for udder cleaning during milking? 1. Yes 2. No

8.1.4. What kind of milk container do you use? **(***tick one or others***)**

No.	Utensil	Utensils used for				
		Milking	Fermented milk	Churning	Butter	Ghee
1	Clay Pot					
2	Glass Container					
3	Wooden Container					
4	Metal container					
5	Woven materials					
6	Plastic container					
7	Gourd					

8.1.5. From where do you get milk containers?

No.	Utensil	Source of Utensils						
		Farm made	Purchased from market	From cooperatives	Union	Donated by NGOs	Donated by GOs	Others (please specify)
1	Clay Pot							
2	Glass Container							
3	Wooden Container							
4	Metal container							
5	Woven materials							
6	Plastic container							
7	Gourd							

8.2. Labor

8.2.1 How many of your family members are working full time on your farm?

Male___________ Female _________Total_____________

8.2.2. Number of family members working part- time on farm

Male______Female__________Total___________

8.2.3. For which activities do you allocate more working hours per day?

During summer season 1) For dairy production______hrs/day

2) For crop production ______hrs/day

During winter season 1) For dairy production__hrs/day

2) For crop production ___hrs/day

8.3. Financial services

8.3.1. Do you have access to credit facility? 1. Yes 2. No

8.3.2 Did you take any credit during last year? 1. Yes 2. No

8.3.3. If your answer is yes, from which organization or financial institution?

1. Governmental organization 2. NGOs 3. Micro finance institution

4. Relatives/parents 5.Union 6. Others_____

8.3.4. In what form did you receive the credit?

1. Cash 2. Inputs for dairy production 2. Others specify!_____________

8.3.5. If you indicated cash, how much was it and what was the interest rate?

1. Amount in Birr_____ 2. Interest rate (%)_____

8.3.6 If your answer is no to Question 1, what are the reasons?

1. No credit facility in the area 4. Lack of information of financial services

2. High interest rate 5. Others (please specify) _____________

3. Collateral requirement

8.4. Milk production

8.4.1. Lactation and reproductive performance of dairy cows

* fill first column only if only 1 breed owned		animal 1	animal 2
Breed (1= Local, 2= Cross)			
Age at first calving			
Last calving date (MM/YY)			
Parity (number of live / still-births)			
Calving interval - if this is not the first calving (months)			
Lactation length (number of months cow is milked)			
Total Daily Milk Production(morning plus evening) in litre	At Calving-initial milk production		
	Yesterday		
Number of milking cows of each breed			

8.4.2. How many times per day do you milk the cows? 1. once 2. twice 3. other, specify___

8.4.3. Mention the major constraints for milk production

1) 3) 5)

2) 4) 6)

8.5. Milk Processing

8.5.1. Do you practice milk processing? 1. Yes 2. No

8.5.2. If your answer is yes, which method do you use? 1. Traditional 2. Modern

8.5.3. What milk products are produced in last lactation length?

	Milk product	Tick appropriate	Amount produced	Amount sold (kg)	Price received per kg (Birr)
1	Butter				
2	Whey (aguat)				
3	Butter milk (arrera)				
4	Ghee (Netir kibe)				
5	Cottage cheese				
6	Other, specify!				

8.5.4. If you use modern processing method, which materials do you have?

1. Cream separator 2. Churner 3 others (please specify) ________________

8.5.5. When do you process milk?

1. All the time 2. During dry season 3. During wet season

4. During fasting months 5. Others (specify) ___

8.5.6. Why do you process milk?

1. Surplus liquid milk 3. Preference of the product

2. To generate better income 4. To increase shelf life 5. Others ____

8.6. Utilization of milk and its products

8.6.1. Liquid milk use aspects

No.	Milk utilization	No of lactating cows	Quantity of milk
1	Total milk produced per day (lt)		
2	Consumed within the household per day (lt)		
3	Giving for neighbors per day (lt)		
4	Kept for processing to other products (lt)		
5	Sold as liquid milk per day (lt)		

8.6.2. What products do you prefer to consume? 1. Fresh milk 2. Sour milk

8.6.3. If you consume fresh milk, do you boil it? 1. Yes 2. No

8.6.3.1. If yes, why?_______________________

8.6.3.2. If no, did you hear it is better for hygiene? 1. Yes 2. No

8.6.4. If you produce butter for what purpose do you use it?

1. Food 2. Cosmetic 3. Gift for neighbors 4. For Sale 5. Others (please specify)_______

8.6.5. What is done with the milk during the fasting period?

1. Throw away 2. Children drinking 3. Sick drinking

4. Old people drinking 5. Others

8.6.6. what are the reasons for milk rejection?

1. Low market access 2. Low milk quality 3. Others specify

8.6.7. In cases of rejections due to low quality, what happens to the rejected milk? *Please tick the appropriate ones.*

	Rejected milk	Low market access	Low milk quality	Others
1	Sell at reduced prices			
2	Use at home			
3	Find new buyers for the milk			
4	It is difficult to find other buyers			
5	Dispose the milk or give away free			
6	Convert into other milk products to sell later			
7	Others, (*please specify*)			

8.7. Milk Marketing

8.7.1. What is your milk marketing system? (Encircle) 1. Informal 2. Formal

8.7.2. To whom do you sell your milk? (Mark correct answer/s with an X). Indicate how much you sold to your buyers and the price you received by completing the table below!

No	Buyers	Amount sold (litres) per month	Amount received (Birr) per month
1	My own cooperative		
2	Private traders		
3	Neighbors		
4	Hotels		
5	Restaurants		
6	Cafeteria		
7	Individuals in the nearest town		
8	Other, specify!		

8.7.3. What transport method do you use to deliver milk to the market or collection center? (Encircle)

1. Man power 2. Donkey 3. Bicycle 4. Others (please specify) ________

8.7.4. How far is your farm from market or collection center?

1. $\leq$ 5 km 2. 6-10 km 3. $\geq$ 11 km

8.7.5. When do you sell milk and milk products?

1. Throughout the year 3. During the fasting months

2. During dry season 4. During wet season 5. During not fasting months

7.6. If you sell, what is the price?

Products	Buyers 1.My own cooperative 5. Restaurants 2.Private traders 6. Cafeteria 3.Neighbours 7. Indv`ls in the nearest town 4.Hotels 8. Other, specify!	Price /liter or kilogram in different season			
		Dry season		Wet season	
		Fasting day	Non fasting day	Fasting day	Non fasting day
1) Whole milk					
2) Butter					
3) Cheese					

SECTION 9: Training and Advisory Services

9.1. Did you receive any kind of training about milk production?

1) Yes 2) No

9.2. If yes, who provided the training?

	Training provider	Indicate (from 1-3) in order of importance of your training provider	Frequency of training	Year of training was provided
1	My Cooperative			
2	NGOs			
3	Union			
4	Government			
5	Private traders			
6	Other (specify)			

9.3. What was the training about? (Please mark the appropriate response with an X)

	Kind of training received	(mark with an X)
1	Proper milking practices	
2	Quality management	
3	Proper animal handling	
4	Milk storage system	
5	Record keeping	
6	Other (specify)	

9.4. Please kindly indicate how you benefited from the training?

Benefits	Tick the appropriate!
1) Increased milk production	
2) Improved quality of product	
3) Timely marketing to fetch higher prices	
4) Advanced marketing strategies	
5) Effective dissemination of information among players	
6) Other, specify…	

SECTION 10: Performances of Dairy Cooperative and Members` Perceptions

10.1. Are you member of dairy cooperative? 1. yes 2, no

10.1.1. If you say no, write the reasons

1, ________________ 2,______________________3,_____________________

4,________________5,______________________6,______________________ 10.1.2. If you say yes, answer the following questions

10.2. When did you join the cooperative?____________

10.3. What kind of services do you receive from your cooperative?

No.	Services	Please mark response with an X
1	Transport services	
2	Quality control	
3	Technical advice	
4	Milk collection and bulking	
5	Credit services	
6	Commercialization	
7	Training	
8	Improved technology	
9	Veterinary services	
10	Other, specify...	

10.4. Have you got second payment for your patronage (being a member)?

1. Yes 1. No

10.5. If YES to question 3, how much did you receive for the years indicated in the table below?

Year	Amount received (Birr)
2000	
2001	
2002	
2003	

10.6. What form of contract do you have with your cooperative? Please encircle your answer!

1. Written contract 2. Verbal contract 3. No contract exists

10.7. List advantages of being member of a cooperative

1, ________________ 2,_____________________3,____________________

4,________________5,_____________________6,_____________________

10. 8. Generally, what is your level of satisfaction with your cooperative performance?

1. Satisfied 2. Partly satisfied 3. Have no opinion

4. Partly dissatisfied 5. Dissatisfied

10.9. Our dairy co-operative is generally not well managed in our locality.

1. Strongly disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly agree

SECTION 11: Animal Health

11.1. How many cattle died at your farm in this year?___________

11.2. Do you know some of the diseases that prevail in your area? If so, encircle approperate!

1. Black leg 3 Rabies 5. Parasites 7. Mastitis
2. Anthrax 4. TB 6. Brucellosis 8. Other ________

SECTION 12: Role of livestock in contributing to household food security

12.1. Household dietary diversity score and food consumption score (HDDS and FCS)

Types of foods	In the last 24 hours, has your household consumed (1=Yes, 0=No)	In the last 7 days, how many days have you consumed these?
A. Staples or food made from staples including teff, millet, sorghum, maize, rice, wheat, or other local grains e.g. bread, biscuits, or other foods		
B. Potatoes or any other foods made from roots or tubers		
C. Vegetables		
D. Fruits		
E. Beans, peas, lentils, or nuts?		
F. Red meat-beef, lamb, goat, liver, kidney, heart, or other organ meats?		
G. Poultry(chicken)		
H. Eggs		
I. Fresh or dried fish or shellfish?		
J. Milk, cheese, yogurt or other milk product		
K. Oils and fats?		
L. Sweets, sugar, honey		
M. Any other foods, such as coffee, tea including milk in tea?		

Appendix C : Questionnaire format for extension agents interview

Date_______/___/_____ Name___________ Code_______ Educational level________

1. Do you assist the farmers to uptake the new technology?

1. Yes 2. No

2. How do you assist the farmers?

1. High frequently 2. Frequently 3. Rarely

3. How the farmers uptake the technologies?

1. Early 2. Moderately 3.Lately

4. Prioritize the problems of dairy farms in their importance order

1. ________________________ 3. ____________________ 5. ____________________

2. ________________________ 4. ____________________ 6. ____________________

5. Mention different opportunities which can used to increase the milk production and productivities

1. ________________________ 3. ____________________ 5. ____________________________

2. ________________________ 4. ____________________ 6. ___________________________

6. What are the main constraints of dairy technology uptake? (*List according to its importance)*

1. ________________________ 3. ____________________ 5. _____________________

2. ________________________ 4. ____________________ 6. _____________________

7. What are the opportunities to increase dairy technology uptake? (*List according to its importance)*

1. ________________________ 3. __________________ 5. ______________________

2. ________________________ 4. _________________ 6. ______________________

Appendix D : Questionnaire format for Coopérative Managers interview

Date_____/___/_____ Name___________ Code_____ Educational level_________

Position in the work___________________________

When this cooperative was established?(Give in year)______________.

How many members does a cooperative have? Male_________Female Total________

What is the trend of cooperative membership in the last five years? 1. Increasing 2. Decreasing

Give reasons for your answer in question 3

1. _________________________________ 4. ______________________________

2. _________________________________ 5. ______________________________

3. _________________________________ 6. ______________________________

What is the trend of milk supply from your members in the last five years?

1. Increasing 2. Decreasing

Give reasons for your answer in question 5

1. _________________________________ 4. ______________________________

2. _________________________________ 5. ______________________________

3. _________________________________ 6. ______________________________

7. Are you paying the milk suppliers according to the milk quality? 1. Yes 2.No

8. If say no, write the reasons

1. _________________________________ 4. ______________________________

2. _________________________________ 5. ______________________________

3. _________________________________ 6. ______________________________

9. What is the price you pay per liter for your suppliers? Complete the table below

Suppliers	Price of milk per litter			
	Wet season		Dry season	
	Fasting	Non- Fasting	Fasting	Non- Fasting
Members				
Non-members				

10. Are you paying according to the quality of milk? 1. Yes 2. No

11. What is the price you receive per liter from your buyers? Complete the table below

Suppliers	Price of milk per litter			
	Wet season		Dry season	
	Fasting	Non- Fasting	Fasting	Non- Fasting
Members				
Non-members				

12. Do you assist the farmers to uptake the new dairy technology?

1. Yes 2. No

13. How do you assist the farmers?

1. High frequently 2. Frequently 3. Rarely

14. How the farmers uptake the dairy technologies?

1. Early 2. Moderately 3.Lately

15. Mention the types of dairy technologies that are transferred to the farmer?

1. ________________________________ 4. ______________________________

2. ________________________________ 5. ______________________________

3. ________________________________ 6. ______________________________

16. Do you think that farmers adopted all transferred dairy technologies? 1. Yes 2. No

17. If you say no, mention the Constraints of dairy technology uptake in their importance order (From economical and social points of view).

1. ________________________________ 4. ______________________________

2. ________________________________ 5. ______________________________

3. ________________________________ 6. ______________________________

18. What are the opportunities for dairy technology uptake?

1. ______________________________ 4. ____________________________

2. ______________________________ 5. ____________________________

3. ______________________________ 6. ____________________________

19. Do you follow up the impact of dairy technologies on household livelihoods? 1. Yes 2. No

20. If you say yes which technology is in his views the most important and why,

1. ______________________3. ______________________ 5. _______________________

2. _____________________ 4. ______________________ 6. _______________________

21. Which are the ones that the farmers opt for easily?

1. ______________________3. ______________________ 5. _______________________

2. _____________________ 4. ______________________ 6. _______________________

22. Which are difficult for farmers to insert in their labor?

1. ______________________3. ______________________ 5. _______________________

2. _____________________ 4. ______________________ 6. _______________________

23. What in his view would help to assist farmers to opt for more new technologies/

1. Training 2. Visit tours? Others specify

24. Compare the impact using different parameters.

Parameters	Before technologies adopted	after technologies adopted	Remark
Milk production			
Frequency animal death			
Prevalence of animal diseases			
Milk consumption in house			
Sending children to the school			
Income from livestock			

25. Do you think inputs for dairy production are available in the area? 1. Yes 2. No

26. If you say yes, mention the inputs available in the area?

1. ______________________________ 5. ____________________________

2. ______________________________ 6. ____________________________

3. ______________________________ 7. ____________________________

4. ____________________________ 8. ____________________________

27. If you say no, mention the constraints to deliver the input?

1. ______________________________ 5. ____________________________

2. ______________________________ 6. ____________________________

3. ______________________________ 7. ____________________________

4. ____________________________ 8. ____________________________

28. Do you think that the quality of milk is good? 1. Yes 2. No

29. If you say no, what are the possible causes for less quality of milk?

1. ______________________________ 4. ____________________________

2. ______________________________ 5. ____________________________

3. ______________________________ 6. ____________________________

30. What are the possible ways of increasing the quality of milk?

1. ______________________________ 4. ____________________________

2. ______________________________ 5. ____________________________

3. ______________________________ 6. ____________________________

31. Do you think that there is a good market access for producers? 1. Yes 2. No

32. If you say yes, mention their market accesses

1. ______________________________ 4. ____________________________

2. ______________________________ 5. ____________________________

3. ______________________________ 6. ____________________________

33. If you say no, write the possible ways to create a good market access for the producers?

1. ______________________ 3. ______________________ 5. __________________________

2. _____________________ 4. ______________________ 6. __________________________

34. What services do you provide for dairy farmers?

1. ______________________ 3. ______________________ 5. __________________________

2. _____________________ 4. ______________________ 6. _________________________

35. How do you see role of dairy cooperatives for dairy production sector?

1. Strong 2. Medium 3.Weak 4. Not known

36. Give reasons for your answer in question 35?

1. ______________________ 3. ______________________ 5. __________________________

2. _____________________ 4. ______________________ 6. _________________________

Appendex E: Curriculum Vitae(CV)

PERSONAL DETAILS

Name: Dehinenet Gezie Woldmichael

Date of birth: June 13, 1975 G C.

Place of birth: Lumamme (Awabel “wereda”), East Gojjam

Nationality: Ethiopian

Sex: Male

Phone number: + 251-(0)933-01-94-93

E-mail: dehinenetfiker@gmail.com

EDUCATIONAL BACKGROUND:

- PhD student, University of Addis Ababa, College of Veterinary Medicine and Agriculture (CVMA), Department of Animal Production Studies(APS), Debre Zeit, Ethiopia: November, 2009 to June, 2014.
- MSc Degree in Tropical Animal Production and Health (TAPH), Faculty of Veterinary Medicine, Debre Zeit, Addis Ababa University, Ethiopia: June, 2008.
- B.Sc. Degree in Animal and Range Science (ARS), Faculty of Agriculture, Mekelle University, Ethiopia: June, 2003.
- Certificate on Elementary School Teacher from Debre Brihan Teacher Training Institute (DBTTI), Ethiopia: June, 1994.

EMPLOYMENT

- Instructor of Animal science, Mertule Mariam ATVET College, Ethiopia: October, 2003 to September, 2009.
- Elementary School Teacher in Amhara National Regional State (ANRS), Ethiopia: July, 1993 to September, 1999.

LEADERSHIP ROLE

1. Administrative and development vice Dean in Mertule-Mariam Agricultural, Technical, Vocational, Educational and Training (ATVET) College from November 19, 2008 to September, 2009.
2. Head of the Animal Science Department in Mertule-Mariam Agricultural, Technical, Vocational, Educational and training (ATVET) College from November, 2003 to November, 2005.
3. Head Teacher (Director) of Elementary School Teacher in Amhara National Regional State (ANRS), Ethiopia: July, 1993 to September, 1999.

ADDITIONAL TRAININGS

1. Certificate on Head Teacher courses for Elementary School from Debre Brihan Teacher Training Institute (DBTTI), Ethiopia: Sept. 3, 1998.
2. Certificate on Computer proficiency from Universal Computer Center, Bahirdar, Ethiopia: Feb.10, 2006.
3. Certificate on Sericulture from Korea International cooperation Agency, Ethiopia: Feb. 8 – 18, 2006.
4. Certificate on Poultry Production and Feeding Management from Ethiopia Agricultural Research Organization (EARO): Feb. 19 – 23, 2007.
5. Certificate on Research Methods (Design of Experiments and survey, Data Management, analysis and interpretation) from International livestock research institute (ILRI), Ethiopia: November 14 – 18, 2011.

6. Certificate on Econometrics model analysis from Unity University, Ethiopia: June 30, 2014.

STUDY PAPERS PRODUCED

1. Review of dairy products value chain in the Ethiopia context; Seminar on current topics (2014) CVMA, AAU.
2. The effect of nutrition management on the reproductive efficiency of dairy cows; seminar on the current topics (ANPS 803) (2010) FVM, AAU.
3. Smallholder dairy production technologies uptake in mixed farming system in Dejen "woreda" of East Gojjam zone, Amhara Regional State, Ethiopia (Debre zeit, MSC Thesis (2008)).
4. Methods of improving the nutritive values of crop residues for dairy cattle feed; Seminar on current topics (2007) FVM, AAU.

PUBLICATIONS

1. **G. Dehinenet**, H. Mekonnen, M. Kidoido, M. Ashenafi and E. Guerne Bleich (2014): Factors influencing adoption of dairy technology on small holder dairy farmers in selected zones of Amhara and Oromia National Regional States, Ethiopia. *Discourse Journal of Agriculture and Food Sciences*, Vol. 2(5): 126-135.
2. **G. Dehinenet**, H. Mekonnen, M. Ashenafi and G. Emmanuelle (2013): Determinants of raw milk quality under a smallholder production system in selected areas of Amhara and Oromia National Regional States, Ethiopia. *Agric. Biol. J. N. Am.*, 4(1): 84-90.
3. **Dehinenet Gezie** and Mekonnen_Hailemariam (2012): Dairy Production Technologies` Uptake in Mixed Farming System, Ethiopia: Dairy technologies transferred for smallholder dairy farmers and adoption constraints, Amazon book store.
4. Mokonnen, H., **Dehinenet, G.** and Kelay, B. (2009):Dairy technology adoption in smallholder farms in"Dejen" destrict,Ethiopia.*Trop anim health Prod.*, Springer, 42:209 – 216.

AWARDS AND NGOs AFFILATION WORK EXPRIENCES

1. **Germany Acadamic Exchange Services (DAAD):** I have got scholarship award for my PhD reseach work from DAAD, German: June 2011 to June, 2014.
2. **International Livestock Research Institutution (ILRI)**: I had been working by PhD research work for three years under the supervision and techinical support of ILRI, Ethiopia: June 2011 to June, 2014.
3. **SNV- The Neatherlands:** I had been working on milk value chain data collection for four months in Selale dairy cooperative areas.
4. **Agri Service Ethiopia**: I had been working on assessment of the socio- economic importance of beekeeping by comparing the tradetional and transitional hives in Enebse Sar Midir Intergrated Food Security Program Offices(IFS PO),East Gojam Zone, Ethiopia: Sept. 23,2003.

MEMBERSHIPS TO PROFESSIONAL ASSOCIATION

- I am a member of Ethiopian Society of Animal Production (ESAP).

REFERENCES

1. Dr. Emmanuelle GuerneBleich, Livestock Officer in FAO Sub Regional Office for East Africa; **Mobile**: 251- (0)911-50-95-28;
   E**-mail**: Emmanuelle.GuerneBleich@fao.org

2. Dr. Mekonene, Haile mariam (Associate professor) Lecture in Addis Ababa University, College of Veterinary Medicine and Agriculture, Debre zeit.
   Mobile: (0)911-66-26-69; **E-mail**: alemu57@yahoo.com

3. Dr. Ashenafi Menegistu (Assistant professor) Lecture in Addis Ababa University, College of Veterinary Medicine and Agriculture, Debre Zeit. **Mobile**:(0)916-82-13-67; **E-mail**: ashenafimengistu@yahoo.com
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