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FDRE TECHNICAL & VOCATIONAL TRAINING INSTITUTE

School of Graduate Studies

Faculty of Agro-Processing Technology

Department of Dairy Processing Technology

Assessment of Artificial Insemination Service among Small and Medium Scale Farmers in Addis Ababa, Ethiopia

MSc Thesis Submitted to the Department of Dairy Processing Technology in Partial Fulfillment of the Requirements for the Degree of Master of Science in Animal Production Technology

By

Fentaye Anmaw

Major Advisor: Abebe Bereda (PhD)

July, 2024

Addis Ababa, Ethiopia

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FACULTY OF DAIRY PROCESSING TECHNOLOGY

ADVISORS' APPROVAL SHEET -1

FEDERAL TECHNICAL AND VOCATIONAL TRAINING INSTITUTE (FTVTI)

This is to certify that the thesis entitled "Assessment of Artificial Insemination Service among Small and Medium Scale Farmers in Addis Ababa, Ethiopia", submitted in partial fulfilment of the requirements for the degree of Master's with specialization in Animal production technology, of the graduate program of the school of dairy processing, and is a record of original research carried out by Fentaye Anmaw Smachew, ID.No. TTMR /168/15 under my supervision and no part of the thesis has been submitted for any other degree or diploma. The assistance and the help received during this investigation have been accordingly acknowledged. Therefore, I recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

Approved by Advisor:

Abebe Bereda (PhD)	__________________	______________
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DECLARATION

This is to certify that this thesis, entitled "**Assessment of Artificial Insemination Service among Small and Medium Scale Farmers in Addis Ababa, Ethiopia,**" submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in "**Animal Production Technology**" to the Graduate Program of the Faculty of Agro-Processing Technology, Federal Technical and Vocational Training Institute by **Mr. Fentaye Anmaw Smachew** (ID. No. TTMR/168/15), is an authentic work carried out by him under my guidance. The matter embodied in this project work has not been submitted earlier for award of any degree or diploma, to the best of our knowledge and belief.

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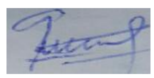
Fentaye Anmaw Smachew		28/09/24

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FEDERAL TECHNICAL AND VOCATIONAL TRAINING INSTITUTE (TVTI)

SCHOOL OF GRADUATE STUDIES

Assessment of Artificial Insemination Service among Small and Medium Scale Farmers in Addis Ababa, Ethiopia

FENTAYE ANMAW

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DEDICATION

This piece of work is dedicated to all my family members, especially my beloved wife Mekides Lingerew, my mom Asratie Chanie, my father Anmaw Smachew, my sister Mastewal Anmaw, and all my brothers, for all the support they have given me to accomplish this study.

BIOGRAPHICAL SKETCH

Fentaye Anmaw Smachew was born in January 1987, E.C., in Gozamin district, East Gojjam zone of Amhara regional state. He completed secondary school at Rebugebeya High School in Sinana District. In 2008, E.C. joined his undergraduate study at Wolkite University to attend his undergraduate study and graduated with a Bachelor Degree in Animal Production and Technology in June 2010. E.C. After his undergraduate studies, he was employed by Debrework College as an instructor. Following three years of teaching, he joined the School of Graduate Studies at the Federal Technical Vocational Training Institute (FTVTI) in July 2016 to earn a Master of Science in Animal Production Technology.

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LIST OF ABBREVIATIONS

AFC	Age at First Calving
AAFUADC	Addis Ababa Farmers and Urban Agriculture Development Commission
LDI	Livestock Development Institute
AFS	Age at First Service
AI	Artificial Insemination
AITs	Artificial Insemination Technicians
CI	Calving Interval
DO	Days Open
NIPP	Number of Insemination per Pregnancy
NSPC	Number of Service per Conception
UNDP	United Nations Development Program
LL	Lactation Length
DMY	Daily Milk Yield
AFC	Age at First Calving
CR	Conception Rate

TABLETABLE OF CONTENTS

LIST OF TABLETABLES

LIST OF FIGURE

`

LIST OF APPENDIX FIGURES

ABSTRACT

The objective of the study was to assess artificial insemination services across the two scales of dairy operations, namely small- and medium-scale farms, in the three selected sub-cities of Addis Ababa, Ethiopia. The three sub-cities (Akaki Kality, Bole, and Yeka) were selected purposefully based on their high numbers of dairy cattle and milk potential, and six representative districts were selected (two districts per sub-city) based on the above-mentioned criteria. A total of 182 dairy farms (75 small and 107 medium-scale) were recruited and interviewed face-to-face using a semi-structured questionnaire. To explore further information, six focus group discussions and six key informant interviews were conducted. A total of 48 frozen semen samples were collected from the center and AI technicians to evaluate the quality of the semen. The data was analyzed using SPSS, version 20 software. Descriptive statistics, including means, standard deviations, and percentages, were used to summarize the data. Quantitative data were analyzed using an independent T-test, while qualitative data were analyzed by chi-square tests. Industrial by-products, commercial feeds, and hay were reported as the top three ranked feed resources for dairy cattle by both small and medium-scale farmers. The main sources of water for dairy cows were tap water (89.2%) and ground water (10.8%). Nearly half of the sample farmers (54.3%) allowed free water access ad libtum for their dairy animals. The major diseases identified in the dairy farms were lympy skin disease, foot and mouth diseases, mastitis, and hypocalcemia, with index values of 0.17, 0.16, 0.15, and 0.14 for the small scale, respectively, while mastitis, lympy skin diseases, and hypocalcemia had index values of 0.14, 0.13, and 0.12 for the medium scale, respectively. Milk yield, disease resistance, and fast growth were the most preferred traits of dairy cows, both on a small and medium scale. Most dairy producers (88.1%) used artificial insemination to inseminate their dairy cows. The overall mean values of milk yield, lactation length, and longevity were 1.48±0.58 liter, 6.63±0.12, and 9.61±1.29 months for local dairy cows, with the corresponding values for crossbred dairy cattle cows' being 12.46±2.51 liter, 7.85±0.99, and 11.77±1 months, respectively. The overall mean values of age at first service, age at first calving, calving interval, days open, and NPSC were 39.89±3.205 months, 48.89±3.58 months, 19.91±2.71 months, 147.66±17.14 days, and 2.16±0.73 for local dairy cattle, respectively, with the corresponding values for crossbred dairy cattle cows' being 21.39±2.46 months, 30.41±2.69 months, 13.19±1.19 months, 90.62±13.12 days, and 1.53±0.67, respectively. The overall mean conception rate (CR) and calving rate based on retrospective data were 72.87% and 63.85%, respectively. With regard to semen quality, the frozen semen motility, live cell, and dead cell were 43.23±19.64, 43.49±17.15, and 56.61±17.11, respectively. Generally, artificial insemination service delivery and adoption rate are high on both small and medium scale of dairy farmers, but inadequate AI technicians and heat detection problem are the major challenges. Therefore, issues with AI technicians and heat detection needs to be addressed.

Keywords: Dairy, Artificial Insemination, Semen, small scale, medium scale

1. INTRODUCTION

In Ethiopia, the agriculture sector contributes 40% to the country's gross domestic product (GDP) and employs 75% of the workforce (AFS, 2021). Livestock is a vital component of agriculture, with Ethiopia having the largest livestock population in Africa, 70 million cattle, 42 million sheep, 52 million goats, 8 million camels, and 56 million chickens (CSA, 2021). Dairy production systems in Ethiopia are broadly categorized into urban, peri-urban, and rural milk production systems based on location (Getachew, 2020). In Ethiopia, indigenous cattle breeds make up 97% of the cattle population and they are characterized by lower productivity and reproductive performance compared to crossed cows (CSA, 2021).

In Ethiopia, the average milk production per day per cow was 1.37 liters (CSA, 2021). The dairy sub-sector's productivity has not reached its potential due to several factors, including poor genetics capacity of indigenous breeds, poor quality and seasonal availability of feed, high disease prevalence and low accessibility to services and inputs, high feed costs, and land shortages (Maris, 2017; Dekebo and Kebede, 2023). To enhance milk production of the country, the Ethiopian government has been implementing various interventions. It is worth mentioning the development of breeding policies, and crossbreeding programs for over 40 years back (Taye,2023). In Ethiopia, genetic improvement of indigenous cattle breeds through crossbreeding mainly via Artificial Insemination (AI) started with the establishment of the National Artificial Insemination Center (NAIC). However, the improved cattle breeds still constitute less than 3% of the total cattle population, which is too small to transform the current subsistence-based smallholder dairy production system into market-oriented commercial dairy production and boost milk production to satisfy current and future domestic demands (Dekebo and Kebede, 2023).

Artificial insemination (AI) is the process of collecting semen from bull, processing it, and then artificially introducing it into the female's reproductive tract to achieve conception. Artificial insemination is recognized as the best effective biotechnological technique for increasing reproductive capacity and has been widely applied in farm animals (Bekele *et al*., 2021; Juneyid *et al*., 2017). The reproductive efficiency of the dairy herd is crucial for the economic success and sustainability of dairy farms.

Various reports have showed that the efficiency of the AI services in the country is very low due to infrastructure, managerial, and financial constraints. In addition, poor heat detection and improper timing of insemination, an in-adequate number and unskilled AI technicians, poor incentive mechanisms for technicians, insufficient functionality of liquid nitrogen centers, and poor semen handling could exacerbate the poor performance of the AI technology (Belege and Muhammed, 2020; Teweldemedhn and Leul, 2020; Hamid *et al*., 2021; Mwaipopo and Mbaga, 2022) . Although artificial insemination was introduced in the country many years ago, recent assessments of its positive impacts and the efficiency in the genetic improvement of indigenous cattle breeds have not been well documented across locations (Ibrahim *et al*., 2021). Artificial Insemination (AI) has become an increasingly important tool for genetic improvement and enhanced productivity in livestock farming across Ethiopia, including urban centers like Addis Ababa. According to the study by Tadesse (2015), there are several critical issues affecting the efficacy of AI services in Addis Ababa. Among the primary concerns were the improper handling and storage of semen, which can significantly reduce its viability and, consequently, the success rate of inseminations. Additionally, the importance of timing in AI procedures is noted, noting that many farmers and AI technicians struggle with accurately determining the optimal time for insemination. These challenges not only decrease the effectiveness of AI services but also potentially discourage farmers from adopting or continuing to use this valuable breeding technology. In Addis Ababa, where urban agriculture plays a crucial role in food security and economic development, addressing these quality issues in AI services becomes paramount for supporting scale farmers and improving overall livestock productivity."

However, the quality of AI services remains a significant concern, particularly in small and medium-scale dairy farms. Additionally, information on the efficiency of AI services, reproductive performance of dairy cows, and challenges associated with AI service in Addis Ababa is not well documented. Therefore, periodic evaluation of AI service efficiency and associated issues is important to make interventions for improving delivery of the AI services in the capital city of the country, where concerned stakeholders (governmental or non-governmental) can easily learn and implement lessons.

1.1. Research Questions

What is the efficiency of artificial insemination and what are the challenges associated with it in small and medium scale of dairy farmers in Addis Ababa?

What is the quality of frozen semen used for artificial insemination in the study area?

What is the productive and reproductive performance of dairy cows in small and medium scale dairy farmers in Addis Ababa?

1.2. Significance of the Study

The study is significant for several reasons. Firstly, it provides valuable insights into the efficiency of AI services in different scales of dairy management, which can contribute to the improvement of reproductive capacity and overall productivity of dairy herds. Secondly, the assessment of frozen semen quality is helpful in identifying any issue or improvement needed in semen handling and storage practices. Lastly, the evaluations of productive and reproductive performances of dairy cows provide important information towards the development of strategies and interventions to enhance milk production and meet the domestic demand.

1.3. Scope of the Study

The study aims to investigate the utilization and effectiveness of artificial insemination (AI) services by small and medium-scale dairy cattle farmers in the Addis Ababa region of Ethiopia. The target population for the study would be small and medium-scale dairy cattle farmers who have access to or are using AI services in their dairy cattle production, as well as the AI service providers, including the semen samples collected from centers and the AI technicians. The key variables to be examined include the farmers awareness and knowledge of AI services, their adoption and utilization rates, the challenges and constraints they face in accessing and using AI, the factors influencing the farmers decisions to use or not use AI services, and the semen quality parameters (such as sperm motility and viability) collected from the centers and the hands of AI technicians. The study would use a mixed-methods approach, combining quantitative semen quality assessments, surveys with farmers and AI service providers, qualitative interviews, and focus group discussions to gain a comprehensive understanding of AI service delivery, semen quality, and the factors that influence the overall effectiveness of the AI services in the sub-cities. The geographical scope would be limited to the Addis Ababa region, as it is a major livestock production area in Ethiopia with a concentration of small and medium-scale farmers who may have varying levels of access to and utilization of AI services.

1.4. Limitation of the Study

Obtaining a representative sample of diverse and dispersed dairy farms across different sub-cities and management scales; ensuring adequate sample sizes for meaningful comparisons; dealing with the unreliable and incomplete data on AI practices and other relevant parameters from dairy farmers; logistical difficulties in accessing and verifying data from various farms and service providers; the challenge of isolating the impact of AI efficiency from other confounding factors like herd management and nutrition; the limited generalizability of findings from selected sub-cities to the entire Addis Ababa dairy sector; resource constraints in terms of finances, personnel, and time that could restrict the scope and depth of the study; and securing the cooperation and trust of dairy farmers, AI service providers, and local authorities, which may pose access and data-sharing challenges.

1.5. Objectives of the Study

1.5.1. General objective

- To assess artificial insemination service among small and medium scale farmers in Addis Ababa, Ethiopia

1.5.2. Specific objectives

- To assess the effectiveness of AI services and reproductive performance of dairy cows in the study area, and
- To evaluate the quality of frozen semen used for artificial insemination in the study area.

2. LITERATURE REVIEW

2.1. Dairy Cattle Production in Ethiopia

Dairy production is one of the major sustenance factors for the rural economy of Ethiopia (Alemneh, 2019). The dairy sector is seen as an important high-value growth sector in the process of agricultural and economic transformation that, moreover, has the potential to provide good income opportunities for the poor (Minten *et al*., 2020). The dairy sector is a major contributor to economic development especially among the developing countries (Ayalew and Abatenhe, 2018). The development of the dairy sector in Ethiopia has considerable prospective opportunity for smallholder employment and income generation and may contribute significantly to poverty alleviation and food and nutrition security. However, livestock production and productivity is low because of poor genetic potential of indigenous breeds, frequent seasonal drought, feed shortage in quantity and quality, high prevalence of rampant animal diseases, and poor infrastructure and animal health service (Fentie *et al*., 2020). Dairy cattle productivity, such as daily milk, lactation yield, and lactation length, as well as reproductive performance, such as age at first service (AFS), age at first calving (AFC), calving interval (CI), days open (DO), and number of services per conception (NSPC), are important traits for the dairy industry's profitability. Reproductive performance is one of the major determinants of dairy cattle productivity. In the highland areas, the agricultural production system is predominantly rural household dairy production system, peri-urban or small scale dairy production system, urban or commercial dairy production system (Taye *et al*., 2023).

2.2. Artificial Insemination Efficiency

2.2.1. History of artificial insemination

As compared to other biotechnologies, artificial insemination (AI) is the most widely used both in developing and in developed countries. This technology has now become a practical technology in commercial dairy cattle programs in both developed and developing countries (Yitayih *et al.*, 2017). From the middle of the twentieth century, the new technologies and techniques of AI transformed dairy cattle husbandry and breeding across dairy-producing countries (Bruno, 2022). The first successful AI was performed in Italy in 1780 and over 100 years later, in 1890, it was used for horse breeding. In Ethiopia, AI was introduced in 1938 in Asmara (the capital city of

Eritrea), the then part of Ethiopia, which was interrupted due to the second world war and restarted in 1952 (Mengistu, 2019).

The introduction of AI in Ethiopia can be traced back to the 1950s and 1960s when the country started receiving technical support from international organizations like the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Development Programme (UNDP). In the 1970s, Ethiopia established AI centers in various regions to support the implementation of AI programs. These centers were responsible for bull semen production, storage, and distribution to AI technicians working in the field. In the 1980s and 1990s, Ethiopia focused on breed improvement programs through AI. The emphasis was on introducing superior genetics to the local cattle population to enhance productivity, disease resistance, and adaptability. This involved importing semen from high-performing cattle breeds, such as Holstein, Jersey, and Brown Swiss, to crossbreed with local Ethiopian zebu cattle. In Ethiopia, even though AI is the most commonly used and valuable biotechnology that has been in operation for over 30 years in the country, the efficiency and impact of the operation have not been well-documented (Yitayih *et al*., 2017).

2.2.2. Definition of artificial insemination

Artificial insemination (AI) or the introduction of semen in the female genital tract utilizing instruments is the first generation of reproductive biotechnologies which was feasible in cattle. It is a process by which sperm are collected from the male, processed, stored and artificially introduced into the female reproductive tract for conception (Mohammed, 2018). Semen is collected from the bull, deep-frozen, and stored in a container with liquid nitrogen at a temperature of minus 196 degrees Celsius and made for use. Artificial insemination is very important for genetic improvement, especially in dairy cattle breeds (Yousuf, 2021). Artificial insemination has become one of the most important techniques ever used for the genetic improvement of farm animals. It has been widely used for breeding dairy cattle as the most valuable management practice available to cattle producer and has made bulls of high genetic merit available to all (Befikadu *et al*., 2019). By importing semen rather than live animals, artificial insemination (AI) technology maximizes the utilization of outstanding males, the transmission of superior genetic material, the rate and effectiveness of genetic selection, and the introduction of new genetic material, because it is simple, economic, and successful, AI is the most important assisted reproductive technology in developing countries (Mathewos *et al*., 2023).

2.2.3. Opportunities and challenges of artificial insemination

Artificial insemination is an essential technique in breeding programs with progeny testing. It provides the opportunity to choose sires that are proven to transmit desirable traits to the next generation and minimizes the risk of spreading sexually transmitted diseases and genetic defects. So far, AI using frozen semen has played an important role in increasing genetic progress by upgrading the reproductive rate of male (Ahmed, 2018). The main opportunities of AI have played an important role in increasing milk production in the study area because the crossbreds that got good traits from exotic breeds gave high milk than local breeds. Artificial insemination has become one of the most important techniques for increasing milk production and genetic improvement of farm animals, increasing genetic progress by upgrading the reproductive rate of the cow (shortening calving interval and increasing lactation length) (Yousuf and Getachew, 2021).

According to Yousuf (2021), production system has influences on AI service and production and reproduction performance of dairy cows. In his study, the major challenges of artificial insemination in dairy cattle are related to AI technicians, semen quality, management factors, and lack of awareness, heat detection, and distance of the AI center. In another study, the same challenges are discovered; however, in both studies heat detection problem is the first leading challenge in artificial insemination (Yousuf and Getachew, 2021). According to Teweldemedhn and Leul (2020), the main challenges AI service which negatively influenced the efficiency of AI service in the Western Zone of Tigray, Ethiopia were a lack of awareness in the community, animal management problems, unskilled artificial insemination technicians (AITs) and inadequacy of AITs. Another study mentioned challenges to artificial insemination practice in dairy cows for smallholders are the competence of artificial insemination technicians, lack of AI inputs and semen handling practice, management of dairy herds, heat detection, and time of insemination (Abebe and Alemayehu, 2021).

2.2.4. Factors affecting artificial insemination efficiency

Artificial insemination (AI) efficiency refers to the effectiveness and success rate of the AI process in achieving pregnancy in dairy cattle. It is a measure of how well the AI program is implemented and how many cows become pregnant as a result of the insemination. Some of the main factors affecting the conception rate of dairy cattle were time of insemination, genotype, body condition scores, age, parity, and AI technicians (Debir *et al.*, 2016). The efficiency of AI in Ethiopia has remained at a very low level due to many constraints including; infrastructural, managerial, and financial constraints, and also due to technical problems such as; poor heat detection, improper timing of insemination, and embryonic death. In addition, the conception rate per AI service is affected by cow related factors including cow fertility, body condition, environmental stresses, bull fertility or quality of semen, the efficiency of AI techniques and skills of the inseminators, care of the semen collected, processed, and stored. The better-managed and well-fed heifers grew faster, served earlier, and calve during the lifetime of the animal. Several factors associated with the success of AI particularly the detection of heat, efficiency of inseminator, communication and transport problems, and quality of the semen have contradictory effects (Shanku, 2022).

According to Tekalign (2021), the major constraint for efficiency of artificial insemination in Essera Woreda of Dawuro Zone was the overall low efficiency (59.05%) of artificial insemination. Conception failure (the leading factor), shortage of semen and liquid nitrogen, heat detection problems, shortage of AI technicians, interruption of weekends and holiday service, and travel long distances to get the service are ranked as among the major constraints of AI service. According to Yehalaw *et al*.(2018), the factors affecting the efficiency of AI were time of insemination (20.2%), nutritional imbalance (20%), management problems (19%), hygiene problems (17.5%), heat detection problems (12.2%), lack of skill in artificial insemination technicians (5.6%) and reproductive problems (5.6%). Therefore, various factors namely the adoption of proper management of dairy farms, improving the insemination skill of AI technicians or inseminators, improving the balanced feeding system, and recording the date of estrus need to be paid urgent attention to improve the efficiency of AI in dairy cows.

According to Teweldemedhn and Leul (2020), factors affecting AI efficiency in west zone of Tigray were availability of artificial insemination technicians (AITs) during regular working hours and on holidays and weekends, a distance of homestead from the AI service center, and the means of communication used by the small-scale farmers. AITs were not available on weekends and holidays when the AITs were not available, 28% of the respondents decided to pass the date without insemination and wait the next 21 days of estrus cycle whilst 47% of the respondents used natural service. According to Yohanis and Tilahun (2018), among the respondents, 47% used AI service regularly without interruption and 53% didn’t get the service regularly due to discontinuation of service on weekends and holidays, shortage of artificial insemination technicians, shortage of input, and long distance to get the service. About their level of satisfaction, more than half of the respondents were unsatisfied with the overall AI service in the study area due to different problems including semen and liquid nitrogen doesn't come on time (29.%), AIT problems (10.5%), heat detection problem (8.8%), conception failure (31.5%), insufficiency support from the concerned body (19.3%).

The causes of AI ineffectiveness on dairy cattle in the Hadiya zone are AI service not being available on time (shortage of input for AI service), heat detection, distance of AI station, shortage of AI technicians and repeat breeder (Desalegn and Eskindir, 2023). Among these causes, shortage of input for AI services is the leading others. The conception rate of inseminated between cross and local dairy cows detected through rectal palpation after 60 days of insemination is 45.7% and, 70.5% respectively and the overall average is 57.8%. The result of the conception rate for local cows was low due to genetic factors, heat detection problems, distance of AI station, inappropriate selection of cows, body condition of the cows, and season (Desalegn and Eskindir, 2023). The overall mean conception rate to first service of cross-bred dairy cow was 64.6±1.06 percent (Birhanemeskel *et al.*, 2017). The conception rate of dairy cattle is 24.69% after three months of pregnancy diagnosis (Fantahun and Admasu, 2017). The rates of conception in local and crossbred cows are 40.8 and 64.8%, respectively. In terms of body condition, a high conception rate (58.6%) in the good body condition score (Haile *et al.*, 2023). The pregnancy percentage of local and crossbred dairy cattle is 54.28% and 59.757% respectively, and the overall of 58.97% (Tadesse *et al.*, 2022).

According to Abas and Ziyad (2022), the pregnancy rate using AI in the local and cross breed is 48.9% and 62.5% respectively, and the overall is 51.8%. In the same study, retrospective data on the conception rate to AI from 2015-2018 in dairy cows was 27.4%, 30.3%, 43.8%, and 47.1%, respectively; the overall average being 38.3%. According to Belege and Muhammed (2020) to the efficiency of pregnancy using AI insemination in the breed of local and cross 72.9 %, and 75.5 % respectively an the overall percentage of 74.67 %. the conception rate in cows between breed for indigenous is 54%, and for crossbred is 69.6% (Debir *et al*.,2016). According to Yehalaw *et al*. (2018) study balance feeding and timing of insemination had a profound impact on the conception rate of cows. The conception rate of cows between breeds for local and cross is 55.9% and 66.6%

respectively, the overall is 64.8%. According to Shanku (2022), the first conception rate is affected by genotype, parity, BCS, age of the cow, time of insemination, and the bull itself.

2.3. Semen Quality

2.3.1. Definition and importance of semen quality

Bull quality semen refers to the characteristics and attributes of semen collected from a bull, specifically in terms of its fertility potential. It encompasses various parameters such as sperm concentration, motility, morphology, and overall sperm health. The quality of bull semen plays a crucial role in determining the reproductive success of artificial insemination (AI) programs (Butler *et al*., 2020). Freezing of semen for successful preservation of spermatozoa, for a longer period of time, is of great importance in livestock breeding and farm management. Researchers found that the use of frozen semen is one of the spectacular developments in modern day AI programs and it could potentially remain viable for 10,000 years. When superior index bulls are used for a limited period of time, the frozen semen is useful and economical. This is also a very cost-effective method of importing exotic germplasm in the form of deep-frozen sperm straw rather than animal, which is very expensive. The quality of frozen semen can be preserved for years if stored in liquid nitrogen at -196°C (Parvin *et al*., 2024). High-quality semen with optimal sperm concentration, motility, and morphology is essential for achieving successful fertilization. Bulls with superior semen quality are more likely to produce viable and motile sperm cells capable of fertilizing oocytes, resulting in higher conception rates and pregnancy rates in breeding females (Butler *et al*., 2020; Bollwein and Malama, 2023). The use of high-quality semen from genetically superior bulls helps accelerate genetic progress in a cattle population. The genetics of bulls are strongly implicated in the productivity of dairy cattle, Moreover, genetics are involved in decreasing greenhouse gas emissions, and bulls with desirable traits such as improved milk production, growth rate, disease resistance, and carcass quality can pass on their genetic traits to the next generation through artificial insemination(Lima-Verde *et al*., 2022; Carvalho *et al*., 2023).

2.3.2. Evaluation methods for assessing semen quality

Sperm quality can be described as the ability of the spermatozoa to move from the site of semen deposition to the site of fertilization, to penetrate an oocyte and activate it to develop an embryo. It can be defined in terms of motility, morphology; plasma membrane integrity, metabolic activity, and ability to acrosome react, among others. All of these sperm characteristics are susceptible to extraneous factors such as climate, level of nutrition, and management practice as well as intrinsic factors such as age (Ahirwar *et al.*, 2018; Sabés-Alsina *et al.*, 2019). Semen evaluation refers to the assessment of the quality of bull semen used for artificial insemination (AI) in breeding programs including, color, odor, pH, viscosity, liquefaction, volume, concentration, morphology, sperm motility, and progression (Tanga *et al*., 2021). It is crucial because the quality of the semen directly affects the success of AI and subsequent reproductive performance in the herd. For a long time, semen evaluation was believed to be the single most important laboratory test for assessing male fertility, however, it remains complex and difficult to standard. In bulls, semen quantity, quality, and/or health status are responsible for a significant percentage of reproductive failure in cattle production. In bulls, factors including age, breed, time and interval of collection, and season of the year affect the semen quality (Pal *et al*., 2018; Tanga *et al*., 2021).

The quality of bull semen used in artificial insemination plays a crucial role in determining the reproductive success and genetic improvement of dairy herds. The quality of frozen semen is determined to support the success of the AI program (Santoso *et al*., 2021). When assessing semen quality, several evaluation methods are commonly used. These methods provide valuable information about various parameters that determine male fertility. Some of the commonly employed evaluation methods are sperm color, sperm viability, pH, semen volume, sperm concentration, sperm motility, sperm morphology, and the presence of any abnormalities or infections (Wang *et al*., 2022). Sperm motility is an important factor in the quality of frozen semen. The capability of sperm to survive during the freezing process is an important aspect of selecting the bull in the AI center. Sperm motility decreases by about 40% during freezing. During the freezing process, the viability of sperm was reduced due to hyperosmotic diluents and temperature changes (Len *et al*., 2019; Indriastuti *et al*., 2020). According to Reda *et al*.(2020), the percentage of sperm motility of cryopreserved semen of HF-cross and purebred Jersey bulls had a mean value of 51.56±1.58 and 43.69±1.75, respectively, with a total average motility of 48.35±1.23. The total percentage of live spermatozoa of HF-cross and purebred Jersey was 66.51±1.30 and 65.45±1.61, respectively, with a total average of 66.08±1.01; moreover, the normal morphology of HF-cross and purebred Jersey was 79.97±1.77 and 81.57±1.65, respectively, with an overall mean value of 80.62±1.24.

According to the Goshme *et al.* (2021) study, the average mass motility of frozen bull semen was 38.4% for pure Holstein-Friesian (HF) and 39.9% for 75% HF crossbred. In the same study percent of motility of frozen bull semen under different locations in Baso, Debre Brihan, Chacha and NAIC is 46.6, 44.1, 39.4, and 47 respectively, and the overall is 44.27. According to Kumar *et al*. (2015) mean of frozen semen motility in pure Jersey bulls and crossbred Jersey bulls 46.11±1.43 and 47.22±1.08 respectively, and the live semen percentage was 58.67±1.02 and 51.63±0.97 for pure Jersey bulls and crossbred Jersey bulls respectively. According to Surahman *et al*. (2021), the motility percentage of the frozen sperms at different breeds such as Angus, Brahman, Fries Holland, Simmental, Limousine, and Bali are 58.8, 56.8, 41.1, 59.7, 49.2 and 44.0 respectively. Viability of the sperms at different breeds of bull Angus, Brahman, Fries Holland, Simmental, Limousine, and Bali are 56.1, 58.2, 51.5, 60.8, 51.6, and 46.9 respectively. According to Pathak *et al*. (2020), the mean value of post-thaw sperm motility of Gir cattle is 58.22±1.71. According to Morrell *et al*. (2018), the mean value of frozen-thawed semen the living percentage of beef bull and dairy bull is 40 ± 11 and 46 ± 8 respectively. Quality of frozen semen in various individuals of Bali bull, the overall mean of sperm motility, viability and sperm abnormality percentage is 69.37±0.41, 77.57±0.25, and 6.50±0.23 respectively (Indriastuti *et al*., 2020).

2.3.3. Factors influencing semen quality in dairy cattle

Dairy bull sperm quality is affected by climatic conditions, even in so-called temperate zones. The timing of heat stress during spermatogenesis determines which aspects of sperm quality are likely to be affected. Husbandry conditions for bulls used for semen collection should be adapted to allow the animals' physiological responses to temperature regulation within the scrotum to operate fully, to mitigate the effects of increased temperature and humidity. Extremes of temperature should be avoided (Lundeheim *et al*., 2019; Sei *et al.*, 2020). One of the most important factors influencing semen characteristics is shown to be the age of bulls at the time of ejaculate collection. As a result of testicular development pre-puberty and around puberty, sperm production tends to increase with age and peak at sexual maturity while starting to gradually decline at older ages due to degenerative changes in the seminiferous tubule (Salimiyekta *et al.*, 2023). The semen quality is affected by many factors, including genetic and non-genetic factors. The genetic factors are heritable traits and are difficult to control in a short period. The non-genetic factors are having a significant effect on the bull's performance and the semen quality. The main factors include temperature, humidity , season, age of maturity, and testicular size (Ahirwar *et al*., 2018). The factors of age of bull at procurement and semen collection, breed, season, and semen collection interval for their effect on semen quality, which is assessed based on volume, mass activity, initial sperm motility, and sperm concentration in fresh semen (Rai and Dorji, 2021). Investigation breed, age, scrotal circumference, body condition score, season, and nutrition affect bull semen quality (Tohura *et al*., 2018).

2.4. Productive and Reproductive Performance

2.4.1. Productive performance traits

Productive performance of dairy cows refers to their efficiency in producing milk and is generally assessed through various indicators such as daily milk yield (DMY), lactation milk yield (LMY), lactation length (LL), parity, and overall average milk yield (Getahun, 2020).The mean daily milk yields of local and crossbred cows, was 1.65 and 4.23 liter per day, respectively (Kassu *et al*., 2022). The average milk yield per day per cow for local and cross breed cows were 1.42±0.15 and 4.50±0.12 respectively in Abuna Gindeberet districts of West Shoa Zone, Oromia Regional State, Ethiopia (Bayissa *et al*., 2017a). Yimam *et al*. (2021) reported that the daily milk yield for local cows was 1.73±0.14, 1.92±0.15 and 1.67±0.02 liters in Bule Hora, Karcha and Dugda Dawa districts, respectively. The mean value of the daily milk yield of crossbred cows at Gidole town, South Ethiopia was 7.29±0.22 liter per day (Kaffe and Amejo, 2023). According to Yonas *et al*.(2020), the average daily milk of crossbred cows in medium and small scale production systems were 14.13±3.4 and 13.75±4.13 respectively in urban set up of Bishoftu, central Ethiopia.

The average daily milk yield was 2.8 and 5.2 liters for local and crossbred dairy cows in Gondar town, Ethiopia (Adane and Ayalew, 2020). The average lactation lengths (LL) of local and crossbred cows were 8.90 and 10 months, respectively (Kassu *et al*., 2022). The mean value of LL of crossbred cows in the present study was found to be 9.9, 9.7 and 9.8 months at Bishoftu, Akaki Kaliti, and Kolfe Keranio, respectively. The average milk production per day were 12.2±2.7, 11.2±2.9, and 11±1.2 liters per cow per day at Bishoftu, Akaki Kaliti, and Kolfe Keranio, respectively (Tekle *et al*., 2016). The average LL of local and crossbred dairy cows was 9.9 and 12.15 respectively in Gondar town, Ethiopia (Adane and Ayalew, 2020). According to the report of Kidane *et al*.(2019) at medium and small scale dairy farms in Ethiopia, the average LL of crossbred cows was 8.09±0.20 and 7.94±0.16 months, respectively.

2.4.2. Reproductive performance traits

Reproductive performance does not usually refer to a single trait but a combination of many traits. The most common indicators of reproductive performance, as reported by many authors, are age at first service, age at first calving, calving interval, days open, number of services per conception, and other fertility traits (Kefale, 2022). Reproductive performance in dairy cattle refers to the ability of cows and heifers to conceive, carry a pregnancy to term, and produce healthy calves. It is an essential aspect of dairy herd management because efficient reproduction directly impacts the productivity and profitability of a dairy operation. The cause for the low performances of dairy cattle might be genetic and environmental factors like feed shortage, low level of management, lack of access to land, disease, lack of proper breeding management such as lack of accurate heat detection and timely insemination might have contributed considerably to long days open, late age at first calving, long calving interval, short lactation length, and low milk production (Ayalew *et al*., 2019). The reproductive performance of the breeding female is probably the single most important factor that is a prerequisite for a sustainable dairy production system and influencing productivity. Reproductive performance is commonly evaluated by analyzing female reproductive traits. Among reproductive performance traits; age at first service, number of services per conception, calving interval, age at first calving, days open, first service per conception, gestation length, calving rate, non-returning and returning rate of service are the bases of profitable production for dairy farm (Teweldemedhn, 2018; Mohammed, 2020).

Especially, the economics of dairy enterprise is based on the efficient reproductive performance of dairy animals (Yonas *et al*., 2020). The reproductive efficiency of the dairy herd is important to the economic success of the dairy farm, also for the continuity of other yields. Because of its advantages such as reducing the incidence of sexually transmitted diseases and increasing the use of genetically superior sires in the selection, artificial insemination is one of the most important reproductive technologies implemented in herd management (Sahin *et al*., 2022). The pregnancy rate of the herd is directly related to the number of inseminations per pregnancy (NIPP). Of course, each cow should become pregnant in single insemination in the herd. Pregnancy is under the influence of many factors such as changes in environment and management for the dam, as the fertility of the bull for semen quality evaluations, adjustments to cell numbers per dose, and culling of ejaculates and/or bulls in fertility among ejaculates and/or bulls released for sale (Sahin *et al*., 2022). Reproductive traits describe the animal's ability to conceive, calve down and suckle the calf to weaning successfully. Reproductive performance is commonly evaluated by analyzing female reproductive traits of a combination of many traits (Nurilign, 2020). The main indicators that would be considered in assessing reproductive performance are age at puberty, age at first calving, calving interval, days open, and number of services per conception (Zenebe *et al*., 2016; Abera *et al*., 2018; Nurilign, 2020; Yonas *et al*., 2020).

2.4.2.1. Age at first service

It is the age at which heifers attain body weight, body condition, and sexual maturity for accepting service for the first time. It influences both the productive and reproductive life of the female through its effect on her lifetime calf crop. Age at first service is influenced by genotype, nutrition, and other environmental factors (Nurilign, 2020). The economy of the farm can be feasible by showing estrous as early as possible for the female animal (Ayeneshet *et al*., 2018). The overall estimated age at first service (AFS) of indigenous dairy cows was 42.61±2.82 months (Abera *et al*., 2018). Similar studies mentioned that the overall mean of AFS of indigenous dairy cows was 38.10±0.4 (Ayeneshet, 2018). The overall average AFS for local and crossbred heifers was 45.27±0.47 and 32.11±1.23 months, respectively in the study of West Shewa, Oromia (Bayissa *et al*., 2017b). The average AFS in crossbred dairy cattle was 24.8 months (range 10 to 48 months) (Birhanu *et al*., 2015). According to Nurilign (2020), least square means of indigenous cattle AFS was reported to be 24.73±0.66, 24.90±0.32, 35.30±0.721, 44.17±10.89, 44.57±0.97, 50.93±3.52, 52.80±0.63 and 37.20±4.063 for Arsi, Barca, Begait, Boran, Fogera, Horro, Metema Zebu, and Ogaden cows, respectively. The overall estimated AFS of local dairy cows in the current study was 42.61±2.82 months (Abera *et al*., 2018). According to Wubshet *et al*. (2020), the overall least squares means indicated that the reproductive traits of AFS for HF dairy cows was 30.5±0.60 months. The average AFS for local and crossbred female dairy cows is 42.23±7.4 and 29.02±2.65 months, respectively. AFS is either advanced or delayed by such factors as environmental particularly nutrition inferences and overall reproductive processes.

The largest AFS in the study of Bekuma *et al*. (2022) was suggested to be the low level of management and poor feeding of calves and heifers at earlier stages. The mean AFS of crossbred dairy cattle has been 26.8 months, however, the difference in value may be due to the type of breeds involved for crossing, level of gene inheritance, environment, and management effects

(Kefale *et al*., 2019). The overall mean of AFS for local dairy cattle in Sidama zone is 44.1±5.9 months and crossbred dairy cattle is 30.3±4.4 months (Debir, 2016). The mean AFS was 808.96±5.42, 822.72±7.80 and 801.75±5.65days, for large, medium, and small scale HF dairy producers, respectively with an overall mean value of 811.14±6.29 days (Amare *et al*., 2019). For the crossbreed dairy cattle the age at first service was 824.30±7.11, 871.87±13.46 and 852.57±7.36 days, for large, medium, and small scale, respectively with an overall mean value of 849.58±9.3 days (Amare *et al*., 2019). According to Shanku (2022), the age at first service for crossbred and local cows was 34.55 and 42.57 months, respectively.

2.4.2.2. Number of service per conception

The number of services per conception is the number of services, whether natural or artificial, required for successful conception. The number of insemination required to produce a live calf is one of the most useful parameters for the measurement of reproductive efficiency (Brhane, 2019). The NSPC depends largely on the breeding system used. It is higher under uncontrolled natural breeding and low where hand-mating or artificial insemination is used. The average NSPC of local cows was 1.59 (Gezu and Azage, 2018). The overall estimated mean for the NSPC (Mean±SD) for local dairy cows in the current study was 2.44±0.73. The mean value for NSPC was significantly higher for lowland than highland and midland. The differences may be attributed to differences in management practices such as mating practices in the lowlands (Abera *et al*., 2018). According to Yonas *et al*.(2020b), the number of service per conception (NSPC) of crossbred dairy cows based on the scale of production was 1.36±1.1, 1.56±1.0, and 2.37±0.8 months for large, medium, and small scale dairy farms, respectively. The overall NSPC is 1.59±1.02 months. The ideal NSPC required for well managed herd ranges from 1.3 to 1.6 months, depending on the overall management and breeding activities (Brhane, 2019). Uncontrolled natural mating shows higher service per conception than artificial ones. If the service per conception in a given farm is above two, it is considered poor. However, in the majority of the poorly managed herd's average of two or more NSPCs are require (Gezu and Azage, 2018; Brhane, 2019).

According to Vijayakumar *et al*.(2019), the NSPC of crossbred Jersey dairy cattle was 3.19±0.20. The NSPC reported in tropical high-land environment results showed that the overall mean was found to be 1.98±0.05 (Wondosson *et al*., 2018). In their studies variations occur due to the management, environment, improper heat detection, and fertility status of the breeding cow leading to differences in a number of services per conception. Similarly, cows with reproductive disorders required more services per conception and had longer intervals from calving to first service and conception. The NSPC for indigenous dairy cows in all production systems with the mean values 2.07±0.63, 1.81±0.44, and 2.29±0.78 in rural, peri-urban, and urban, respectively. Similarly, the NSPC for crossbred dairy cows in all production systems with the mean values 2.29±0.66, 1.77±0.42, and 1.64±0.54 in rural, peri-urban and urban, respectively (Bayesa,2021).

The NSPC of cross-dairy cattle reported around Addis Ababa and Bishoftu had a mean of 1.93 months (Zenebe *et al*., 2016). NSPC values greater than 2.0 should be regarded as poor natural service conception, whereas artificial insemination users 1.5 up to 2.3. This might indicate that there are problems in using AI methods due to various reasons, of these factors, feed availability, time of insemination, and heat detection play a major role. Higher NSPC results from either failure to conceive at a given service and/or failure to maintain pregnancy, thus requiring repeated services (Gezu and Azage, 2018). The least squares mean NSPC for dairy cows is 1.60±0.03 (Engidawork, 2018). The overall least squares mean indicated that the reproductive trait of NSPC for HF dairy cow ratio of 1.6±0.05 and affected by parity, while the season of calving had a non-significant effect on NSC (Wubshet, *et al.*, 2020). The NSPC of cross-breed dairy cattle are 1.8, in fact, excellent herd management and performance of cows can be associated with lower services per conception (Kefale *et al*., 2019). The NSPC for crossbred dairy cattle for large scale 1.36±1.1, medium scale 1.56±1.0, and small scale 2.37±0.8 months (Yonas *et al*., 2020). The overall mean of number of service per conception for local dairy cattle in Sidama Zone is 2.4 and for crossbred dairy cattle is 1.8 (Debir, 2016).

The mean of number of service per conception is 1.16±0.5, 1.75±0.67, 1.63±0.56, for large, medium and small scale HF dairy producers, respectively with an overall mean value is 1.51±0.58 and for cross breed dairy cattle 1.85±0.59, 1.68±0.56, 1.57±0.61, for large, medium and small scale respectively and the overall mean value is 1.7±0.59 (Amare *et al.*, 2019). The average mean of dairy cattle for NSPC under large scale farm in Southern Highland Zone of Tanzania is found to be 1.39±0.05 and under small scale farm is 2.58±0.44 (Mwaipopo and Mbaga, 2022). The NSPC is 2.2 and 1.4 for local and crossbred dairy cattle respectively and the overall mean is 1.7. The NSPC in natives was higher than a crossbred cow (Desalegn and Eskindir, 2023). Average number of service per conception of crossbred dairy cows is 1.67± 0.04 (Birhanemeskel *et al*., 2017).The mean NSPC is 1.95 ±0.41 and when only those cows/heifers that have got pregnancy were considered, the mean NSPC is 1.47 ±0.053 (Jemal and Lemma, 2016).

2.4.2.3. Age at first calving

This is a time where heifers deliver or give birth to a calf for the first time. It is one of the important reproductive traits contributing to the economic return of dairy cows. A reduction in AFC minimizes the raising costs, shorten the generation period, and consequently take full advantage of the number of lactations per head. Earlier first calving enhanced lifetime productivity of cows. It is an important factor in determining the overall productivity of dairy cows (Ayeneshet *et al.*, 2018). Under their studies the estimated overall means of indigenous dairy cow in different district age at first calving was 47.10±0.66 months. The longer age at first calving observed here may be related to environmental situation and farming practices which may effect on the cattle growth. Age at first calving for indigenous dairy cows the mean values 53.71±10.41, 49.81±12.68 and 41.50±6.52 in rural, peri-urban and urban, respectively. Similarly, age at first calving for crossbred dairy cows with the mean values 42.95±9.13, 39.49±5.62 and 37.82±5.70 in rural, peri-urban and urban, respectively (Bayesa and Eyob, 2021). The least squares mean of Arsi, Barca, Begait, Boran, Fogera, Horro, Metema zebu and Ogaden breeds age at first calving (AFC) obtained in the study was 33.53±.643, 30.00±.458, 45.12±6.203, 52.67±8.545, 54.03±4.289, 54.23±4.966, 50.17±4.378 and 50.57±0.515 months respectively (Nurilign, 2020). The overall estimated age at first calving (AFC) in different agro-ecology was 52.30±2.73 months. These could be due to availability of feed resources since environmental factors particularly nutrition may affect the growth and maturity of heifers and development of reproductive organ properly in order to undertake its function properly (Abera *et al*., 2018).

According to Wubshet *et al*.(2020), the overall least squares means indicated that reproductive traits of AFC for HF dairy cow was 39.76±0.67 months. Age at first calving of local and crossbred dairy cows were 51.73±6.97 and 38.14±5.43 months, respectively. The desirable age at first calving in local breeds is 3 years and 2 years in cross bred cattle. The highest age at first calving observed here might be related to environmental conditions and husbandry practices which may affect the cattle growth. Hence, good husbandry practices especially in dry seasons can improve age at first calving (Bekuma *et al.*, 2022). The overall mean of AFC for crossbred dairy cattle has 37 months, however, some variations have been due to different in breed and animal management (feeding management, heat detection and timely insemination, health control and climate (Kefale *et al*., 2019). The mean AFC of crossbred dairy cattle for large scale was 28.39±2.6 month, medium scale 30.35±2.24 month, and Small scale 32.68±1.9 month (Yonas *et al*., 2020). The overall mean of AFC for local dairy cattle in Sidama zone is 51.9±5.9 month and crossbred has 39.3±3.2 month (Debir, 2016). The overall mean of Age at first calving for local dairy cow is 57.08±0.61 month and for cross bred is 40.79±1.23 month in west Shewa, Oromia (Bayissa *et al*., 2017b).The mean age at first calving for HF was 1085.01±6.49, 1083.33±5.49 and 1094.63±8.34 days for large, medium and small scale HF dairy producers, respectively with an overall mean value of 1077.06±5.66 days. The mean age at first calving was 1099.62±7.06, 1148.18±13.41 and 1128.53±7.37days for large, medium and small scale crossbreed dairy producers, respectively with an overall mean value of 1125.44±9.28 days (Amare *et al*., 2019). According to Shanku (2022) study age at first calving in months for cross and local is 29.60 and 39.07 respectively.

2.4.2.4. Calving interval

This is the time between two successive births and measures cattle herds' reproductive efficiency. According to Kefale *et al.* (2019), the calving interval of crossed dairy cattle was 15.5 months. The difference of the finding from other might be due to animal management, climate and geographical difference. Calving interval for indigenous dairy cows with the mean values (26.42±1.33, 25.49±1.09 and 25.57±1.33 in rural, peri-urban and urban, respectively). Similarly, calving interval for crossbred dairy cows with the mean values 25.47±1.35, 25.60±1.23 and 24.15±1.71 in rural, peri-urban and urban, respectively (Bayesa and Eyob, 2021). The least squares mean of Arsi, Barca, Begait, Boran, Fogera, Horro, Metema zebu and Ogaden breeds calving interval in the study was 14.67±0.116, 13.20±0.346, 17.06±0.040, 18.70±3.551, 21.47±3.496, 14.80±2.706, 17.50±2.211, and 16.40±0.866 months respectively (Nurilign, 2020). The overall estimated mean CI in the current study was 20.08±0.90 months. The differences in calving interval could be due to longer time taken by dairy cows to conceive due to the effect of nutrition and other management aspects like health care within consecutive calving among agro ecology (Abera *et al*., 2018). According to Wubshet *et al*. (2020) the overall least squares means indicated that reproductive traits of CI for HF dairy cow was 446.1±6.79 days. The CI of local and crossbred dairy cows were 15.03±1.04 and 14.48±1.19 months, respectively. Nevertheless, age and breed of cows, calving season and availability of forage may contribute prolong calving interval (Bekuma *et al*., 2022). The mean of CI for crossbred dairy cattle in large scale dairy farm was 12.71±3.4 month, medium scale 12.84±1.0 month and small scale 13.71±1.3 month (Yonas *et al*., 2020).

The overall calving interval for local dairy cattle in Sidama zone is 23.6±4.4 month and crossbred is 17.1±4.5 (Debir, 2016). The overall CI for both local and crossbred cows in the study districts were 20.93±0.22 and17.69±1.23 months, respectively in West Shewa Oromia (Bayissa *et al.*, 2017b). Least squares mean of CL for local and cross breed dairy cattle in central highlands of Ethiopia is 525.08 and 611.92 days respectively (Amare and Zeleke, 2018). The mean calving interval for HF dairy cattle was 374.41±1.19, 375.02±1.99, and 381.18±2.12 days for large, medium and small scale HF dairy producers, respectively with an overall mean value of 376.87±1.77 days. Although for crossbreed dairy producers, the mean calving interval value was 373.04±2.18, 376.12±1.37 and 375.01±2.82 days for large, medium and small scale crossbreed dairy producers with an overall mean value of 374.72±2.12 days (Amare *et al*., 2019). According to Shanku (2022) study calving interval for cross and local dairy cattle breed is 38.60 and 48.02 months respectively.

2.4.2.5. Days open

Days open (DO) is the period from date of parturition to the subsequent date of successful conception or it is the interval between date of calving and date of conception. It is one of the best indicator variables, which is most commonly used to measure fertility performance in dairy cattle. DO directly affect CI, which plays a vital role in the achievement of dairy farms. DO is the part of the calving interval that can be shortened by improved herd management. Long days open and consequently, prolonged CI may affect the overall economic revenues of the dairy herd (Ayeneshet *et al*., 2018). DO affects lifetime production and generation interval, days open should not exceed 80 to 85 days, if a calving interval of 12 months is to be achieved. Increases in the number of days open between calving and conception, also known as days open, influences profitability of the dairy industry. This influence is partly attributed to factors such as increased breeding cost, increased risk of culling and replacement costs, and reduced milk production (nurilign, 2020). According to nurilign (2020) the least squares mean of Arsi, Barca, Begait, Boran, Fogera, Horro, Metema Zebu and Ogaden breeds of days open was 6.30±0.755, 8.42±0.108, 8.20±0.361, 8.70±3.516, 8.13±2.721, 4.80±0.300, 6.63±0.379,and 6.15±0.379 months respectively. DO for indigenous dairy cows with the mean values 5.55±1.14, 4.19±0.90 and 4.35±0.86 in rural, peri-urban and urban, respectively. Similarly, open days for crossbred dairy cows with the mean values 4.18±0.92, 4.38±0.97 and 3.51±0.98 in rural, peri-urban and urban, respectively (Bayesa, 2021). According to Wubshet *et al*. (2020) the overall least squares means indicated that reproductive traits of DO for HF dairy cow was 181.7±7.01 days. According to Kefale *et al*. (2019) study the days open of crossed dairy cattle was 197 days, the days open was affected by genetic makeup, calving period, calving season, and parity. The overall average DO for local and crossbred heifers were 191.40±0.35 and 113.08±0.31 days, respectively in West Shewa, Oromia (Bayissa *et al*., 2017b). The mean of days open for HF dairy cattle is 91.24±1.06, 99.75±1.82, 100.54±2.36 days for large, medium and small scale farm and the overall value is 97.18±1.75 days and for cross bred dairy cattle is 93.25±1.24, 109.41±2.16, 106.41±1.69 a days for large, medium and small scale farm and the overall value is 103.02±1.70 days.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted in the capital city of the country, Addis Ababa, which serves the administrative center for Federal Democratic Republic of Ethiopia. The city is divided into 11 sub-cities and 116 districts. Addis Ababa is located in the central highlands of Ethiopia and lies between 8°55´00" and 9º07´00"North and 38º4´and 38º50´East with an altitude of 2200-3200 m above sea level. The city has an estimated population of over three million people (NMSA, 2010).The long rainy season in Addis Ababa extends from June to September with annual average rainfall and temperatures of 1000 mm and 16^{O}C, respectively. During the rainy season, the relative humidity of the city ranges from 70 and 80%, while in the dry season, it varies between 40 and 50%. According to the 2023 reports from Farmers and Urban Agriculture Development Commission, Addis Ababa has a total dairy cattle population of 20,114. The distribution of dairy cattle's across the sub-cities is as follows: Yeka (4533), Bole (4276), Lemi Kura (1947), Akaki Kaliti (1256), Nifas Silk (2130), Kolife (3810), Gulelie (942), Arada (100), Kirkos (400), Lideta (473), and Addis Ketema (246).

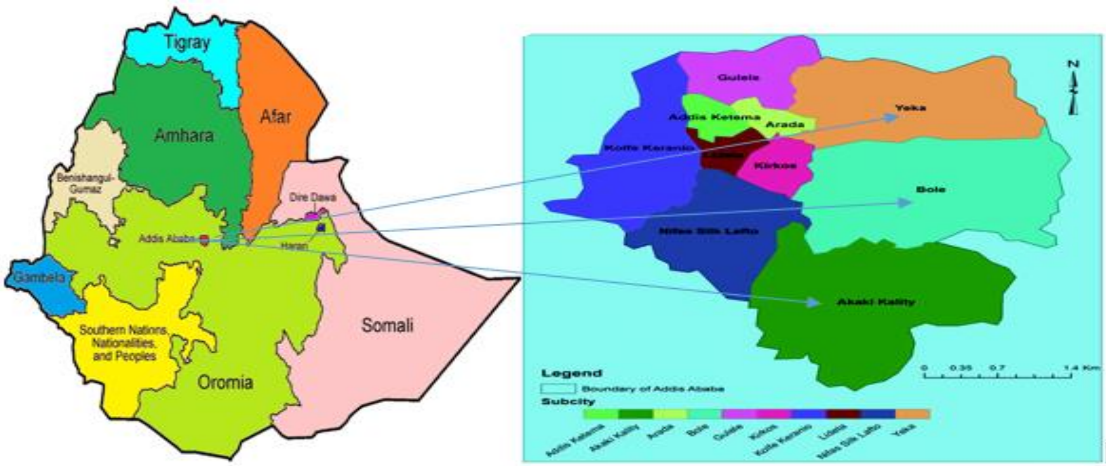

Figure 1. Map of study area

3.2. Research Design

The study consists of two parts: a survey and laboratory work to determine quality of bull frozen semen. For the survey part, a single visit formal survey method was used to gather all the necessary data from small and medium scale dairy farms on feeding, housing, vaccination or treatment, factors affecting the efficiency of artificial insemination, and productive and reproductive performance of the dairy cows in the study area. The laboratory part involved determining the quality of 100% blood level HF bull frozen semen (motility percentage, viability cell) collected from the hands of AI technicians and centers.

3.3. Sampling Technique and Sample Size Determination

Three sub-cities (Akaki Kality, Bole, Yeka) were selected purposively from the eleven sub-cities of the capital city of the country based on their high numbers of dairy cattle and milk potential. The districts and *kebeles* within these sub-cities were also nominated purposively, considering the number of farms that included both small and medium scale operations. The farms were then stratified into small (having less than or equal five lactating cows) and medium scale (having greater than five but less than thirty lactating cows) farms categories based on number of milking cows. In each stratum, proportional sampling techniques were employed to determine the sample size of the farms. There are 335 total farms in the study area and out of those farms select 182 representative farms (75 small-scale and 107 from medium scale) were recruited using systematic random sampling techniques. To determine sample size, Yamane (1967) formula for finite and large populations was used with a 95% confidence level and a 0.05 precision level. The formula used to obtain this sample size is presented below.

$$n = \frac{N}{1 + \mathrm{N}\ (\mathrm{e2})}$$

Where, N= population size, e= expected error and n= sample size

Thus, $n = \frac{335}{1+335\ (0.05)}$ =182

Table 1. Sampling layout for survey study

Selected sub-cities	Number of district in the sub-city	Name of Selected districts	Number of farms in the selected districts	Sample size in each district	No. of dairy farms selected in each scale of operation		Total
					Small scale	Medium scale	
Bole	13	01	10	5	2	3	19
		12	25	14	11	3	
Akaki	13	07	70	42	22	20	92
Kality		10	100	50	29	21	
Yeka	12	09	40	26	4	22	71
		11	90	45	7	38	
Total							182

3.4. Data Sources and Collection Methods

3.4.1. Primary data sources

Primary data was collected from farm owners and artificial insemination technicians using a semi-structured questionnaire. The questionnaires mainly focused on herd sizes, feeding, housing, health care, factors affecting AI efficiency, identification of estrus signs, timing of insemination, and the productive and reproductive performance of dairy cattle under different scales of dairy management.

Key informant interviews were conducted with six senior animal production and breeding experts in each district along with two senior experts from each sub city to gain a comprehensive understanding of artificial insemination delivery in the sub-cities. In addition, one focus group discussion (FGD) was conducted with forage development expert, animal breeding experts, senior dairy farmers and AI technicians per district to gather in-depth information of the study. The groups were organized with consideration of gender balance and seniority. The discussions were facilitated by the principal investigator of the research. The checklist that accommodated general questions used to triangulate and explore further information. The discussion focused on the status of dairy production, challenge and opportunities of AI and the way forward for better implementation of artificial insemination in the study district.

3.4.2. Secondary data sources

Secondary data such as cattle population and number of farms to complement the current study were collected from Addis Ababa Farmers and Urban Agriculture Development Commission Office (AAFUADCO). In addition, farm record books and AITs monthly reports were used to obtain information from the records on productive and reproductive performances of dairy cows. A retrospective study was carried out to gather pertinent data from the farm owners and AI inseminator's records. The data collected from 2020 to 2023 were utilized for the current study. Based on these records, the conception rate and calving rate of dairy cows for each year were determined. The following formulas were used to calculate the conception rate and calving rate:

$$\text{Conception rate} = \frac{\text{Numbers of cow pregant}}{\text{Numbers of cow ineminated}} \text{x}100, \quad \text{Calving rate} = \frac{\text{Numbers of cow calved}}{\text{Numbers of cow mated}} \text{x}100$$

3.5. Semen Evaluation Procedure

Frozen semen samples from the Livestock Development Institute (LDI) Center and AI technicians were analyzed using a high-quality phase-contrast microscope along with a slide warmer and water bath. A total of 48 semen straws of pure HF bulls were assessed: 24 straws from the center and 24 straws from three AI technicians. The analysis focused on the percentage of mass motility and the presence of live and dead sperm cells. It was conducted at the LDI laboratory at Kality Center. The following procedures were used for semen quality analysis: First, the straws were removed from the liquid nitrogen and thawed in a water bath at 37 degrees Celsius for 30 seconds. After thawing, the straws were carefully taken out with forceps and wiped with a clean cloth. A clean, grease-free glass slide was then prepared, warmed, and adjusted to normal body temperature to prevent cold shock during microscope examination. A drop of thawed semen was spread to the edges of a cover slip, transferred to a warmed slide, and then examined under a phase-contrast microscope at 200× magnification. The percentage of sperm mass motility in the frozen semen was determined by placing approximately 1–2 droplets of semen on a pre-warmed slide covered with a warm cover slip. Using a phase-contrast microscope, spermatozoa moving in a straight line were progressively counted from the slide in at least 15 different fields of the slide following the procedures reported by Garner and Hafez (2016). The number of motile cells was determined by counting approximately 250 cells across at least 15 fields. The proportions of live and dead spermatozoa were performed using the eosin-nigrosine dye exclusion staining technique and a wet smear method using formal saline. For evaluating the viability, first, the straws were removed from the liquid nitrogen and thawed at 37°C for 30 seconds in a water bath. Immediately after thawing, the straw was taken out, wiped with a clean cloth, and broken open.

A drop of semen was placed on a pre-warmed slide covered with a warm cover slip, and 2 drops of 1% eosin solution and 5 drops of 10% nigrosine were added. The stain and semen mixture was gently mixed on a pre-warmed slide, and two smears were prepared and air-dried. Oil immersion was used to count random fields on the slides with a phase-contrast bright field microscope to obtain a representative percentage of live sperm. A maximum of 100 sperm cells were counted in different fields to determine the percentage of live (unstained) and dead (pink-stained) sperm cells using the tally counter.

3.6. Data Analysis

After collecting and coding all the data, it was entered into MS Excel, cleaned, and then analyzed using SPSS, version 20 software. Descriptive statistics, including means, standard deviations, and percentages, were used to summarize the data. Quantitative data obtained from the survey study were analyzed using an independent T-test, while qualitative data were analyzed by chi-square tests. Significant differences among groups were considered when the P-value was less than 0.05. The rank index was also used to evaluate the overall major feed resource, common dairy cattle diseases, breeds and traits preferences, and the purpose of keeping dairy cows, and major challenges of AI service delivery across the study area. The following formula was used to calculate the indices:

$$\text{Index} = \frac{\sum [(r*HH \text{ in rank first}) + (r-1)*HH \text{ in rank second}) + \ldots + 1*HH \text{ rank last}) \text{ for single factor}]}{\sum [(r\ HH \text{ in rank first}) + (r-1)*HH \text{ in rank second}) + \ldots + 1*HH \text{ rank last}) \text{ for all factors}]}$$

Where, HH =number of respondent households, r = rank value given for the least important factor, and 1 is given to the most important factor in the enumerated list.

The statistical models are:

Model I: For semen quality parameters

$Y_{ij} = \mu + a_i + b_j + e_{ij}$ Where;

Y_{ij} = the observed values of semen quality (motility and viability)

μ = the overall mean

a_i = the effect of the ith semen location (LDI and AI technicians)

b_j=Effect of jth semen production period (different batch code or production date)

e_{ij} = random residual error

Model II: For AI efficiency and reproductive performance of dairy cows (survey data)

$Y_{ij} = \mu + a_i + e_{ij}$ Where;

y_{ij}=response variable

μ =Overall mean

a_i=fixed effect of ith (i= small and medium scale dairy farm)

e_{ij}= residual error

4. RESULTS AND DISCUSSION

4.1. Socio-demographic Characteristics of the Households

Table 2 presents the sex, marital status, level of education, field of specialization, and age of the interviewed households in the current study area. From the total sample household, 69.3% and 74.8% of them were male, while 23.7% and 25.2 of them were female-headed for small and medium-scale dairy producers, respectively, with an overall 72.05% of the households being headed by males and 27.95% being female-headed. This indicated that males made more contributions to dairy farming and/or management than females in the study area. This finding agrees with the findings of Kidane *et al.* (2019), who reported males were the major contributors to dairy farming, accounting for 78.82% and 81.98% for medium and small scales, respectively, in Ethiopia. The majority of the respondents, 73.3 and 72%, were married on a small and medium scale, respectively, with an overall mean of 72.65%. This implies that dairy production activities are dominated by married people across both small and medium-scale dairy producers, and the reason could be that households keep mostly crossbred dairy cows to lead life and support their family members using the income generated by selling dairy products. These findings are consistent with Kidane *et al.* (2019), who reported that 76.47% and 70.27% on a medium and small scale, respectively, with an overall 70.76% of married farmers in Ethiopia. Most of the married farmers were engaged in various dairy farming activities to generate income to meet household needs.

Regarding education level, about 36% and 28% for small and medium scale, respectively, with an overall 32% of the household heads having attained secondary school, while the remaining significant portion of household heads either attended lower grades limited to reading and writing or had never been to school. This finding aligns with Adane and Ayalew (2020), who reported that overall, 46.67% of respondents whose educational level was secondary school were highly participating in dairy production in Gonder town. Similarly, the current study is similar to that of Kidane *et al.* (2019), who reported that the majority of the dairy producers who had a secondary school highly participating in dairy production were 67.06% and 66.67% for medium and small scales, respectively, with an overall 66.86% in Ethiopia. About 9.3% and 11.6% for small and medium scale, respectively, with an overall 10.45% of the household heads having education ranging from diploma to master's degree in the fields of animal production, information and communication technology (ICT), management, and accounting and finance. However, none of them specializing in animal production are involved in medium-scale operations (Table 2). This indicates that the participation of a person in medium-scale dairy farm is not profession-based. However, education plays a significant role in affecting household income, and it could increase the adoption of new livestock improvement technology by the community (Duro, 2022).

The overall mean value of total family size based on developmental period per household in the study district was 4.86±2.07, which is presented in Table 2. Concerning the age distribution of family size, the majority of the sample respondents are 25–44 years old, with overall mean values of 0.84±0.88 and 0.82±0.71 for male and female, respectively. The overall mean values across small and medium-scale production were 0.84±0.88 for males and 0.82±0.71 for females. This result indicates that the workforce is predominantly composed of working-age adults. The mean values for most age groups are fairly similar between small-scale and medium-scale production, indicating that the age distribution of the workforce is not significantly different between these two production scales. The mean age of the sampled household heads in the study area was 47.77±10.89 and 45.21±11.66 years for small and medium scales, respectively, with an overall mean value of 46.49±10.90 years. This shows that, irrespective of the scale of dairy farming in the study areas, dairy production is primarily managed by individuals in their productive working years. This finding agrees with Kidane *et al*. (2019), who reported that in Ethiopia, dairy farming run by categories of productive working age groups had 42.98±8.06 and 43.35±8.54 years for small and medium scales, respectively, with an overall mean value of 43.17±8.3 years.

Table 2. Socio-demographic characteristics of the households in the study areas

Variables		Scale of production			p-value
		Small-scale (n=75)	Medium-scale (n=107)	Over all (N=182)	
		%	%	%	
Sex	Male	69.3	74.8	72.05	0.419
	Female	30.7	25.2	27.95	
Marital status	Single	13.3	16.8	15.05	
	Married	73.3	72.0	72.65	0.515
	Divorced	4	0.9	2.45	
	Widowed	9.3	10.3	9.8	
Level of education	Illiterate	10.7	8.4	9.55	
	reading and writing	18.7	15.0	16.85	0.717
	1-4 grades	13.3	16.8	15.05	
	5-8 grades	12.0	20.6	16.3	
	9-12 grades	36.0	28.0	32	
	Diploma	8.0	8.8	8.4	
	Degree	1.3	1.9	1.6	
	Masters	0	0.9	0.45	
Fields of specialization	Animal production	28.57	0	14.29	0.334
	ICT	28.57	8.33	18.45	
	Management	14.29	41.67	27.98	
	Accounting and finances	14.29	33.33	23.81	
	Construction	14.29	8.33	11.31	

	Language	0	8.33	4.16	
Family size (Mean±SD)					P-value
Total family		4.99±1.96	4.72±2.18	4.86±2.07	0.391
Under 1 year	Male	0.4±0.20	0.07 ±0.25	0.24±0.23	
	Female	0.8±0.27	0.09 ±0.29	0.45±0.28	
1-14 years	Male	0.56±0.74	0.54±0.74	0.55±0.74	
	Female	0.41±0.70	0.46±0.74	0.44±0.72	
15-24	Male	0.57±0.87	0.39±0.77	0.48±0.82	
	Female	0.45±0.81	0.57±0.9	0.5±0.85	
25-44	Male	0.85±0.95	0.82± 0.81	0.84±0.88	
	Female	0.85±0.71	0.79±0.71	0.82±0.71	
45-64	Male	0.48±0.50	0.44±0.50	0.46±0.5	
	Female	0.31±0.46	0.27±0.45	0.29±0.45	
Above 65	Male	0.13±0.34	0.09±0.29	0.11±0.32	
	Female	0.19±0.39	0.18±0.38	0.19±0.39	
Age(Mean±SD)		47.77±10.89	45.21±11.66	46.49±10.9	0.45

4.2. Experience of dairy farming and landholding

The experience of dairy farming and land holding is presented in Table 3. The average dairy farming experience of the respondents was 10.55±5.70 and 12.05±5.71 years for small and medium-scale dairy farms, with an overall mean of 11.3±5.71 years. In the present study, the mean value of experience with adopting dairy technologies was 8.43±3.6 and 9.49±3.26 years in small and medium-scale dairy farms, with an overall mean value of 8.96±3.43 years. The experience in implementing improved dairy farming technologies such as use of improved breed, artificial insemination, improved forage, and health services was significantly different ($P<0.05$) on a small and medium scale. This indicates that medium-scale farms may have more familiarity in dairy farming and the adoption of new technologies than small-scale dairy producers.

The overall mean value of total land size reported in the current study area was 0.82±1.37 hectares per household, with a mean of 0.74±1.25 and 0.9±1.48 for small and medium-scale dairy producers, respectively. Land is one of the pre-requisites for the establishment of a dairy farm;

however, the total land size of the dairy producers in the study area was less, which indicates that urban dairy farmers don't have sufficient land availability for dairy production. This study is similar to Kiros *et al.* (2018), who reported that 95% and 90% of dairy farmers from urban Bishoftu and urban Sululta responded that they totally don't have separate land for dairy production in selected urban and peri-urban areas of the central highlands of Ethiopia. The mean value of forage land was 0.04±0.09 and 0.12±0.33 hectares for small and medium scales of production, with an overall mean of 0.08±0.21 and a significant difference ($p<0.05$) between small and medium scales of production. This indicates medium-scale dairy producers adopt improved forage and cover more land for forage production purposes than small-scale producers. The overall mean value of land used for irrigation was 0.24 hectares, with medium-scale producers having more land for irrigation (0.35±0.69 hectares) compared to small-scale producers (0.13±0.39 hectares) and a significant difference ($p<0.05$) between the small and medium scales of production. This implies that medium-scale dairy producers have a higher contribution to food security and generate additional income corresponding to dairy farming activity than small-scale producers.

Table 3. Experience of dairy farming and landholding (Mean ± SD)

	Scale of production			
Variables	Small scale (n=75)	Medium scale (n=107)	Over all (N=182)	p-value
Dairy farming experience (years)	10.55±5.70	12.05±5.71	11.3±5.71	0.082
Experience with adopting dairy technologies	8.43±3.61	9.49±3.26	8.96±3.43	0.04
Total land size (ha)	0.74±1.25	0.9±1.48	0.82±1.37	0.45
Grazing land	0.06±0.22	0.11±0.42	0.09±0.32	0.28
Crop land	0.23±0.66	0.35±0.87	0.29±0.77	0.27
Forage land	0.04±0.09	0.12±0.33	0.08±0.21	0.01
Irrigation land	0.13±0.39	0.35±0.69	0.24±0.54	0.01

4.3. Cattle herd size and composition

Cattle herd size and composition in the study area are presented in Table 4. The total average number of cattle was 14.99±5.79 in the study area, and of these, lactating cows were dominated over the rest of the group of cattle with an overall mean value of 8.41±3.46. This indicates that dairy producers are primarily targeted on milk production due to high milk demand in Addis Ababa. However, significantly larger numbers of lactating dairy cows per household were observed in medium-scale farms 13.28±5.70 than smallholders 3.53±1.21. This might be because medium-scale producers have better resources (land, capital, and access to genetics) to invest in crossbred and purebred dairy cattle breeds. The average crossbred heifers per household was reported to be 2.04±1.50, with significantly lower crossbred heifers in small-scale farmers 1.63±1.11 than in small and medium-scale dairy farms 2.44±1.88. This indicates that medium-scale dairy farms have higher numbers of crossbred heifers due to a focus on herd growth and improvement. But the number of male calves and oxen was relatively lower than the rest of the group of cattle, as shown in Table 4. This is because dairy farming is the primary focus in Addis Ababa, as the city has a high demand for dairy products to meet the needs of its large and growing population. Keeping a large number of male calves or oxen may not be feasible or economical due to the higher feed and space requirements.

Table 4. Cattle herd size and composition (Mean ±SD)

Cattle type	Scale of production			
	Small scale (n=75)	Medium scale (n=107)	Over all (N=182)	p-value
Total number of cattle	4.+95±2.29	25.02±9.28	14.99±5.79	
Heifers for local breed	0.20±0.70	0.08±0.42	0.14±0.56	0.20
Heifers for cross breed	1.63±1.11	2.44±1.88	2.04±1.50	0.000
Male calves local(<6 months)	0.05±0.28	0.05±0.30	0.05±0.29	0.88
Male calves cross (<6 months)	0.13±0.41	0.66±1.06	0.79±0.74	0.000
Female calves local (<6 month)	0.35±0.08	0.01±0.1	0.18±0.45	0.00
Female calves cross (<6 month)	0.83±1.14	4.12±2.65	2.48±1.90	0.000
Bull local breed	0.24±0.63	0.83±2.42	0.54±1.53	0.02
Bull crossbreed	0.21±0.50	0.29±1.01	0.25±0.76	0.546
Oxen local	0.19±1.75	0.50±1.22	0.35±1.46	0.088
Oxen crossbreed	0.05±0.32	0.09±0.42	0.07±0.37	0.491
Dry cows local	0.13±0.58	0.05±0.21	0.09±0.40	0.218

Dry cows crossbreed	0.56±0.86	1.73±1.61	1.15±1.24	0.000
Local breed lactating cows	0.25±0.72	0.08±0.28	0.17±0.50	0.055
Crossbreed lactating cows	3.53±1.21	13.28±5.70	8.41±3.46	0.000

4.4. Dairy cattle management

4.4.1. Dairy Cattle feed and feeding

The major feed resources of dairy cattle identified in the study districts were compound feed, agro-industrial by-products, hay, crop residues, and improved forages for small and medium-scale dairy farms (Table 5). Compound feed (pre-mixed feed that is formulated to meet specific nutritional needs) was the most commonly used dairy cattle feed for medium-scale dairy producers, with an index value of 0.27, followed by agro-industrial by-products and hay, with index values of 0.22 and 0.20, respectively. In contrast, for small-scale producers, agro-industrial by-products were the dominant feed resources, having an index value of 0.24, followed by compound feed and hay with index values of 0.21 and 0.2, respectively. This study indicates that both small and medium dairy producers prefer highly concentrated feed types over lower-quality feeds to maximize milk production. This preference is facilitated by the presence of many agro-industrial processing plants and feed processing plants in and around the study area. The findings of this study are comparable to those reported by Kiros *et al.* (2018), where concentrate feed was a major cattle feed resource (55%) in Bishofitu town. However, the results differ from those of Hochiso *et al.* (2020), where concentrate feed had the least index value (0.09 for highland and 0.11 for midland) compared to other feed sources in Misha district of Ethiopia. Medium-scale farms likely have better access to a wider range of feed sources, especially compound feeds that are the sole or primary feed source for animals, providing all the necessary nutrients for growth, maintenance, and production. This is because medium-scale farmers may have better access to credit, loans, or other financial resources to invest in purchasing compound feed in bulk. Conversely, small-scale farms may be more constrained in their feed choices, relying on readily available and less expensive options such as basic concentrate supplements (wheat bran, bean bran, cotton seed cake).

Table 5. Major feed resources of dairy cattle in the study area

	Rank

Scale	Feed type	1st	2nd	3rd	4th	5th	6th	Index	Rank
Small scale (n=75)	Industrial by-products	58	8	7	1	1	0	0.24[a]	1
	compound feed	2	66	5	1	1	0	0.21	2
	Hay	13	20	31	8	3	0	0.19	3
	Crop residue	13	12	6	19	24	1	0.15	4
	Improved forage	5	3	15	18	33	1	0.13	5
	Natural pasture	0	0	0	1	74	0	0.09	6
Medium scale (n=107)	Compound feed	101	3	3	0	0	0	0.27[a]	1
	Industrial by-products	2	88	14	2	1	0	0.22	2
	Hay	11	36	41	16	3	0	0.20	3
	Crop residue	7	30	14	28	28	0	0.17	4
	Improved forage	3	5	19	27	53	0	0.13	5

The same subscription letter indicates have significant differences

4.4.2. Dairy cattle water source and watering frequency

The primary water sources for dairy cattle in a study area were tap and ground water, as presented in Table 6. The majority of dairy farmers, both in small-scale (84%) and medium-scale (94.4%) production, use tap water as their primary water source. Overall, 89.2% of the farmers use tap water. In contrast, a smaller proportion of small-scale farmers (16%) use ground water, while only 5.6% of medium-scale farmers rely on ground water. The overall percentage of farmers using ground water was 10.8%. The difference in water source usage between small-scale and medium-scale farmers is statistically significant ($p<0.05$). This suggests that the scale of dairy production is a significant factor in determining the choice of water source for these farmers. The higher reliance on tap water among medium-scale farmers compared to small-scale farmers could be attributed to factors such as better infrastructure, access to municipal water supply, or a preference for the perceived quality and reliability of tap water. Conversely, the relatively higher proportion of small-scale farmers using ground water may be due to limited access to tap water. The current study is similar to that reported by Fesseha (2020), who found that tap water (67.7%) was the primary source of water for dairy cattle in and around Hawassa town. Regarding the frequency of watering, a significant proportion of both small-scale (50.7%) and medium-scale (57.9%) farms provided water for their dairy cattle in free access or *ad libitum* during the dry season. The remaining farms have varying watering frequencies, with 25.3% of small-scale farms providing water three times a day, compared to 28% of medium-scale farms. The findings reported by Fesseha (2020) contradict the concept of *ad libitum* water provision for dairy cattle. According to the study, most farmers (55.6%) in and around Hawassa town provide water for their dairy cattle only once a day, rather than offering free and continuous access. The majority of the farms use concrete feed and water troughs, with 74.7% small-scale and 85% medium-scale farms. Plastic troughs are also used less frequently, with 25.3% on small-scale farms and 15% on medium-scale farms.

Table 6. Water source and watering frequency of dairy cattle in the study area

Parameters		Scale of production			p-value
		Small scale (n=75)	Medium scale (n=107)	Over all (N=182)	
		%	%	%	
Water sources	Tap	84	94.4	89.2	0.021
	Ground	16	5.6	10.8	
Frequency of watering	Once a day	0	0	0	0.227
	Twice a day	24.0	14.0	19	
	three times a day	25.3	28.0	26.65	
	Ad libitum	50.7	57.9	54.3	
Types of feed and water troughs	Plastic material	25.3	15	20.15	0.08
	Concrete	74.7	85	79.85	

4.4.3. Dairy cattle housing

The major types of dairy cattle housing and floor in the study area are presented in Table 7. For housing type between small-scale and medium-scale dairy farms, the majority (81.33%) of small-scale farms used a traditional free-stall design, whereas the majority (83.18%) of medium-scale farms used a modern barn without individual cattle pens. Overall, the most common housing type is the modern barn without pens, accounting for 48.26% of all farms. The openings between the individual pens are likely equipped with basic gates or dividers, often made of wood and metal, to allow for the separation and management of individual animals. There was a significant difference

($p<0.05$) in housing type between small and medium-scale dairy farms. This implies that small-scale producers did not use modern barns for their dairy cattle due to a lack of resources. Their dairy cattle barns were constructed in local, available materials in cost-effective manners, regardless of ensuring cow comfort. However, in medium-scale farms, the number of crossbred milking cows was larger than in small-scale farms, which may demand better comfort and management than local breeds. This might be the driving factor in to improve their dairy barns and thereby improving the productivity of the animals. Regarding floor types, the majority of overall farms (95.19%) used concrete floors, with a higher proportion of medium-scale farms (100%) using concrete compared to small-scale farms (95.19%). There is also a small percentage (8%) of small-scale farms that use stone slab flooring, which is not present in medium-scale farms.

Table 7. Housing type for dairy cattle in the study area

Housing type	Scale of production			p-value
	Small (n=75)	Medium (n=107)	Overall (N=182)	
	%	%	%	
Traditional free stall	81.33	10.28	45.80	0.000
Modern barn with Individual cattle pen	1.33	6.54	3.94	
Modern barn without individual cattle pen	13.33	83.18	48.26	
Open barn	4	0	2	
Floor types				
Earthen	1.33	0	0.67	0.006
Concrete	90.37	100	95.19	
Stone slab	8	0	4	

4.4.4. Dairy cattle disease management

The result presented in Table 8 reveals that the most prevalent diseases among dairy cows in both small-scale and medium-scale production systems were lumpy skin disease (LSD), mastitis, foot and mouth disease (FMD), and hypocalcemia. The most prevalent dairy cattle diseases in the study area were Lumpy Skin Disease (LSD), Foot and Mouth Disease (FMD), Mastitis, and Hypocalcemia (milk fever), with index values of 0.17, 0.16, 0.15, and 0.14 in small-scale dairy farms, respectively. This finding suggests that LSD was particularly prevalent on small-scale farms, likely due to factors such as less stringent biosecurity measures (inadequate fencing, poor hygiene practices, and a lack of foot baths) and limited access to veterinary services. The current study aligns with the findings reported by Debebe and Fesseha (2020) and Fasil *et al*. (2016) in Hawassa town, Ethiopia, that lympy skin diseases (LSD) are the leading health problem, accounting for 42.6% and 30.1% of cases, respectively.

However, in medium-scale dairy farms, the major diseases challenging the productivity of dairy cattle in the study area were mastitis, LSD, hypocalcemia, FMD, and black leg, with index values of 0.14, 0.13, 0.12, 0.1, and 0.1, respectively. This indicates that the prevalence of mastitis is demonstrably higher on medium-scale dairy farms due to several key factors. Firstly, the animals on these farms are housed in close proximity, which significantly increases the likelihood of pathogen transmission and spread. Additionally, the overcrowding often present in medium-scale operations can lead to increased stress levels, poor hygiene, and greater exposure of the animals to mastitis causing pathogens. Furthermore, the poor maintenance of milking equipment and inadequate cleaning and sanitization protocols commonly observed in medium-scale dairy farms can directly contribute to the proliferation of mastitis-causing bacteria. The current finding contrasts with previous studies reported by Fesseha (2020) in and around Hawassa Town and Aweke and Mekibib (2017) in Addis Ababa, which reported lower prevalence rates of mastitis in dairy cattle (25.3%) and (10.4%), respectively. However, the current study aligns with findings reported by Tolosa *et al*. (2021), who observed a high prevalence of mastitis (20.57%), a major reproductive disorder of dairy cattle in and around Bale Robe, Oromia Regional State, Ethiopia.

Table 8. The most common dairy cattle disease in the study area

	Small-scale (n=75)									
Diseases	R1	R2	R3	R4	R5	R6	R7	R8	R9	Index
LSD	56	9.3	9.3	25.3	0	0	0	0	0	0.17[a]
FMD	18.7	37.3	16	18.7	9.3	0	0	0	0	0.16[a]
Mastitis	26	18.7	18.7	9.3	9.3	0	9.3	0	0	0.15[a]
Hypocalcemia	12	44	32	0	0	5.3	0	6.7	0	0.14
Anthrax	0	0	9.3	18.7	34.7	18.7	0	0	18.7	0.10
Blackleg	0	0	9.3	18.7	28	18.7	16	0	9.3	0.09[a]
Pasterlosis	0	0	0	0	18.7	25.3	37.3	18.7	0	0.07[a]
Brucellosis	9.3	0	0	0	9.3	0	9.3	37.3	34.7	0.06

Foot root	0	0	0	0	0	18.7	28	44	9.3		0.05[a]
	Medium-scale (n=107)										
Diseases	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Index
Mastitis	54.2	22.4	11.2	12.1	0	0	0	0	0	0	0.14[a]
LSD	52.3	4.7	5.6	12.1	16.8	8.4	0	0	0	0	0.13[a]
Hypocalcemia	9.3	13.1	52.3	9.3	13.1	2.8	0	0	0	0	0.12
FMD	15.9	15.9	28	0.9	10.3	11.2	9.3	8.4	0	0	0.10[a]
Blackleg	19.6	17.8	0	8.4	26.2	18.7	0.9	5.6	2.8	0	0.10[a]
Uterine prolapses	28	8.4	16.8	1.9	11.2	0.9	16.8	12.1	3.7	0	0.09[a]
Foot root	18.7	9.3	0.9	8.4	9.3	0.9	14	18.7	16.6	3	0.08[a]
Brucellosis	11.2	17.8	0	8.4	20.6	4.7	8.4	18.7	3.2	6.1	0.08
Anthrax	15.9	7.5	2.8	1.9	18.7	16.8	10.3	2.0	8.4	15.8	0.07
Pasterlosis	0	8.4	8.4	9.3	28	9.0	4.7	15	7.5	9.7	0.06[a]

LSD=Lympy skin diseases, FMD=Foot and mouth diseases R=ranks; the same subscription letters on small and medium scale have significant difference

4.4.5. Calf management system

The results presented in Table 9 reveal important insights into the availability and differences in calf facilities between small-scale and medium-scale dairy farms. Overall, 76.2% of the farms had adequate calf facilities (calving area, navel treatment, and colostrum feeding). However, a significantly higher percentage of medium-scale farms (89.7%) had adequate calf facilities (calving area, navel treatment, and colostrum feeding) compared to small-scale farms (62.7%). This indicates a statistically significant difference ($p<0.05$) in the availability of adequate calf facilities between the two production scales. The results suggest that medium-scale dairy farms may have better access to resources, infrastructure, and knowledge to support their calf management practices. In contrast, small-scale farms appear to face more challenges in providing adequate calf facilities, which could impact the health and well-being of their calves. Furthermore, the study found that the types of calf facilities also varied significantly between small-scale and medium-scale farms ($p<0.05$). Colostrum feeding was the primary calf care practice, adopted by 44.89% of farms, followed by both calving area and colostrum feeding (29.87%), calving area only (19.47%), and navel treatment only (5.67%). This implies that colostrum feeding is a widely accepted and essential practice for ensuring the health and well-being of calves, regardless of the farm's size or production methods. The current study findings differ from those reported by Sanjay *et al.(2023*) in India, where colostrum feeding was observed at a significantly higher rate of 99.33%, but the current study findings on navel treatment are comparable to this study's reported rate of 9.67% of farmers only practice. Similarly, Barman *et al*. (2023) reported that colostrum feeding (77%) was the first special care for the calf in Rajbanshi dairy farmers India. Medium-scale farms prioritized dedicated birthing areas for pregnant animals, often equipped with facilities for storing and warming colostrum. This approach was adopted by 42.71% of medium-scale farms. Small-scale farms, on the other hand, were less likely to have specialized birthing spaces. Instead, they focused on providing colostrum feeding facilities, with 59.57% of small-scale farms having these resources. Dairy farms, both small-scale and medium-scale, face a significant challenge in calf mortality. The study found that a majority of farms across both production scales reported experiencing calf deaths. On average, approximately 74.8% of small-scale farms and 72.0 percent of medium-scale farms reported calf mortality incidents. The primary causes of calf mortality were identified as diseases (58.68% of cases), sudden death (32.92% of cases), and dystocia at birth (3.7% of cases). These findings are consistent with a previous study reported by Fentie *et al*. (2020) diseases were the leading cause of calf mortality, accounting for 73.2% of cases in the urban and peri-urban dairy production systems of Ethiopia. The major causes of mortality in calves were diarrhea (50.21%), pneumonia (36.26%), and navel bleeding (15.86%) in the study area. The current study is inconsistent, as reported by Uro (2020), who found that pneumonia (13.48%) and diarrhea (12.77%) were less of the causes of calf's mortality in and around Wolaita Sodo Town, Ethiopia. The current findings on the major causes of calf mortality align with previous research conducted in Ethiopia's urban and peri-urban dairy production systems, reported by Fentie *et al*. (2020), which identified diarrhea (46.4%) and pneumonia (9.4%) as the primary disease-related causes of calf mortality. Further supporting this study, Abebe *et al*. (2023) found in southern Ethiopia diarrhea to be the leading cause of mortality (62.1%), followed by pneumonia (13.8%). Similarly, Yayesew and Temesgen (2023) reported diarrhea (52%) and pneumonia (20%) as major causes of calf mortality in Akaki Kality.

Table 9. Calf management practice in the study area

Parameters		Scale of Production: Small scale (n=75)	Medium scale (n=107)	Overall (N=182)	p-value
Adequate calves facility	Yes	62.7	89.7	76.2	0.000
	No	37.3	10.3	23.8	
Types of calves facilitates	Calving area only	19.15	19.79	19.47	0.000
	Navel treatment only	4.26	7.29	5.76	
	Colostrum feeding only	59.57	30.21	44.89	
	Both calving area and colostrum feeding	17.02	42.71	29.87	
Calves mortality	Yes	74.8	72.0	73.4	0.677
	No	25.2	28.0	26.6	
Cause of mortality	Diseases	61.11	56.25	58.68	0.776
	Small and weak at birth	1.85	5	3.43	
	Accident and sudden death	33.33	32.5	32.92	
	Dystocia	3.7	3.75	3.73	
	Overfeeding of milk and water	0	2.5	1.25	
Calves diseases	Diarrhea	51.52	48.89	50.21	0.874
	Pneumonia	30.33	42.22	36.26	
	Navel ill	18.18	13.53	15.86	

4.5. Dairy cattle breed preference in the study area

The results presented in Table 10 show the rank preferences of different breeds of cattle in small-scale and medium-scale farming operations. Crossbred dairy cows are the most preferred breed in both small-scale and medium-scale farms, with higher index values of 0.35 and 0.36, respectively. This suggests that crossbred dairy cows often exhibit hybrid vigor, which can lead to higher milk yields, better growth rates, and improved fertility and health compared to their purebred counterparts. And this breed may have better adaptation capacity to the local environmental conditions, such as climate, feed resources, and disease challenges, compared to purebred breeds. This increased productivity can make crossbreds more attractive to dairy farmers seeking to maximize their returns (Galukande *et al*., 2013).Purebred HF cattle are the second most preferred in both small-scale (index 0.25) and medium-scale (index 0.25) farms. This indicates that the high milk production potential of HF cattle is valued by farmers, regardless of the scale of their operations. The preference for purebred Jersey cattle is significantly lower in both small-scale and medium-scale farms compared to crossbred and HF cattle. The preference for Jersey cattle is slightly higher on medium-scale farms, with a higher index value of 0.2 in the third rank compared to small-scale farms that have an index value of 0.17 in the fourth rank. However, this low preference could imply that the awareness, understanding, and familiarity of the Jersey breed's characteristics and potential benefits may be limited among the farmers. The preference for local breeds was lower on both small-scale (index 0.22) and medium-scale farms (index 0.19) compared to crossbred and HF cattle. This lower preference could imply that local-breed dairy cows may have lower productivity (production and reproduction performance) compared to improved or crossbred dairy cattle. Numerous studies have consistently demonstrated a strong preference for crossbred animals among Ethiopian livestock producers. The current study is similar to the findings reported by Janssen (2016), who found that all 100 percent of the respondents in Jimma town preferred crossbred animals over purebreds. Similarly, Haile and Tesfahun (2022) reported that the majority (81.67%) of respondents in the Gedeo agroforestry area favored crossbred livestock breeds. In contrast, a study conducted by Lukuyu *et al.* (2019) in Western Kenya revealed that the Friesian and Ayrshire breeds were the most popular, each being selected by 34% of respondents as their preferred dairy cattle type.

Table 10. Dairy cattle breed preference in the study area

Scale	Breed	Rank					
		R1	R2	R3	R4	Index	Rank
Small scale (n=75)	Crossbred	68	21.3	10.7	0	0.35	1
	Purebred HF	17.3	24.0	48.0	10.7	0.25	2
	Local breed	14.7	33.3	13.3	38.7	0.22[a]	3
	Purebred Jersey	0	21.3	28.0	50.7	0.17[a]	4

Medium scale (n=107)	Crossbred	67.3	21.5	11.2	0	0.36	1
	Purebred HF	18.7	29	40.2	12.1	0.25	2
	Purebred Jersey	0.9	29.9	35.5	33.6	0.2[a]	3
	Local breed	13.1	19.6	13.1	54.2	0.19[a]	4

HF= Holstein Friesian, R=ranks; the same subscription letters on small and medium scale have significant difference

4.6. Trait preference for selection of dairy cattle

The major preferred traits as reported by the sample respondents were milk yield, disease resistance, fast growth, temperament, physical appearance, and coat color of the dairy cow (Table 11). Results of the present work showed that ranking of traits with the index value for both small and medium scale of dairy farms milk yield (0.25 and 0.28) was the most preferred trait by farmers, followed by diseases resistance (0.20 and 0.22), fast growth (0.18 and 0.19), temperament (0.17 and 0.14), physical appearance (0.14 and 0.1), and coat color (0.05 and 0.06) respectively. The strong preference for milk yield among small and medium-scale dairy producers in Ethiopia is likely driven by the need to meet the growing demand for milk from urban consumers and milk processing plants. As the population and urbanization have increased, these producers have prioritized selecting breeding cows with high milk production traits to ensure they can supply the required volumes of milk. Additionally, farmers in both small and medium-scale dairy operations have focused on traits beyond just milk yield, also prioritizing disease resistance and fast growth in their breeding decisions. This suggests a holistic approach to selecting dairy animals that can thrive in the local production environment while also meeting the market's milk quantity and quality requirements. The emphasis on these multifaceted breeding goals underscores the producers' understanding of the need to balance productivity, profitability, and sustainability in their dairy enterprises. The current finding is similar to ranking milk yield first by dairy farmers in the report of Amanuel (2023), where milk yield was the most preferred traits (index 0.25) of dairy cattle in Hadiya zone. Bereda *et al*. (2024) also reported that milk yield was the first trait preferred (index 0.12) by farmers for Holstein-Friesian crossbred dairy cows in Angolelana Tera district, North Shewa zone, Ethiopia; Zewdu *et al*., (2018) milk yield were the first preferred traits (index 0.37) by farmers in Enebsie sar midir district in East gojjam zone, Ethiopia; Janssens, (2016) milk yield were first traits preferred by farmers for local (index 0.26) and cross (index 0.25) dairy breed in Jimma town, Ethiopia; Gebremichael *et al*., (2015) milk yield were the first trait preference of farmers for dairy cattle (index 0.21) in Central Zone of Tigray, Northern Ethiopia; and Haile and Tesfahun (2022), milk yield was the primary interest of the dairy cattle keeper (index 0.31) in the Gedeo Agroforestry of Ethiopia. However, the current study is contrary to what was reported by Zewdu *et al*. (2018): traction power is the first trait preference of cattle by farmers in Hulet eju enese and Aneded district in East gojjam zone Ethiopia; and Bereda *et al. (2024*) found that milk fat (index 0.16) and disease resistance (index 0.13) were the first traits that were preferred by farmers for jersey crossbreed and indigenous breed, respectively, in Angolelana Tera district, North Shewa zone, Ethiopia.

Table 11. Trait preference for selection of dairy cattle

Scale	Traits	Rank							
		1st	2nd	3rd	4th	5th	6th	Index	Rank
Small scale (n=75)	Milk yield	68	21.3	10.7	0	0	0	0.25	1
	Diseases resistance	0	68	16	16	0	0	0.20	2
	Fast growth	2.7	13.3	53.3	30.7	0	0	0.18	3
	Temperament	0	13.3	84.0	1.3	1.3	0	0.17	4
	Physical appearance	0	2.7	29.3	48	20	0	0.14	5
	Coat color	0	0	0	0	20	80	0.05	6
Medium scale (=107)	Milk yield	96.3	0	3.7	0	0	0	0.28	1
	Diseases resistance	0.9	76.6	11.2	11.2	0	0	0.22	2
	Fast growth	2.8	6.5	0	71	22.4	0	0.19	3
	Temperament	0	6.5	86	4.7	0	0	0.14	4
	Physical appearance	0	9.3	0	13.1	47.7	29.9	0.10	5
	Coat color	0	0	0	0	29.9	70.1	0.06	6

4.7. Purpose of keeping cattle

Farmers keeping dairy cattle for different purposes such as milk, cash, insurance, meat and manure in the study area as presented in Table 12. The primary purpose of farmers keeping cattle in small and medium-scale farms were milk production, with index values of 0.29 and 0.31, respectively. This implies milk production is the main source of income and livelihood for farmers regardless of scale of operation with rapidly expanding urban population with increasing demand for dairy products and relatively smaller landholdings. And also infrastructure and market access make it easier for farmers to sell their milk and dairy products. Selling live animals were the second most important purpose keeping cattle in both small-scale and medium-scale with index values of 0.26 and 0.24, respectively. This suggests that cash income was also a significant consideration for farmers, likely for household expenses, investments, or other financial needs. Insurances were the third ranks for both small-scale and medium-scale index value of 0.23 dairy farmers. Meat and manure were indicated as the least purposes for small and medium scale of dairy producers. The current finding is similar to reported by Amanuel (2023) cattle were kept primarily for milk production (index 0.33) and besides source of income through selling live animal (index 0.26) in Hadyia Zone; Hailemariam (2018) who reported that the primary purpose of keeping cattle was for milk production for urban (0.57) and peri-urban (0.53) farming in Ziway-Hawassa milk shed, Ethiopia; Haile and Tesfahun (2022) milk production was the primary purpose of dairy cattle keeping by farmers in Gedeo Agroforestry of Ethiopia; Alilo (2022) the primary purpose of keeping dairy cattle was the source of milk and milk products for home consumption and market total frequency of 60 in Southwestern Ethiopia. However, the current result is inconsistent reported by Gebremichael *et al.*, (2015) farmers kept dairy cattle primary for generating income which accounts 35.6% in Central zone of Tigray, Northern Ethiopia.

Table 12. Purposes of farmers keeping dairy cattle in the study area

Scale	Purposes	Rank						
		1st	2nd	3rd	4th	5th	Index	Rank
Small scale (n=75)	Milk	65.3	28.0	6.7	0	0	0.29	1
	Cash	21.3	46.7	18.7	18.7	13.3	0.26	2
	Insurance	13.3	25.5	48.0	13.3	0	0.23	3
	Meat	0	0	13.3	54.7	32.0	0.12	4
	Manure	0	9.3	16.0	22.7	52.0	0.10[a]	5
Medium scale	Milk	65.4	31.8	2.8	0	0	0.31	1
	Cash	17.8	43.9	26.2	12.1	0	0.24	2

(n=107)	Insurance	16.8	24.3	46.7	12.1	0	0.23	3
	Meat	0	0	12.1	.55.1	32.7	0.12	4
	Manure	0	0	12.1	21.5	66.4	0.10[a]	5

The same subscription letters on small and medium scale have significant difference

4.8. Dairy Cattle Breeding Practice

The results presented in Table 13 provide a detailed indication of the breeding practices employed in the study area. The result reveals that artificial insemination (AI) is the dominant breeding method utilized in the study area, with an overall adoption rate of 88.1%. This finding indicates that AI is the most widely practiced form of breeding among dairy producers in the study area. In the study, there was a relative prevalence of other breeding approaches, with the use of both improved bulls and AI accounting for 8.6% of breeding practices and the utilization of local bulls comprising 3.35%. However, the data suggests that natural mating was a relatively limited practice in the study area. Across small and medium-scale farms, dairy producers utilized AI as the primary mating option for their dairy animals, with percentages of 82.7% and 93.5%, respectively. This might be due to the availability of adequate AI technicians with the necessary infrastructure in Addis Ababa as compared to many other parts of the country, besides the proximity of AI centers where the semen is produced and distributed nationally. In addition, farmers who are living in Addis Ababa were exposed to various dairy technologies, including AI technologies that can transform the dairy sub-sector. Natural mating was less practice, which accounts for 3.35% because keeping bulls is expensive due to feeding and watering, housing, and health care management. Therefore, AI is a crucial alternative to reducing the cost of feeding bulls. There is a significant difference in the use of breeding methods between small-scale and medium-scale farms ($p<0.05$). This indicates that medium-scale dairy producers were more likely to use AI than small-scale dairy producers due to possessing greater financial resources and economic flexibility, highly participating in AI training programs, and the perceived benefits of AI in terms of genetic improvement and herd management, especially the supplementation of compound feed to dairy cattle. The current study is similar to those reported by Haile and Tesfahun (2022), who found that artificial insemination was the dominant breeding method 96.1% of the Gedeo Agroforestry of Ethiopia; Aweke and Mekibib (2017) who found that 74.03% of artificial insemination was the dominant breeding method in the capital city of Addis Ababa, Ethiopia. However, the current finding is contrary reported by Janssens (2016) none of farmers were used artificial insemination for breeding method in Jimma Town, Ethiopia; Yousuf and Getachew, (2021) farmers were used artificial insemination for breeding method accounts 45% in case of Sayo district West Wollega zone,Ethiopia; Benti *et al*., (2021) farmers were used artificial insemination for breeding method which accounts 2.0% in Bako Tibe District of West Showa Zone, Ethiopia; Mekonnen and Berhe, (2023) farmers were used artificial insemination for breeding method accounts 2.3% in the Western Zone of Tigray Region, Ethiopia; Zewdu *et al*., (2018) farmers were used artificial insemination for breeding method accounts 6.7% were used AI in East Gojjam zone, Ethiopia.

Regarding the artificial insemination service in the study area, most dairy producers satisfy, as presented in Table 13. A total of 57.5% of dairy producers were satisfied, and 42.5% were not satisfied with the overall artificial insemination service in the study area. This indicates that overall, farmers are generally satisfied with the AI services available, regardless of their small and medium farm sizes. The current findings are consistent with those reported by Amanuel (2023), who found that 62.2% were satisfied and 37.8% were not satisfied with the AI services in Hadiya Zone, Southern Ethiopia. The current study is inconsistent, as reported by Bekele *et al*. (2021). 38.8% of farmers were satisfied and 61.2% of dairy producers were not satisfied with the overall artificial insemination service in two selected districts of West Hararghe zone; Mathewos *et al*. (2023) found that 21.5% of dairy producers were satisfied with the AI service and 78.5% of farmers were not satisfied with the overall artificial insemination service in Kacha Bira district of Southern Ethiopia. Similarly, Juneyid *et al*. (2017) reported that 55.8% of farmers were not satisfied by artificial insemination services; the rest (44.2%) were satisfied in Tullo district, West Hararghe, Ethiopia. The majority of small-scale (76%) and medium-scale (95.3%) farms reported that the AI technicians did not arrive at the right insemination moment for the dairy animals. As a result, the animals were delayed another 21 days until they resumed the next cycle. This is due to a shortage of trained and qualified AI technicians available to serve the dairy farmers; the existing AI technicians may be overloaded with service requests and have inadequate transportation infrastructure (i.e. Motorbikes). There is a significant difference ($p<0.05$) in how small-scale and medium-scale dairy farm owners decide to use AI technology when faced with delays in AI technician services. This suggests that small-scale dairy producers are more likely to use natural mating (17.3%) compared to medium-scale producers (4.7%). All small and medium-scale dairy farmers communicate with AITs by calling them (100%) when the animal shows heat signs, as none of them have hired AI technicians on their farms. This finding differs from the finding reported by Mathewos *et al*. (2023) that means of communication dairy farmers with AI technicians for AI service were taken their cows to the AI station (50%) in Kacha Bira District of Southern Ethiopia. Regarding the AI cost per service per cow at one insemination, the overall mean value was 285.26±37.40 in the study area. The majority of farmers on a small scale (81.3%) and 100% on a medium scale, with an overall percentage of 90.65%, were willing to accept an increased service charge as long as the service was reliable and regular. While there was a highly significant difference between small and medium farms (p<0.05), it seems that medium-scale farms, with their larger herds, are more likely to pay more because delays in insemination can really hurt their milk production and profits, and they also have more money to spend for the service.

Table 13. AI delivery system in the study area

		Scale of production			
Parameters	Category	Small scale (n=75)	Medium scale (n=107)	Overall (N=18)	p-value
Breeding methods	Local bull	6.7	0	3.35	0.013
	AI	82.7	93.5	88.1	
	Improved bull and AI	10.7	6.5	8.6	
Satisfaction with the AI service	Yes	53.3	61.7	57.5	0.261
	No	46.7	38.3	42.5	
Decision of farm owners delay for AI tech	Wait for another 21 days	76.0	95.3	85.65	0.000
	Use natural mating with local or improved bulls	17.3	4.7	11	
	Use natural mating with local bull	6.7	0	3.35	
Do you have hired AI tech?	Yes	0	0		
	No	100	100	100	
Ways of communication with AI technicians	Call to AITs when the animal shows heat signs	100	100	100	
Willingness of raising the service charge?	Yes	81.3	100	90.65	0.000
	No	18.7	0	9.35	
Payment per service in birr (Mean±SD)		287.33±31.94	283.18±42.86	285.26±37.40	

4.9. Heat detection methods

The method of heat detection, major signs of cows during heat, and time of insemination are presented in Table 14. The farmers detected their cows that came in heat by using herdsman information, teaser bull, and regular follow-up during the morning and night, with an overall percentage of 9.55%, 2.95%, and 87.5%, respectively. The most common sign of heat varied by farm size, with bellowing (40.0%) being prevalent in small-scale farms and clear mucus discharge (38.3%) in medium-scale farms. Overall, dairy producers detected cows in heat by observing a range of signs, including bellowing (33.5%), clean mucus discharge (29.15%), reduced milk yield (12.25%), standing when mounted by others (10.5%), restlessness and redness of the vulva (7.25%), mounting on other animals (4.5%), and reduced appetite (2.75%). This indicated that farmers inseminated their cows when they observed signs of bellowing and clear mucus discharge, particularly in small-scale and medium-scale farms, respectively. However, these were not always reliable indicators. Therefore, farmers should have followed the gold standard for heat detection, which is observing a cow standing still and allowing other cows to mount her. This could have been achieved by filling their knowledge gaps through visual aids, training, focus group discussions, practical experience, and ongoing support and guidance.

The current findings align with Mathewos *et al*. (2023), who reported that bellowing (48.5%) was the most common heat detection method used by farmers in the Kacha Bira district of southern Ethiopia. However, these findings contrast with those of Kebebew and Beke (2018), who reported that clean mucus discharge (34.8%) was the most prevalent heat detection method used by farmers in and around Adama town. Similarly, Juneyid et al. (2017) reported that mounting on other cows (41.4%) was the most common sign of heat detection methods used by farmers in Tullo district, West Hararghe, Ethiopia. The majority of farmers (97.05%) inseminated their crossbreed cows in the morning or afternoon following the observation of heat signs, while a small percentage (2.95%) inseminated immediately upon detection. The current finding was aligned with Rugwiro *et al*. (2021), who found that 76.4% of farmers inseminated cows in the afternoon if heat was detected in the morning and scheduled insemination for the following morning if heat was observed in the afternoon in Rwanda. However, the current finding is in contrast with Mathewos *et al*. (2023), who reported that only 21% of farmers inseminated in the afternoon after morning heat detection and

20% inseminated the following morning after afternoon detection in the Kacha Bira district of southern Ethiopia. Similarly, Kebebew and Beke (2018) found that only 22.7% of farmers inseminated cows in the afternoon after morning heat detection and 23.7% inseminated the following morning after afternoon detection in and around Adama Town.

Table 14. Major heat detection methods of dairy cattle on the farms

Variables	Category	Scale of production			
		Small scale (n=75)	Medium scale(n=107)	Overall (N=182)	p-value
Methods of heat detection	Herdsman information	10.7	8.4	9.55	0.587
	Using teaser bull	4.0	1.9	2.95	
	Regular follow-up during morning and night to check the sign of the heat	85.3	89.7	87.5	
Signs of heat	Mounting of a cow on other animals	5.3	3.7	4.5	0.266
	Standing when mounted by other	10.7	10.3	10.5	
	Clean mucus discharge	20.0	38.3	29.15	
	Bellowing	40.0	27.1	33.55	
	Restlessness and redness of vulva	8.0	6.5	7.25	
	Reduce appetite	2.7	2.8	2.75	
	Reduce milk yield	13.3	11.2	12.25	
Time of insemination	As heat sign is seen	4.0	1.9	2.95	0.387
	Morning and afternoon principle	96.0	98.1	97.05	

4.10. Productive and Reproductive Performance of Dairy Cows

4.10.1. Productive performance of dairy cows

The productive performance of dairy cows in the study area, including daily milk yield, lactation length, and longevity, is presented in Table 15. The mean daily milk yield for local dairy cows was 1.47 ± 0.56 liters for small-scale farms and 1.49 ± 0.59 liters for medium-scale farms, with an overall mean of 1.48 ± 0.58 liters. For crossbreed cows, the mean daily milk yield was 11.39 ± 1.61 liters for small-scale farms and 13.5 ± 3.44 liters for medium-scale farms, resulting in an overall mean of 12.46 ± 2.51 liters. A significant difference ($p<0.05$) was observed in milk yield between small-scale and medium-scale farms for crossbred dairy cows. This suggests that dairy cows on medium-scale farms produce higher milk yields compared to those on small-scale farms.

This difference could be attributed to several factors, including the provision of more balanced and higher-quality feed rations, leading to better nutritional status and increased milk production in crossbred cows. Medium-scale farms may also have access to better breeding programs and artificial insemination services, resulting in cows with superior genetics and higher milk production potential. They also often have better infrastructure, such as improved housing facilities, efficient milking equipment, and readily available veterinary care, which positively impact milk yield and employ more skilled labor dedicated to managing the cows, ensuring better care and contributing to higher milk production. The current result observed in local breed cows is lower as compared with 1.89±0.05 litter of daily milk yield per day per cow, but for cross-bred dairy cows, it is higher as compared with 7.41±0.31 litter of daily milk yield per day per cow reported by Dinkissa *et al. (2022*) in Waliso and Ilu Districts of Oromia, Ethiopia.

The average lactation lengths (LL) for local breed cows were 6.42±0.74 and 6.83±0.69 months for small and medium farms, respectively, with an overall average LL of 6.63±0.12. While the average lactation length for cross-breed dairy cows was 7.62±1.10 and 8.08±0.88 months for small and medium-scale dairy farms, respectively, the overall average lactation length was 7.85±0.99 months. There is a significant difference ($p<0.05$) in LL observed between small-scale and medium-scale farms for both local and crossbred dairy cows. This implies that medium-scale dairy farms often have longer lactation lengths compared to small-scale farms for both local and crossbred cattle due to factors such as better nutrition and herd management, access to a wider pool of genetic resources for selective breeding, availability of advanced technologies and resources for optimizing the cows' environment, and economies of scale that allow for more investment in herd health and productivity programs, all of which contribute to improved overall health and productivity of the herd, leading to enhanced lactation persistence on medium-scale farms (Kebede *et al*,2017). The average longevity for local cows was 9.53±1.19 and 9.68±1.38 months for small and medium-scale farms, respectively, with an overall average longevity of 9.61±1.29, and for cross-bred cows, it was 11.73±1.46 and 11.8±1.79 months for small and medium-scale farms, respectively, with an overall average longevity of 11.77±1.63 months.

4.10.2. Reproductive performance of dairy cows

The average age at first service (AFS) for local bred cows was 39.63±3.45 and 40.14±2.96 months for small and medium scale farms, respectively, with an overall mean value of 39.89±3.205 months, and for cross-breed cows, the AFS was 21.52±2.68 and 21.24±2.27 months for small and medium scale farms, respectively, with an overall mean value of 21.39±2.46 months. The present study had lower average age at first service (AFS) values for both local and crossbred dairy cattle compared to previous studies. For local breed heifers, the present average AFS was lower than the mean values reported by Dinkissa *et al*. (2022) in Waliso and Ilu Districts, Oromia, 44.88±0.57 months; Belay (2016) in Sidama Zone, Southern Ethiopia, 44.1±5.9 months; and Bekuma *et al*. (2022) in central Tigray, 42.23±7.4 months. Similarly, the present average AFS mean value for crossbred dairy cattle was lower than the reports of Dinkissa *et al*. (2022) in Waliso and Ilu Districts, Oromia were 24.43±0.29 months; Belay (2016) in Sidama Zone, Southern Ethiopia were 30.3±4.4 months; Bekuma *et al*. (2022) in West Wollega Zone, Gimbi District, Ethiopia were 29.02±2.65 months; and Kidane *et al*. (2019) in Ethiopia were 28.3 ±9.31 months.

The mean age at first calving (AFC) for local breeds of cows was 48.53±3.42 and 49.25±3.74 for small and medium scale farms, respectively, with an overall mean of 48.89±3.58 months, and for cross-bred cows, it was 30.53±3.05 and 30.25±2.39 months, respectively, with an overall mean value of 30.41±2.69 months. The present study reported lower mean values for age at first calving (AFC) compared to the findings of previous studies. Belay (2016) reported an AFC of 51.9±5.9 months for local cattle and 39.3±3.2 months for crossbred cattle in the Sidama Zone of southern Ethiopia. Similarly, Dinkissa *et al*. (2022) reported an AFC of 53.94±0.56 months for local cattle and 33.43±0.29 months for crossbred cattle in the Waliso and Ilu Districts of Oromia, Ethiopia, and Abrha *et al*. (2020) reported an AFC of 43.3±2.7 months for local cattle breeds in central Tigray. The overall mean caving interval (CI) for both local and crossbred cows in the study districts was 19.91±2.71 and 13.19±1.19 months, respectively. There is a significant difference ($p<0.05$) in calving interval between small-scale and medium-scale dairy farms for both local and crossbred dairy cattle, which indicates that medium-scale farms have shorter calving intervals compared to small-scale farms. This can be attributed to the greater resources and improved management practices on medium-scale farms, which allow for better nutrition, access to advanced technologies and veterinary care, more efficient genetic selection and breeding strategies, and economies of scale that enable greater investments in the herd's reproductive performance, ultimately leading to shorter calving intervals for both local and crossbred dairy cows.

The mean of days open for local bred cows was 154.33±19.63 and 140.98±14.64 months for small and medium scale of dairy farms, respectively, with an overall mean of 147.66±17.14, and for cross-bred dairy cows, the mean of DO was 94.79±16.64 and 86.85±9.12 months for small and medium scale of dairy farms, respectively, with an overall mean of 90.62±13.12 months. There was a statistically significant difference ($P<0.05$) in DO between small-scale and medium-scale production systems for both local and crossbred cattle, with medium-scale systems having a shorter DO than small-scale systems due to the enhanced management practices and resources available on medium-scale farms. Factors such as better nutrition, regular pregnancy diagnosis, improved veterinary care, and more efficient genetic selection and breeding strategies on medium-scale farms likely contribute to faster uterine involution, earlier detection of estrus, and more timely breeding. The present findings on days open for local dairy cows were shorter than those reported by Dinkissa *et al*. (2022) in the Waliso and Ilu Districts of Oromia, Ethiopia, who reported that days open were a mean of 161 ± 0.41 days, and Abrha *et al*. (2020) in central Tigray, Ethiopia, who reported that days open were a mean of 201.47 ± 61.21 days. However, the present findings on days open for local cows were longer than the mean of 103.02 ± 1.70 days reported by Kidane *et al*. (2019) in Ethiopia.

The mean value of number of service per consumption (NSPC) for local breed cows was 2.25±0.84 and 2.07±0.62 for small and medium scale of dairy farms, respectively, with an overall mean value of 2.16±0.73, and the mean value of number of service per consumption (NSPC) for cross breed cows was 1.61±0.73 and 1.44±0.60 for small and medium scale of farms, respectively, with an overall mean value of 1.53±0.67. The present study's overall mean value of the number of services per conception (NSPC) for local breed cows was higher than reported by Dinkissa *et al*. (2022) in Waliso and Ilu Districts of Oromia, Ethiopia, which was 1.69 ± 0.06. However, it was lower than reported by Belay (2016) in the Sidama Zone, Southern Ethiopia, where the number of services per consumption (NSPC) was 2.4. For crossbred cows, the present study overall mean NSPC was lower than reported by Belay (2016) in the Sidama Zone, Southern Ethiopia, where the number of service per consumption (NSPC) was 1.70 ± 0.10; Kidane *et al*. (2019) found that in Ethiopia, the number of service per consumption (NSPC) was 1.7 ± 0.59.

Table 15. Productive and reproductive performance of dairy cattle

Parameter	Cattle type	Scale of production: Small scale (n=75) (Mean±SD)	Medium scale (n=107) Mean±SD)	Overall (N=182) Mean±SD)	p-value
Age at first service	Local	39.63±3.45	40.14±2.96	39.89±3.205	0.283
(Months)	Cross	21.52±2.68	21.24±2.27	21.39±2.46	0.47
Age at first calving	Local	48.53±3.42	49.25±3.74	48.89±3.58	0.188
(Months)	Cross	30.53±3.05	30.25±2.39	30.41±2.69	0.506
Calving interval	Local	20.75±2.52	18.99±2.88	19.91±2.71	0.000
(months)	Cross	13.76±1.35	12.64±1.05	13.19±1.19	0.000
Days open (days)	Local	154.33±19.63	140.98±14.64	147.66±17.14	0.000
	Cross	94.79±16.64	86.85±9.12	90.62±13.12	0.000
Number of service per	Local	2.25±0.84	2.07±0.62	2.16±0.73	0.101
conception (number)	Cross	1.61±0.73	1.44±0.60	1.53±0.67	0.092
Milk yield (litter/day)	Local	1.47±0.56	1.49±0.59	1.48±0.58	0.79
	Cross	11.39±1.61	13.5±3.44	12.46±2.51	0.000
Lactation length	Local	6.42±0.74	6.83±0.69	6.63±0.12	0.000
(months)	Cross	7.62±1.10	8.08±0.88	7.85±0.99	0.003
Longevity (years)	Local	9.68±1.38	9.53±1.19	9.61±1.29	0.44
	Cross	11.8±1.79	11.73±1.46	11.77±1.63	0.769

SD=standard deviation

4.11. Conception and calving rates

The graph presented in Figure 2 shows the trends in conception rate and calving rate of dairy cows from 2020 to 2023 for both small and medium-scale farms. Retrospective data obtained from dairy farmers' artificial insemination service recording books and from the recording books of AI technicians from 2020 to 2023 revealed the trend of conception rate and calving rates between small and medium-scale farms. The result showed that a high conception rate of 82.88% and 89.75% was recorded by the year 2023 for both small and medium-scale farms, respectively. While the least (64% and 54.85%) were recorded by the year 2020. The trends of the conception rate from 2020 to 2023 for small-scale farms show that the conception rate has gradually increased over the years, going from 64% in 2020 to 82.88% in 2023. While for medium-scale farms, the conception rate fluctuated more, starting at 54.85% in 2020, dipping slightly in 2021 to 56.05%, and then sharply increasing to around 89.75% in 2022 and 2023. The overall annual conception rate obtained in the current study was 72.87%. This implies that the overall conception rate for medium-scale farms has been higher than for small-scale farms, except in 2020 (54.85%), when small-scale farms had a slightly higher rate. The current result of the conception rate is higher than reported by Debir *et al*. (2016b), whose conception rate was 60.4% in the Southern Region of Ethiopia; in the case of Dale District, Abdula and Bilal (2022) conception rate was 38% in dairy cows in Tullo District, Western Haraghe, Ethiopia; and Kebebew and Beke (2018) conception rate was 62.25% in Wondo Genet District, Sidama regional state of southern Ethiopia. However, the current result of the conception rate is lower than reported by Haile and Yoseph (2018); the conception rate was 81.3% of Holstein Frisian cows at Alage dairy farm, Ethiopia.

According to the retrospective data, the overall percentage calving rate obtained in the study area was 63.85%. A relatively higher calving rate of 79.03% and 83.27% for inseminated cows was observed in 2023 for small and medium-scale farms, and the lowest rate of 42.67% and 42.12% was observed in 2020 for small and medium-scale farms. The trend of calving rates increased for both small and medium-scale farms over the 2020–2023 period. For small-scale farms, the calving rate went from 42.67% in 2020 to 79.03% in 2023, and for medium-scale farms, the calving rate increased from 42.12% in 2020 to 83.27% in 2023. This implies that the overall trend shows that calving rates have improved for both small and medium-scale dairy farms from 2020 to 2023, but medium-scale farms have consistently outperformed small-scale farms due to better access to resources, including veterinary care (control brucellosis and abortion), improved nutrition, high financial capacity to invest in infrastructure and technology that optimize reproductive management practices, such as artificial insemination and pregnancy diagnosis, and more effective herd management strategies like fulfilling calving areas. The current finding of the calving rate is lower than reported by Haile and Yoseph (2018); the calving rate was 76.92% of Holstein Frisian cows at Alage dairy farm, Ethiopia.

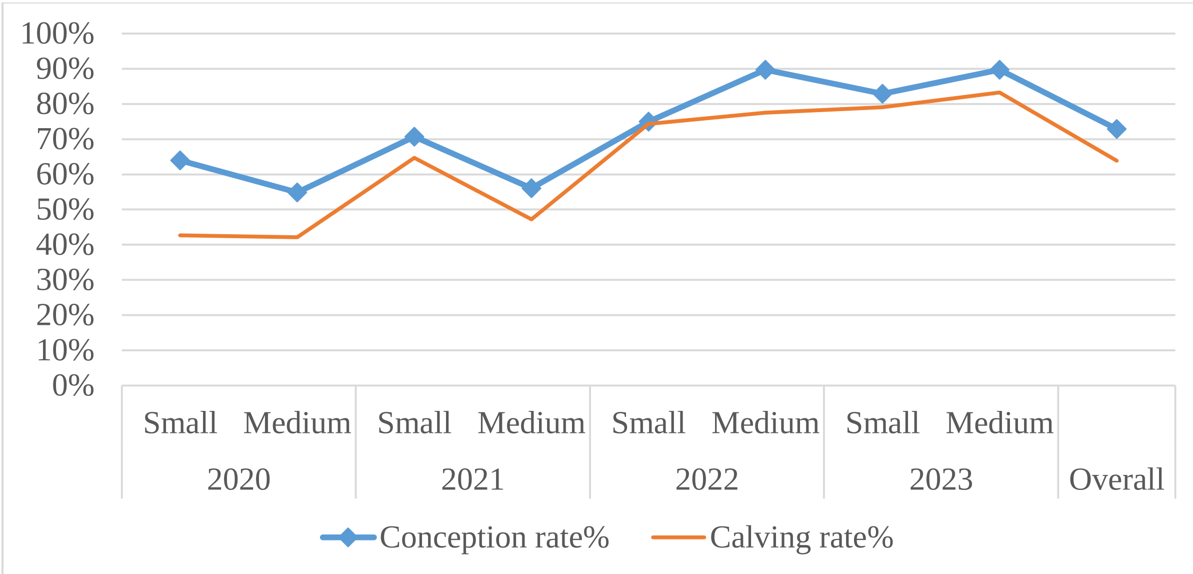

Figure 2. Retrospective data showing the conception and calving rate of cows from year 2020-2023.

4.12. Dairy Technology Adoption

The status of dairy technology adoption in the study area is presented in Table 17. The adoption of dairy technologies in smallholder dairy farming remains a promising strategy in Ethiopia to improve farm productivity, farm incomes, reduce poverty, improve food security, and ensure environmental sustainability (Korir *et al*., 2023). Adoption of new and improved technologies leads to increased milk production (Abbasi and Nawab, 2021). Almost all of the farmers (96%), irrespective of scale, adopted AI technology, with all of the medium-scale farms adopting the technology. Adoption of AI technology is necessary to increase the productivity and profitability of farms, reduce waste, improve environmental practices, compute on the market, and satisfy demands by producing surplus milk (Berhane *et al*., 2018). This finding is higher among AI adopters than reported by Korir *et al.* (2023). The adoption of AI technology was 86% in Ethiopia, and according to Osman *et al*. (2017), the adoption of artificial insemination technology by farmers was 13.3% in Nahir Atbara locality, Kassala State, Sudan. Farmers in the study area rarely used improved bulls for breeding, with only 11.8% doing so. This is because they preferred using artificial insemination (AI) technology, which helped them save money on feed, space, and healthcare costs associated with keeping bulls. Nearly half of the respondents (56.25%) practiced record-keeping pertaining to their dairy farms, but a larger portion of medium-scale (64.5%) farmers keep the necessary farm records than small-scale (48%) farms. The current result indicates that there is a significant difference ($p<0.05$) between small and medium-scale dairy production in the adoption of AI technology and in keeping farm records. This suggests that medium-scale farms are more likely to be using AI and have better record-keeping practices compared to small-scale farms due to their greater financial resources, ability to manage larger volumes of data, easier access to technical experts and consultants, and regular evaluation of farm profitability. All farms included in the current study used factory-based concentrate feeds with the main ingredients of wheat bran, bean bran, and cotton seed cake. This result is higher than reported by Osman *et al*. (2017), whose adoption of concentrate feed was 18.3% in Nahir Atbara Locality, Kassala State, Sudan. Similarly, Barman *et al.* (2023) reported that 49.5% of dairy producers used concentrated feed for the dairy cows in Rajbanshi Dairy Farmers, India. While improved fodder development was practiced by a minority of farmers (28%) on small-scale farms and a slightly higher proportion (36.4%) on medium-scale farms, the overall adoption of improved forages like alfalfa, sesbania, elephant grass, and Rhodes grass remained low, averaging just 32.2%. The majority of farmers (67.8%) did not adopt these improved forages due to limited land availability, indicating that most farms still rely on natural grass hay as their primary source of bulk feed. The current study is lower than reported by Balcha *et al*. (2023), who found that the overall adoption of improved forage by farmers was 38.8% in Agula and Maychew, Northern Ethiopia.

None of the farms utilize practices such as urea treatment of crop residues and silage making, both of which are recognized as effective methods for improving feed quality (Markos *et al*., 2023). The adoption of feeding dairy cows based on milk production was limited in the study area. Overall, only 32.4% of the dairy farmers reported that they fed their milking cows based on milk production, while the remaining 67.6% did not adopt this practice. The adoptions based on farm scale showed that 29.3% of small-scale farmers fed their cows based on milk production, while 70.7% did not. For medium-scale farmers, 35.5% fed their cows based on milk production, while 64.5% did not feed their cows based on milk production. The current result is higher than reported by Osman *et al.* (2017), whose adoption of farmers feeding their milking cows based on milk production capacity was 18.3% in Nahir Atbara locality, Kassala State, Sudan. However, lower than reported by Barman *et al.* (2023), farmers feed their cows based on milk production performance at 60.5% in Rajbanshi dairy farmers India.

Regular animal health management is another dairy technology component that determines the productive and reproductive performances of dairy cattle. Animal health management includes treatments for diseases and regular vaccinations against disease prevention measures before the occurrence of different diseases. The current study found that the majority of dairy farms, both Small-scale and medium-scale, had high adoption rates of vaccination and treatment for their dairy cattle. The overall results showed that 93.85% of the dairy animals were vaccinated, and 92.1% received treatment for various diseases. Small-scale farmers reported that 93.3% vaccinate their dairy cows, while 6.7% do not, and medium-scale farmers reported that 94.4% vaccinate their dairy cows, while 5.6% do not. Regarding the adoption of health treatment, small-scale farmers reported that 90.7% provided treatment for their dairy cattle, while 9.3% did not, and medium-scale farmers reported that 93.5% provided treatment for their dairy cattle, while 6.5% did not. The current result is lower than reported by Osman *et al*. (2017), who found that the adoption of farmers vaccinated for disease prevention in cows was 100% in Nahir Atbara Locality, Kassala State, Sudan. Adoption of improved housing for dairy cows was examined from the standpoint of cow comfort, which includes factors such as sufficient space, comfortable bedding materials, adequate ventilation, and lighting within the farm households. The result noted that farmers provided adequate ventilation (83.7%), light (84%), comfortable bedding materials (49.1%), and adequate space (58%) in dairy barns for their dairy cows. However, a significant difference ($p<0.05$) was found between the small and medium scales of production in the provision of a well-ventilated house for their dairy animals. This implies that medium-scale farms have sufficient ventilation facilities due to their high economic capacity to construct the house with mush wire between the wall and roof of the house, install artificial ventilators, and install wholes on the walls for free air circulation in the farms. Additionally, medium-scale farms have knowledge and information about the about the importance of ventilation for animal health and productivity because of the large number of dairy cows. The current finding is similar to that reported by Barman *et al*. (2023), who found that adequate ventilation of 84% was provided for the dairy cows in the dairy barn of Rajbanshi dairy farmers, India. However, not similar to what was reported by Barman *et al*. (2023), only 45% of dairy producers provided adequate light for the dairy cows in the dairy barns of Rajbanshi dairy farmers, India.

Table 16. Dairy technologies adoption practice in the study area

Parameters	Good dairy farming practices		Small scale (n=75)	Medium scale (n=107)	Overall (N=182)	p-value
			%	%	%	
Animal breeding	Use of AI technology	Yes	92	100	96	0.003
		No	8	0	4	
	Use of Improved bulls	Yes	13.3	10.3	11.8	0.53
		No	86.7	89.7	88.2	
	Keeping farm records	Yes	48	64.5	56.25	0.027
		No	52	35.5	43.75	
Animal feed	Use of factory based concentrate feed	Yes	100	100	100	
		No	0	0	0	
	Use of home based prepared concentrate	Yes	0	4.7	2.25	0.84
		No	100	95.3	97.75	
	Use of improved forages (alfalfa, sesbanaia, elephant grass, Rhodes grasses)	Yes	28	36.4	32.2	0.23
		No	72	63.6	67.8	
	Use of urea treated crop residues	Yes	0	0	0	
		No	100	100	100	
	Use of silage	Yes	0	0	0	
		No	100	100	100	
	Feeding milking cows based on milk production	Yes	29.3	35.5	32.4	0.38
		No	70.7	64.5	67.6	
Animal health	Dairy cow vaccination	Yes	93.3	94.4	93.85	0.768
		No	6.7	5.6	6.15	
	Dairy cattle treatment	Yes	90.7	93.5	92.1	0.49
		No	9.3	6.5	7.9	
Dairy barn	Provision of ventilation	Yes	72	95.3	83.7	0.000
		No	28	4.7	16.3	
	Provision of lighting	Yes	80	87.9	84	0.15
		No	20	12.1	16	
	Creating comfortable bedding materials	Yes	44	54.2	49.1	0.18
		No	56	45.8	50.9	
	Adequate space	Yes	56	59.8	58	0.44
		No	44	38.3	42	

4.13. Climate Smart Dairy Farming Practices

The adoption of dairy farming practices varies between small-scale and medium-scale farms, but overall, the majority of dairy farmers recognize the importance of these practices. Medium and small scale farms had unproductive dairy cows that accounted for 90.7% and 100%, respectively. This suggests that farmers have a higher adoption rate of culling unproductive dairy cows from their farms through selling and slaughtering practices. Culling unproductive animals can have a positive impact on the climate by reducing the overall herd size and the associated greenhouse gas emissions from livestock. Removing unproductive animals also helps to improve the efficiency of the dairy enterprise, leading to a lower carbon footprint per unit of milk or meat produced (Capper, 2020). The current finding is lined with reported by Balcha *et al*., (2023) 45.9% of farmers were adopt culling of unproductive cows from their farms while 54.1% were not adopt in Agula and Maychew, Northern Ethiopia. Regarding to artificial insemination 92% of small-scale farms used artificial insemination, compared to 100% of medium-scale farms. The implementation of AI technology is a key strategy for developing climate-smart dairy farming practices. It helps to reduce greenhouse gas emissions per unit of product by enhancing herd health, improving reproductive performance, and optimizing herd size by focusing on a smaller number of high-producing animals (Maindi *et al.,* 2020).

The result showed that for both small-scale and medium-scale farmers, implementing animal health and welfare was the same as 72% in the study area. Proper animal health and welfare practices can contribute to increased productivity and reduced disease incidence, which are crucial for the overall sustainability of the dairy enterprise. Regarding manure management practices, they were slightly more prevalent in small-scale farms (46.7%) compared to medium-scale farms (43%), but the overall adoption rate of 44.85% suggests room for improvement in this area. This suggests that farmers on small-scale farms use manures as fertilizer for crop production and irrigation purposes, whereas medium-scale farmers remove cow manure without utilizing it. Effective manure management can contribute to climate change mitigation by reducing methane emissions from improper storage or disposal of manure. Proper manure handling, treatment, and utilization as a fertilizer can help to sequester carbon in the soil, improving soil health and reducing the need for synthetic fertilizers, which have a higher carbon footprint. The current finding is lined with reported by Balcha *et al*., (2023) only 23.5% of farmers were adopt manure management from their farms while 76.5% were not adopt in Agula and Maychew, Northern Ethiopia.

The major reasons farmers were not adopting technologies in the study areas are indicated in Table 17. Lack of resources (42.05%), high cost of dairy technologies (41.7%), and lack of awareness (14%) were the major reasons farmers did not adopt different dairy technologies for both small and medium-scale farms in the study area. This suggests that access to necessary resources (land, water, equipment, inputs, etc.) was a more significant challenge, especially for small-scale producers. Regarding the cost of technology, 32% of small-scale and 51.4% of medium-scale farms reported the cost of technology as a constraint. The higher percentage among medium-scale farms indicates that the cost of adopting new technologies and practices is a more acute problem for them compared to small-scale producers. This finding agrees with the reported Taddese (2019) cost of technologies. 45.16% of the respondent households mentioned the reasons for not adopting dairy technologies in Basona Warena Woreda, Amhara Region, Ethiopia.

Table 17. Farmer's adoption of climate-smart livestock practices

		Scale of production		
		Small scale (n=75)	Medium scale (n=107)	Overall (N=182)
		%	%	%
Culling of unproductive animals	Yes	90.7	100	95.35
	No	9.3	0	4.65
Artificial insemination	Yes	92	100	96
	No	8	0	4
Animal health and welfare	Yes	72.0	72.0	72
	No	28.0	28.0	28
Manure management	Yes	46.7	43	44.85
	No	53.3	57	55.15
Reason not farmers adopting dairy technologies				
Lack of awareness		18.7	9.3	14
Lack of extension agent		2.7	1.9	2.3
Lack of resources		46.7	37.4	42.05
High cost of the technologies		32.0	51.4	41.7

4.13.1. Manure Utilization and management system

The result presented in Table 20 shows that 53.3% of small-scale and 57% of medium-scale dairy farmers sampled respondents were not using the manure for any home or agricultural purposes. At present, 54.7% of small-scale and 61.7% of medium-scale farms remove manure without any productive use. Regarding manure utilization, a large proportion of dairy farmers utilized cattle manure for composting (32% and 31.8% in small and medium-scale dairy farms, respectively) as a fertilizer for cropping and for irrigation farms. However, using manure for biogas was not a common practice, although urban farmers had better initiations towards biogas utilization.

Table 18. Manure management and utilization system

Manure management	Small scale (n=75)	Medium scale (n=107)	Overall
	Percentage	Percentage	
Composting	32	31.8	31.9
Fuel	12	3.7	7.85
Sell	1.3	2.8	2.05
Biogas	0	0	0
Removed without purpose	54.7	61.7	58.2

4.14. Major Challenges of AI service delivery

The artificial insemination service in the study area faces multiple challenges that hinder the success and improvement of reproductive performances in the dairy industry. Heat detection, delay time of insemination, shortage of AITs, insufficiency support, long-distance from the service, and shortage of liquid nitrogen and semen were the major challenges of AI delivery in the study area. The current survey study showed that heat detection and time of insemination were ranked as the top challenges, with index values of 0.28 and 0.3 in small and medium-scale farms, respectively. Insufficient and/or inaccurate estrus detection and the late arrival of the AITs led to delayed insemination, reduced conception rates, and extended calving intervals. This result aligns with Yousuf (2021), who reported heat detection was one of the major problems of AI service in the West Wollega zone. The second major issue was the shortage of AITs, with index values of 0.24 and 0.25 for small and medium scales of production, respectively. Regarding artificial insemination technicians (AITs), the main constraints include an inadequate number of AITs, heat detection problems, unskilled AITs, issues with liquid nitrogen and semen storage, and a and a lack of infrastructure and semen quality, as presented in Table 20. The inadequacy of AITs was the leading problem, with an index value of 0.21 in the study area. This was followed by heat detection problems and unskilled AITs with index values of 0.18 and 0.16, respectively.

Table 19. The major problems of AI service forwarded by farm owners

Scale	Major problems of AI service delivery	Rank						
		1st	2nd	3rd	4th	5th	Index	Rank
Small scale (n=75)	Heat detection and time of insemination problems	62.7	26.7	10.7	0	0	0.28	**1**
	Shortage of AITs	14.7	56	24	4	1.3	0.24	**2**
	Insufficiency support of concerned body	16.0	16.0	61.3	6.7	0	0.21	**3**
	Long-distance from the service	1.3	4	28	66.7	0	0.15[a]	**4**
	Shortage of liquid nitrogen and semen	4	1.3	1.3	61.3	32	0.12[a]	**5**
Medium scale (n=107)	Heat detection and time of insemination problems	54.2	35.5	10.3	0	0	0.3	**1**
	Shortage of AITs	20.6	43	27.1	7.5	1.9	0.25	**2**
	Insufficiency support of concerned body	19.6	19.6	54.2	6.5	0	0.24	**3**
	Long-distance from the service	0.9	1.9	6.5	46.7	43.9	0.11[a]	**4**
	Shortage of liquid nitrogen and semen	2.8	1.9	1.9	37.4	56.1	0.10[a]	**5**

AITs=Artificial insemination technicians; the same subscription letters on small and medium scale have significant difference

Table 20. Summarized artificial insemination service problems forwarded by AITs

Challenges	Rank								
	R1	R2	R3	R4	R5	R6	R7	R8	Index
Inadequacy of AITs	62.5	37.5	0	0	0	0	0	0	0.21
Heat detection problem	25	25	25	12.5	12.5	0	0	0	0.18
Unskilled AITs	12.5	12.5	25	37.5	12.5	0	0	0	0.16
Liquid nitrogen issue/semen storage	0	12.5	37.5	25	25	0	0	0	0.15
Lack of infrastructure	0	12.5	12.5	25	12.5	12.5	25	0	0.12
Semen quality	0	0	0	0	37.5	62.5	0	0	0.09
Long distance	0	0	0	0	0	25	75	0	0.06
Interruptions in holydays and weekends	0	0	0	0	0	0	0	100	0.03

AITs=Artificial insemination technicians; R1,R2,R3,R4,R5,R6,R7,and R8=rank1,2,3,4,5,6,7,and 8 respectively

4.15. Frozen Semen Quality evaluation

4.15.1. Frozen semen mass motility and Viability cell Percentage based on location

The current study examined the laboratory results of frozen semen mass motility, sperm live cells, and sperm dead cells, as presented in Table 21. The findings revealed that the mass motility of frozen bull semen averaged 55.83±5.63 at the center and 30.63±7.64 in the hands of AI technicians, with an overall mean value of 43.23±7.14. There was a statistically significant difference ($p< 0.05$) in frozen sperm motility between the AI technicians' hands and the center. The lower level of motility observed at the AI technicians' level could be attributed to differences in semen handling and storage practices, transportation methods during insemination, and exposure to various environmental stresses. Additionally, the loss in mortality might be due to the inconsistent topping up of liquid nitrogen gas due to its unavailability.

The current findings showed higher mortality compared to the 38.4% reported by Goshme *et al*. (2021) for pure Holstein Friesian semen in the North Shewa zone, Ethiopia, but lower than the motility reported by Hasan *et al*. (2020) in Bangladesh, Bayissa *et al*. (2017a) in the Western Gojjam Zone of the Amhara Region, Ethiopia, and Reda *et al*. (2020) in the South Wollo Zone, Ethiopia, for Holstein Friesian bulls, where the frozen sperm mass motility averaged 68.19±0.46, 51.66±15.62, and 51.56±1.58, respectively. According to a study by the IAEA and FAO (2005), if 40% or more of the semen is actively moving forward after freezing and thawing, its quality is considered acceptable for artificial insemination. However, in the present study, the thawed spermatozoa motility was below this recommended threshold, which may be linked to a low conception rate or poor fertility outcomes. The mean values of live sperm cells from the AI technicians' hands and the center were 40.33±7.52 and 46.66±5.77, respectively, with an overall mean of 43.49±6.65. This finding was lower than the 58.1±1.06 reported by Engidawork (2018) and 66.51±1.30 reported by Reda *et al.* (2020) for frozen semen live cells in pure HF and crossbred HF in the Harari National Regional State and South Wollo Zone, Ethiopia, respectively. The mean values of dead sperm cells from the AI technicians' hands and the center were 59.71±9.51 and 53.50±6.71, respectively, with an overall mean of 56.61±8.11. The present finding was higher than the average proportion of dead sperm cells, 38.5%, reported by Hemecho and Tuffa (2021) in the Hawassa Artificial Insemination Center, Sidama, Ethiopia.

Table 21. Frozen semen quality (Mean ±SD) from100% HF based on location

Parameter	Source	N	mean±SD	Overall (N=48)	p-value
Frozen semen mass motility	Center	24	55.83±5.63	43.23±7.14	0.001
	AITs	24	30.63±7.64		
Frozen semen live cell	Center	24	46.66±5.77	43.49±6.65	0.207
	AITs	24	40.33±7.52		
Frozen semen died cell	Center	24	53.50±6.71	56.61±8.11	0.215
	AITs	24	59.71±9.51		

N= number of sampled straws; HF = Holstein Friesian, SD=standard deviation; AITs=Artificial insemination technicians

4.15.2. Frozen semen mass motility and viability cell

The overall means of frozen semen mass motility, live cell, and dead cell based on production period in the current study were 43.23±8.42, 43.50±7.27, and 56.60±7.22, respectively. The current finding is lower than reported by Engidawork (2018). The mass motility of frozen semen from HF bull was 49.6 ± 0.86 in selected districts of Harari National Regional State, Ethiopia, and Morrell *et al.* (2018) found that the mass motility of frozen semen from HF bull was 59% in Sweden**.** This variation might be due to the differences in frozen semen handling practices, transportation, storage facilities, liquid nitrogen gas filling, and the proximity of the district to the Livestock Development Institute (LDI). The production batch or period had no effect ($P>0.05$) on frozen semen motility. The percentage of live spermatozoa observed in the current study was lower than the 58.3% reported by Engidawork (2018) and the 46% reported by Morrell *et al*. (2018). In contrast, the percentage of dead spermatozoa observed in the current study was higher than the 49% reported by Moore *et al*. (2018). The result of the current study indicated that both live and dead sperm cells in frozen semen were significantly ($P<0.05$) affected by the production batch or period.

Table 22. Frozen semen quality (Mean ±SD) based production batch/period

Variable	Batch number	N	Mean±SD	p-value
Sperm motility	batch 1	7	34.29±7.87	0.327
	batch 2	4	28.75±6.59	
	batch 3	20	44.75±5.08	
	batch 4	17	48.53±6.56	
	Overall	48	43.23±8.42	
Sperm live cell	batch 1	7	45.00±5.23	0.026
	batch 2	4	30.25±6.06	
	batch 3	20	51.20±9.18	
	batch 4	17	36.94±3.04	
	Overall	48	43.50±7.27	
Sperm dead cell	batch 1	7	55.00±7.23	0.022
	batch 2	4	70.00±4.72	
	batch 3	20	48.80±9.18	
	batch 4	17	63.29±3.69	
	Overall	48	56.60±7.22	

N = number of straw per sample; B1 = production date 15/04/2024; B2 = production date 22/04/2024; B3 = production date 07/05/2024 and B4= production date 13/05/2024

5. CONCLUSION AND RECOMMENDATIONS

5.1. CONCLUSION

Lactating cows were the predominant group of cattle in both small and large-scale farms. The current study shows a significant reliance on artificial insemination (AI) among both small and medium-scale dairy producers in Addis Ababa, with an overall adoption rate of 88.1%. The widespread use of commercial feed, agro-industrial by-products, and hay indicates that farmers prioritize concentrated and nutritious feed sources to maximize milk production. Crossbred dairy cattle are preferred for their higher milk yields and earlier reproductive maturity compared to local breeds, underscoring the farmers' focus on productivity. Despite these advancements, the study identifies a high calf mortality rate, primarily due to infectious diseases such as diarrhea and pneumonia and prevalent dairy cattle diseases like lumpy skin disease (LSD), foot and mouth disease (FMD), mastitis, and hypocalcemia (milk fever). However, several challenges impede the full potential of dairy farming in the study area. The key constraints include inadequate resources, high technology costs, and significant issues with heat detection and timing of insemination. The quality of frozen semen varies, with lower motility and higher dead sperm percentages observed at the hands of AI technicians compared to the central storage, indicating the need for improved handling and storage practices. In addition, the shortage of trained AI technicians exacerbates these issues, further hindering reproductive efficiency. Addressing these challenges through better resource allocation, cost reduction strategies, enhanced training for AI technicians, and improved heat detection methods could significantly enhance the efficiency and productivity of dairy farming in Addis Ababa.

5.2. RECOMMENDATIONS

Based on the study results, the following recommendations are forwarded:

- Efforts should be made to guarantee a consistent and affordable supply of dominant feed sources for both small and medium-scale dairy producers, particularly for small-scale farmers with limited financial resources. This will help maintain the nutritional needs of dairy cattle, thereby improving milk production.
- Implement robust disease prevention and control measures for prevalent diseases like LSD, FMD, mastitis, and hypocalcemia. This includes vaccination programs, improved biosecurity measures, early disease detection and treatment, proper herd management practices, and comprehensive mastitis control programs. Additionally, recruiting dedicated AI technicians and ensuring timely arrival when cows are in heat is crucial. Training farm owners and herdsmen to recognize heat signs and the importance of improved forage and feed techniques will enhance feed quality and availability.
- Invest in the recruitment, training, and deployment of qualified AI technicians to meet the demand for timely service. Strengthen training and supervision of AI technicians on proper semen handling, storage, and transportation procedures to minimize quality degradation during field-level insemination. Implement regular monitoring and quality control checks of frozen semen at both the production center and field levels to address any quality issues promptly. Monitoring the recording systems of farm owners and AITs will help evaluate AI efficiency parameters and identify areas for further improvement.

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APPENDEX

This survey questionnaire is to be completed on Assessment of Artificial insemination efficiency in different scale of dairy management in the selected sub-Cities of Addis Ababa, Ethiopia.

Annexe 1: Questionnaire Format Remainder to enumerators

Make a brief introduction of yourself and greeting to each farm owner before starting data capturing process. After getting consent, clearly outlined the objective of the survey and ask each target question briefly and clearly to the farm owner. Please fill out the questionnaire according to the farmer's response instead of your personal opinion. Make sure all the questions are clearly addressed before close up the data capturing process. Please do not use English terms or words while discussing with farm owner and do not forget the local unit.

Enumerator's Name_________________ Date ____________

Part I. Demographic characteristics of the households

- ✓ Please tick the appropriate answer where applicable

Sub city_________district__________ kebele_______code no_______

1. Sex	1= male 2= female
2. Age	------------------------
3. Marital status	1=single 2=married 3=divorced 4=widow
4. Level of education	1=illiterate 2=reading and writing 3=1-4 grades 4=5-8 grades 5=9-12 grades 6= diploma 7= degree 8= master and above
5. Diploma and above, field of specialization	1= Animal production 2= Dairy processing 3= if any------

6. Total number of household members including the household head

Age Category (in years)	No. of members in the household		
	Male	Female	Total
Under 1 years			
1-14 years			
15-24 years			
25-44 years			
45-64 years			
>65 year			

Part II. Socioeconomic characteristics of the household

1. Information on experience of dairy farming

	Experience	Years	Remark
1.	Experience of respondent in dairy farming	---------in years	
2.	Experience of respondent in improved dairy farming technologies	----------in years	

	A= Cross breed cow	---------in years	
	B= Artificial insemination (AI)	---------in years	
	C =Improved forage varieties	---------in years	
	D= Management (housing)	---------in years	
	E= Health service	---------in years	

2. Landholding/ farm size

Item	Own (ha)	Rented out (ha)	Rented in (ha)	Communal (ha)
Grazing land				
Crop (including fallow land)				
Forage production				
Irrigated land				
Other specify it…				
Total land size (ha)				

3. Number of livestock by type, sex and age

Livestock type	Breed type			Total
	Local bred	Cross bred	Purebred	
Heifer				
Male Calves (< 6 months)				
Female calves (< 6 months)				
Bull				
Oxen				
Dry cows				
Lactating cows				
Sheep				
Goat				
Chicken				

4. Dairy cattle management

1. What are the feed sources used for dairy cattle	A=natural pasture B= crop residue C= factory based compound feed D= improved forage E= hay F=homemade (Agr.ind.by product) concentrate
2. Do you conserve feed for dry season?	1= yes 2= no
3. Which method used for conserved feed?	1= hay 2= silage
4. If feed conserved in the form of silage, which fodder is used?	1=elephant grass 2=nippier grass 3=maize 4=sorghum 5=other specify it--------
5. Do treat crop residue?	1= yes 2=no
6. If yes, which treatment methods of crop residue enhancement	1=physical 2=chemical(urea/IBM) 3=biological

7. What are the sources of water for dairy cattle?	A=Pond B=river C=pipe water D=ground water
8. Frequency of watering for dairy cows in the dry season?	A=Once a day B= twice a day C= three times a day D= adelibtum
9. What do you use as feed and water troughs?	A=Made of plastic material B= Made of metal C= Concrete D= other specify________
10. In what type of house do your cows manage?	A=traditional B=modern with individual stall C=modern with individual stall
11. Is there any health problem on your farm	1= ye 2= no

12. If yes, what are the major health problem	Rank			
	1	2	3	4
Pneumonia				
Mastitis				
Lice/tick				
Internal parasite infestation				
Bloating				
Lameness				
FMD				
Anthrax				
Pasterlosis				
Blackleg				
Others (Specify it-------)				

13. Do you have a vaccination program/treatment in place to ensure optimal health?	1= yes 2= no
14. If yes, for what disease	

5. Calf management
1. Do you fulfill calf facility A) Yes B) no
2. If yes, which facility is fulfilled A) calving area B) navel treatment C) colostrum feeding
3. Is their presence of calf mortality in your farm? 1) yes 2) no
4. If yes, what are cause of mortality 1) disease 2) small and weak at birth 3) accident and sudden death 4) dystocia 5) malnutrition
5. Disease that related to calf mortality 1) diarrhea 2) Pneumonia 3) other specify it----------
6. Breed, AI delivery system, and the problem of AI service

1. Breeds of dairy cow they kept						
Bred	Which bred you keep	Which bred prefer more				
		Rank				
		1st	2nd	3rd	4th	5th
1=Local bred						
2=Cross bred						
3=Pure bred HF						

4=Pure bred Jersey						
5=Other specify it and give rank						

2. Trait preference of dairy cow

Traits	Rank					
	1	2	3	4	5	6	7
Milk yield							
Twinning ability							
Coat color							
Appearance							
Temperament							
Disease Resistant							
Fast Growth							
Other (specify it…)							

3. For what purpose you keep dairy cattle?

Purpose	Rank				
	1	2	3	4	5
Milk					
Meat/beef					
Insurance					
Manure					
Draft power					
To sell a live animal/finance					
Others (specify it……)					

4. What type of mating practices do you use for your cows?	A=Local bull B=Improved bull C=AI D= both
5. Are you satisfied with the current AI delivery service?	A=Yes B=no
6. If no, what is the reason for this?	A=the service is not available on weekends & holidays B= there is a shortage of AITs C= there is a shortage of inputs/liquid nitrogen, semen D=inadequate skills of AI technicians
7. What do you do when the AI technicians are not arriving on time?	A=Wait for another 21 days B=Use natural mating with improved bulls C= Pass the day without breeding
8. Do you have hired AI tech?	1=Yes 2= No
9. If no, how do you communicate with AI technicians?	1=AITs visit the farm daily 2= Call to AITs when the animal shows heat signs 3= Take the cows to the AI station
10. How many AI services are required for one successful pregnancy?	A=1 B= 2 C=3 D= 4 and above

11. How much payment per service	----------------------
12. If you are provided with reliable and regular service, would you mind raising the service charge?	1=Yes 2= No
13. How do you detect the estrous period?	A=Herdsman information B=Using teaser bull C=Regular follow-up during morning and night to check the sign of the heat, other specify------
14. What are the major signs of estrus?	A=Mounting of a cow on other animals B= Standing when mounted by other C= Clean mucus discharge D= Bellowing E=Restlessness F= Swollen/redness vulva G=reduce appetite
15. When you inseminate your cow?	A=As heat sign is seen B= morning and afternoon C=on the same day afternoon

16. What are the major problems of AI service delivery in your farm?

Major problems	Rank				
	1	2	3	4	5
Shortage of liquid nitrogen and semen					
Shortage of AITs					
Heat detection problems					
Insufficiency support of concerned body					
Long-distance from the service					

7. Reproductive and productive performances of dairy cattle

Variables	Local breeds	Crossbred cattle	Purebred HF	Purebred Jersey breeds
Average age at first service for heifers (months)				
Average age at first calving of heifers (months)				
Average milk yield (liters)				
Average days open (days)				
Average calving interval (months)				
Average Longevity (years)				
Average lactation length (month				
Number of AI service required for successful conception (No.)				

8. Technology Adoptions

Parameters	Good dairy farming practices	Yes /no	Trend of milk yield after adoption of the technology	Trends of reproductive performances (DO, CI, AFS, AFC)

			(1=increasing2=decreasing)	(1=increasing2=decreasing)
Animal breeding	Use AI			
	Improved bulls			
	Recorded keeping			
Animal feed	Factory based concentrate feed			
	Home prepared concentrate (protein, energy and mineral) feeds			
	Improved forages (alfalfa, sesbanaia, elephant grass, desho grasses)			
	Enhance crop residues using urea			
	Silage making			
	Feeding milking cows as per milk production			
Animal health	Vaccination			
	Treatment			
Dairy barn	Adequate ventilation			
	Light			
	ComforTableTable bedding materials			
	Adequate space			
7.1 If you are not adopt those technology what are the reason for resistance?		1=Lack of awareness 2=Lack of extension agent 3= Lack of resource 4=not interested 5=cost of technology		

9. Climate smart dairy farming practices

Practices	Yes/no	Management system
Use only productive improved breeds (culling less productive animals)		A=Sell B=Slaughter
Improved fodder		A=Cultivation of high yielding high protein and digestible genetically improved perennial pastures, fodders and legume varieties
Feed conservation		A=Silage B=hay

Artificial insemination		A= Improvement of animal genetics for targeted traits to improve productive, and reproductive traits
Animal health and welfare		A=comforTableTable housing B= proper ventilation C=timely veterinary care D= disease prevention E=provision of feed and water
Manure management		Rank

	Rank				
	1	2	3	4	5
Composting					
Biogas					
Fuel					
Construction					
Sell					
Others (specify it…..)					

10. Recording of inseminator book data

1. What is retrospective data obtained the from artificial insemination service recording book from 2020-2023 Years?

Variable	Years of insemination								Total
	2020		2021		2022		2023		
	Local	Cross	Local	Cross	Local	Cross	Local	Cross	
Number of animals inseminated									
Number of conceived									
Number of calve born									

Part III. Focus group discussion

Questionnaire presented for focus group discussion

1. How do you understand the current AI delivery of your district?	
2. What is the status of AI in dairy farm in your district?	
3. Is AI doing well in your area in general terms?	1) Yes 2) no
4. The AI service successful in your area in particular?	1) Yes 2) no
5. What needs to be improved for better implementation of AI technologies?	1) ----------------------- 2) ----------------------- 3) -----------------------
6. What are the major challenge and opportunities of AI service in your sub city/district?	
Challenge	Opportunity
7. Do you know the implementation of dairy technology adoption in your districts?	1) Yes 2) no

8. If yes, in what kinds of technologies?	1) Improved breed 2) improved feed 3) better housing 4) AI services 5) vet. Services
9. What are the challenges and opportunities of dairy technology adoption in your district?	

Part IV. Key informant interview

Questionnaire presented for key informant interview

1. Do farm owners participate in dairy technology adoption? 1) yes 2) no
2. If yes, in what kinds of technologies? 1) Improved breed 2) improved feed 3) better housing 4) AI services 5) vet. Services
3. What are the status of dairy technology adoption in your districts? (adoption of breed, feeding, housing condition, AI service and veterinary service)-------------------------------------
4. What are the challenges and opportunities of dairy technology adoption in your district?

Challenge	Opportunity

5. What is your overview on the way forward for better implementation of dairy technology adoption in your districts? ---

Part V. Questionnaire used to collect information from AITs

1. How do you understand the current AI delivery of Addis Ababa and your district?	
2. What is the Status of AI in dairy farm in your district?	
10. Do you trust the quality of semen available in your area?	1) Yes 2) no
3. What is the major challenge and opportunity of AI delivery in your district	
Challenges	Opportunities
Liquid nitrogen issue/semen storage	Extension service
Lack of awareness in the community	Feed access
Delayed time of insemination	Market access (milk)
Inadequacy of AITs	Best breed for improved genetic potential
Animal management problem	Others specify it
Heat detection problem	
Unskilled AITs	
Interruptions in holydays and weekends	
Disease problem	
Lack of infrastructure	
Long distance from AI service center	
Poor communication	

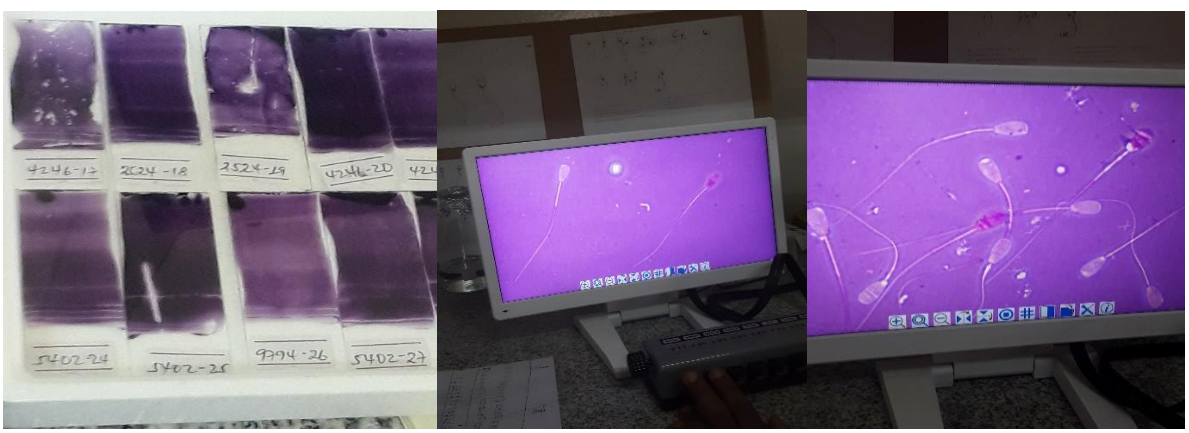
Semen quality	
Others (specify it…)	

4. What do you think the way forward AI service in your district? ------------------------------

Appendix figure

Appendix figure 1. Key informant interview with District Animal production and animal breeding experts

Appendix figure 2. Questionaries’ filling progress



Appendix figure 3. Smear making and identified live and dead cell count within bright field phase contrast microscope

Appendix figure 4.sample storage Liquid nitrogen containers and Analysis of semen motility in progress at LDI

Appendix figure 5. Housing system in the study area

Appendix figure 6. Improved forage and water sources in their farm