MEKELLE UNIVERSITY

COLLEGE OF DRY LAND AGRICULTURE AND NATURAL RESOURCES

DEPARTMENT OF ANIMAL, RANGELAND AND WILDLIFE SCIENCES

The productive and reproductive performance of local and crossbred dairy cows kept under rural and urban production systems in Endamekoni and Maichew town, southern Tigray, Ethiopia.

By

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As thesis research advisor, I hereby certify that I have read and evaluated this thesis entitled "**The productive and reproductive performance of local and crossbred dairy cows kept under rural and urban production systems in Endamekoni and Maichew town, southern Tigray, Ethiopia**" prepared under my guidance by Asmelash Brhanu. I recommend that to be submitted as fulfilling the thesis requirement.

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As member of the Board of Examiners of the MSc Thesis Open Defense Examination, we certify that we have read and evaluated the thesis prepared by Asmelash Brhanu and examined the candidate. We recommended that the thesis to be accepted as fulfilling the thesis requirement for the degree of Master Science in Agriculture (Livestock Production and Pastoral Development).

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Dedication

I dedicated this thesis manuscript to my loved wife Muluraya Reda, my daughter Herat Asmelash, Rodas Asmelash my beloved mother teacher Tekahush Brhanu, and my father teacher Birhanu Nugssie and, my beloved aunt Debese Asefa and all my families for their unreserved love and encouragement in the process of my life.

Table of contents

Contents Page

List of tables

List of Figure's

List of abbreviations and acronyms

AFC----------------- Age at first calving

AFS------------------Age at first service

AI--------------------Artificial insemination

AI--------------------Artificial insemination

AP-------------------Advanced Placement Program

ARC---------------- Agricultural research center,

BCS-----------------Body condition score

CADU--------------Chilalo Agricultural Development Unit

CCI -----------------Calving-to-conception interval

CI -------------------Calving interval

CI--------------------Calving interval

CSA-----------------Central Statistics Authority

DA-------------------Developmental Agents

DALC---------------Duration after last calving

DDE-----------------Dairy development enterprise

DO-------------------Day open

EARO---------------Ethiopian Agricultural Research Organization

EARO---------------Ethiopian agricultural research organization

ESAP----------------Ethiopian Society of Animal Production

ETB------------------Ethiopian birr

FAO-----------------Food and Agriculture Organization

Fig-------------------Figure

GDP-----------------Gross domestic product

HARC---------------Holetta Agricultural Research Centre

IAR ----------------- Institute of Agricultural Research

IBC-------------------Institute of Biodiversity Conservation

ILCA-----------------International Livestock canter for Africa

ILCA-----------------International Livestock Centre for Africa

ILRI------------------International livestock research institute

IPS------------------- International Project Service

LIVES---------------Livestock and irrigation value chain for Ethiopian small holder

MCLP----------------Mixed crop and livestock pro

Abstract

This study assessed the productive and reproductive performance of local and crossbred dairy cows in rural and urban production systems of Endamekoni wereda in southern zone of Tigray, Ethiopia. The primary objective was to address the lack of sufficient information regarding the reproductive and productive performance of dairy cows in this region, particularly for crossbreds with varying levels of exotic blood. To categorize cattle in to specific exotic blood levels (50%, 50-62.5%, 62.5-75% and >75%) breeding records, herd or farm records and traceback generation. Crossbred cattle consistently outperformed local breeds across all exotic blood levels. Age at first service (AFS) was significantly lower in crossbreds: 31.8 months for 50-62.5% exotic blood, 29.26 months for 62.5-75% exotic blood, and 18.52 months for >75% exotic blood, compared to 39.62 months for local breeds. Similar trends were observed for age at first calving, calving interval (CI), days open (DO), and number of services per conception (NS/C). Family size was larger in rural households compared to urban ones. Male-headed households were more prevalent than female-headed ones. The average age of household heads was within a productive range. Higher herd sizes were observed in rural production systems. Grazing was the primary feed type in rural areas, while artificial insemination (AI) was more prevalent in urban areas. Factors hindering AI adoption included shortages of technicians, bull services, and inputs. Dairy farmers prioritized access to improved feed and breeds. Urban farmers showed a stronger preference for improved breeds. Opportunities for optimizing dairy cattle productivity included increased AI usage, favorable climate, and access to brewery by-products. This study provides valuable insights into the reproductive performance of local and crossbred dairy cows in Endamekoni wereda. The findings highlight the potential benefits of crossbreeding and the importance of addressing constraints related to AI adoption and feed availability. Understanding these factors is crucial for developing effective strategies to improve dairy cattle productivity and support sustainable livelihoods in the study area.

KEYWORDS: EXOTIC CROSSBRED, HEIFERS, DAIRY COWS, PRODUCTIVE AND REPRODUCTIVE PERFORMANCE, DAIRY ETHIOPIA, REPRODUCTION TRAITS, RURAL, URBAN, ENDA MEHONI.

1. Introduction

Ethiopia boasts the largest livestock population in Africa, a crucial sector contributing significantly to the national economy. Of the estimated 60.39 million cattle, 54.68% are female (CSA, 2018). However, low genetic potential within these indigenous breeds hinders milk and meat production (Shiferaw et al., 2003). Beyond genetics, substandard feeding, inadequate healthcare, and poor management practices further depress productivity (Zegeye, 2003). Consequently, productive and reproductive traits, crucial for profitable dairy production (Lobago et al., 2007), remain subpar. Ethiopia showcases a variety of dairy production systems: Lowland Pastoral Systems: Found in lowlands, these systems rely on grazing and transhumance (Desta, 2002). Rural Highland Smallholder Systems: Predominant in the highlands, these systems integrate crop cultivation and livestock rearing, favoring diverse farm animals (Desta, 2002). Large-Scale Commercial Systems: Primarily state-owned or private, these operations focus on market-oriented dairy production with exotic breeds around Addis Ababa (Ketema & Tsehay, 1995; Azage et al., 2000). Urban Systems: Urban systems specialize in milk production and sales within cities, utilizing stall feeding under limited land resources (Azage et al., 2013). This study specifically investigates rural and urban dairy production systems, recognizing the high urban demand for milk and its products. While Ethiopia boasts the largest livestock population in Africa, 75% of its cattle reside in rural smallholdings (Alemu 2019). Despite their primary use for traction, these indigenous breeds also contribute to milk and meat production (Tadesse & Dessie, 2003). However, dairy potential remains largely untapped (Tadesse & Dessie, 2003), hindering both food security and nutritional intake (FAO, 2019). Despite boasting an average per capita milk consumption of 43.3 kg annually (FAO, 2019), the sector faces significant challenges. To address these limitations, Ethiopia embarked on crossbreeding initiatives five decades ago, aiming to enhance the genetic potential of indigenous cattle and boost dairy productivity (Million Tadesse, 2018). Early efforts focused on interbreeding local zebu cattle with Holstein-Friesian or Jersey breeds to improve milk production (Aynalem et al., 2011). While crossbreeding with improved exotic breeds offers undeniable potential, past endeavors lacked a clear breeding policy regarding desired levels of exotic inheritance and optimal breed choices (Aynalem et al., 2011). The knowledge gap lies in the lack of comprehensive data on the comparative performance of local and crossbred dairy cows under various production systems, the factors influencing their performance, the adoption and effectiveness of ART, and the specific challenges and opportunities faced by dairy farmers, especially in milk marketing.

1.2. Objectives of the study

1.2.1. General objectives

The main objectives of the study are:

- ✓ To assess and compare the productive and reproductive performance of local and crossbred dairy cows under rural and urban production systems in the study area.
- ✓ To identify the major constraints affecting the productive and reproductive performance of local and crossbred dairy cows, and recommend appropriate intervention strategies to improve their performance.

1.2.2. Specific objectives

- ✓ To assess the productive and reproductive performance of local and crossbred dairy cows kept in rural and urban production system systems
- ✓ To identify factors affecting the production and reproduction performance of local and crossbreed dairy cows under rural and urban dairy production systems
- ✓ To assess the use of assisted reproductive technology (ART) in local and crossbred cows and factors that affect the adoption of these technology in urban and rural production systems
- ✓ To indicate challenges and opportunities on performance of local and crossbreed cows in urban and rural areas
- ✓ To assess constraints and opportunities of milk marketing

1.3. Statement of the problem

Despite large number of livestock population, the productivity of per unit of animal and the contribution of this sector to the national economy is low. This situation is generally accredited to different factor such as, shortage of feed, lack of improved breed, breeding strategies, and lack of appropriate health services (Gezahegn et al., 2017). Productivity and reproductively of crossbred dairy cattle (short Age at Puberty, AFC, DO, CI and NSC) is believed to be higher than that of local dairy cattle.

Increasing milk production demand has led to a decline in reproductive performance of dairy cows due to a prolonged inter calving period. Although, if a cow does not calve every 365 d there is an additional cost on the system, the calving interval has continued to increase with time in all breeds (Hare et al., 2006a). Pryce et al. (2004) pointed out an unfavorable relationship between milk production and calving interval. Selection for high milk yield in dairy cattle generally is accompanied by a decline in fertility (Oltenacu and Broom, 2010). In order to maximize productive life, a cow must be bred within 80- 90 days after calving. This will enable it to produce a new calf every 12.5- 12.8 month. Longer calving intervals have determinant effect on the lifetime milk production (Gaines, J.D., 1989). Whether producers use AI or natural selection, heat detection is a critical component of good productive management on the farm. Success in the breeding program is measured by calving interval, which is mostly a function of day to first services. According to Hubble (2007), to predict future heat or calving date and to manage the cows in either case (AI or NS) recording of cows in heat and date of service is necessary.

Different finding indicated different result about reproductive performance in different parts of the country (Lobago, F., et.al, 2006). A number of researches have been conducted to evaluate reproductive and productive performance of indigenous and crossbreds especially for different exotic blood levels crossbred of dairy cows under a relatively controlled condition at research centers, government owned farms and in some urban and peri urban dairy areas of a country (Shiferaw et al., 2003). Artificial insemination is not merely a novel method of bringing about impregnation in females. Instead, it is a powerful tool mostly employed for livestock improvement. In artificial insemination the germ plasma of the bulls of superior quality can be effectively utilized with the least regard for their location in faraway places. By adoption of artificial insemination, there would be considerable reduction in both genital and non-genital diseases in the farm stock. However, in the present study area, though large number of smallholder dairy farm is available, there is no sufficient information pertaining reproductive and productive performance of their dairy cows. In addition to these, Constraints on reproductive and production performance of crossbred with different exotic blood level and local dairy cattle under different production systems are not understood. There is a prerequisite of recognition the major challenges of expansion of crossbred dairy cattle and input delivery, milk and milk product marketing problem under current dairying system. For this reason, the study of reproductive performance of the dairy cows in the present study area is highly needed for further development of strategies and prioritization of possible intervention options for performance improvement, since it has dominant importance to livestock owners, extension agents, veterinarians and researchers.

1.4. Significance of the study

This study aimed to assess the production and reproduction performance of indigenous and crossbreed dairy cows in southern Tigray, Ethiopia. By understanding the factors affecting these performances, the study aimed to provide insights for improving dairy production systems and implementing appropriate interventions. This information is crucial for policymakers, NGOs, and other stakeholders to develop strategies for enhancing the productivity and sustainability of dairy cattle in the region.

1.5. Scope of the study

The scope of the study was assessing performance of both indigenous and crossbred dairy cows at rural and urban production systems. The study was mainly focused on the difference of productive and reproductive performance between local and crossbred dairy cow as well as within same blood level across the two production systems. The study was also covered the status of the Assisted Reproductive Technology (ART) such as Artificial Insemination (AI) used by farmers and different institutions also in the study area. The challenges and opportunities for crossbred dairy cattle were also assessed in the study area.

1.6. Limitations of the study

Shortage of financial resource for running the study could set as limitation for survey. The lack of adequate awareness of household farmers on what they should gave the information’s during data collections was one of the limitations in this study. The other limitation of this study was inexact probability of blood level of the dairy animals these taken for survey sample due to absence of sufficient dairy cattle breeding records. Due to difficulty geographic location of the woredas the peripheral areas could not assess during the survey, so that there may be less chance of representation on the sample.

2. Literature review

2.1. Historical Development in Crossbreeding and Crossbred Cattle in Ethiopia

Ethiopia's modern dairy farming journey began in the 1950s when improved breeds like Friesian and Brown Swiss were introduced to enhance the local zebu cattle. This marked a shift from traditional dairy farming to more productive systems. Crossbreeding programs, led by organizations like CADU and ARDU, further expanded dairy farming in Ethiopia. Research on crossbreeding indigenous breeds with exotic breeds like HF, Jersey, and Simmental was conducted in various regions. Ethiopian International Agricultural Research (EIAR) demonstrated crossbreeding practices at multiple locations. The crossbreeding program aims to improve dairy cattle by combining the best traits of different breeds. This strategy enhances productivity, adaptability, and overall performance, contributing to the growth of the dairy sector in Ethiopia.

Table 1: Dairy cattle crossbreeding program

Dairy cattle crossbreeding program		
Breeding program location objectives	Breeding program location objectives	Breeding program location objectives
Fogera cattle genetic improvement	Western Ethiopia Amhara region	Crossbreeding with HF * for milk production • Conservation of pure Fogera and • Increase milk production of Fogera breed through pure breeding and Community based breeding

Holetta Research center crossbreeding Borena cattle with HF	Central Ethiopia, Holetta	Evaluation of different crossbred animal for milk production, reproduction adaptation • Increase milk production through crossbreeding, • Production of selected crossbred bulls for AI, • demonstration and pre-scaling up F1 & 75% females
Adaberga Jersey cattle breed improvement pure breeding of jersey cattle	Central Ethiopia, Adaberga	Increase milk production through pure breeding • Production of pure breed Jersey bulls for AI and NM
Debre Zeit Research center herd crossbreeding HF with local Borena Cattle	Central Ethiopia, D/Zeit	Evaluation of performance of high-grade dairy cattle for Increase milk production and reproduction
development of composite breed HF* Arsi breed	Adami Tulu research center	Development of composite breed from two breed crossing

Source: Million Tadesse (2018)

The practice of crossbreeding exotic and local cattle breeds has been undertaken by various governmental and non-governmental organizations in Ethiopia since the 1950s. The goal was to improve milk production by introducing the superior genetics of breeds like Holstein-Friesian and Jersey to indigenous zebu cattle.

However, these efforts often lacked a clear breeding policy, leading to inconsistent results. Technical, socioeconomic, and organizational challenges further hindered progress. While natural service was promoted to improve dairy breeds, its long-term sustainability remains uncertain due to the potential difficulties in bull replacement.

2.2. Dairy cattle production system in Ethiopia

The total cattle population for the country is estimated to be about 60.39 million. Out of this total cattle population, the female cattle constitute about 54.68 percent and the remaining 45.32 percent are male cattle. On the other hand, the results obtained in rural Ethiopia's indicated that 98.24 percent of the total cattle in the country are local breeds. The remaining are hybrid and exotic breeds that accounted for about 1.54 percent and 0.22 percent, respectively (CSA, 2018).

Dairy cattle production system in Ethiopia depends on herd size of indigenous breeds of cattle. Dairy cattle production systems in Ethiopia belong to any of the following four major livestock production systems: "As reported by (Desta, 2002)" major systems of dairy production in Ethiopia are lowland pastoral systems, rural highland small-holder system, large scale commercial production and urban and per-urban systems. According to Reda (2001), milk production systems can be broadly categorized into urban, peri-urban and rural milk production systems, based on location.

2.2.1. The rural small holder (crop-livestock) dairy production system

The Ethiopian highlands possess a high potential for dairy development and occupying the central part of Ethiopia, over about 40% of the country (approx. 490.000 km2) and are the largest of their kind in sub-Saharan Africa (Tedla et al, 1989). This production system predominantly exists in the highland agro–ecological zone, where the climate favors both crop cultivation and livestock rearing as complementary enterprises and major types of farm animals except camels are found and farmers usually prefer to keep mixtures of farm animal species. The milk production in this production system depends on with high number of indigenous breeds and small amount in cross breeds of cattle. The majority of milking cows are indigenous animals which have low production performance with the average age at first calving is 53 months and average calving intervals is 25 months. In this farming system all the feed requirement is derived from native pasture and a balance comes from crop residues and stub grazing.

2.2.2. Pastoral and agro-pastoral dairy cattle production system

The described system is prevalent in arid and semi-arid regions, where livelihoods revolve around livestock and their products. Nomadic or semi-nomadic practices are common, as herders migrate in search of water and pasture. While there are challenges in adopting modern technologies, some communities have adapted to improve their practices. However, the system remains vulnerable to droughts and resource scarcity, posing risks to both human and animal well-being.

2.2.3. Urban and peri-urban small holder dairy production system

Both the urban and peri-urban systems are located near or in proximity of Addis Ababa and regional towns and take the advantage of the urban markets (Mohamed A.M. et.al 2004). Urban dairy cattle production systems in general are located in cities and/or towns for production and sale of milk, with little or no land resources, using the available human and capital resources mostly for specialized dairy production under stall feeding conditions (Azage et al 2013). By virtue of their location, urban producers are not expected to have access to agricultural or pasture land, as the operation takes place within cities and as a result, they are forced to buy feed (Zegeye 2003). Peri-urban dairy systems are located in rural areas or at the periphery of the urban areas which have relatively better access to urban centers in which dairy products are highly demanded (Azage et al 2013). These systems are contributing immensely towards filling the large demand-supply gap for milk and milk products in urban centers, where consumption of dairy products is remarkably high and they are the main suppliers of raw milk to the processors of different scales (Zelalem et al 2011). Of the total urban milk production, 73 percent is sold, 10 percent is left for household consumption, 9.4 percent goes to calves and 7.6 percent is processed into butter and ayib (cheese). In terms of marketing, 71 percent of the producers sell milk directly to consumers (Reda 2001). Dairying in urban and peri-urban areas creates employment opportunities and provides farmers a chance to use land, labor and feed resources to generate regular income (Gillah et al, 2012). These market-oriented urban and peri-urban systems are emerging as important components of the milk production systems in Ethiopia. The most important benefits are increased income, employment generation, food and nutrition, organic waste recycling and uplifting social status (Gillah et al, 2012).

The urban and peri-urban systems are being intensified through the use of crossbred dairy cows, purchased and conserved feed and stall-feeding (Azage et al, 2010). According to Assaminew S. and Ashenafi M, 2015, the average head of Crossbred cows was higher in urban than that of peri-urban dairy cattle production system and the total cattle heads which includes cross and local breeds, Grazing land holding and Land allocated for forages were higher in peri-urban production system.

2.2.4. Commercial dairy cattle production system

This system is a specialized market oriented dairy operation practiced by the state sector and very few private commercial farms. Most of these farms are located in and around Addis Ababa and basically keep exotic dairy stock (Ketema and Tsehay, 1995) and Azage et al, 2000)).

2.3. Herd Size and Composition with in Systems Production Different

In Ethiopia, most raw milk production originates from small-scale farmers maintaining local cattle breeds rather than high-yielding crossbred cows (Gebretnsae M., 2017). Large-scale farms, possessing 50 or more cattle, hold a greater number of livestock overall, including a higher proportion of local cattle, compared to small-scale farms (Gebretnsae M., 2017). However, urban and peri-urban areas exhibit a higher prevalence of crossbred cattle due to heightened farmer awareness of their milk production potential (Melku, 2017). This stands in contrast to rural areas where local breeds predominate. The average cattle holding per household in Fogera woreda is approximately 7.3, with variations observed across different regions (BELETE A., 2006).

2.4. Reproduction and production performance of dairy cattle

Although efforts were made at developing breeding program for various livestock species in the country, all did not materialize due to lack of commitment and consultation with various stakeholders (Aynalem et al., 2011). The success of dairy production in general and crossbreeding programs in particular needs to be monitored regularly by assessing the productive and reproductive performance under the existing management system. Moreover, evaluation of reproductive and productive performance of indigenous and crossbred dairy cattle under small holder production systems is essential for the development of appropriate breed improvement strategies (Negussie et al., 1998). Given suitable government recognition, access to market and services, there is great potential for development of smallholder dairy scheme in peri-urban and urban areas (Stall and Shapiro 1996). Reproduction and productivity of crossbred's dairy cattle are believed to be higher than that of local zebu, but the performance status of different exotic blood level crossbred and local dairy cows in different farming system of Ethiopian highland both in production and reproductive traits a little understood. A number of research's have been conducted to evaluate reproductive and productive performance of indigenous and crossbreds especially for different exotic blood levels crossbred of dairy cows under a relatively controlled condition at research centers, government owned farms and in some urban and peri-urban dairy areas of a country (Shiferaw et al., 2003).

2.4.1. Age at First Calving (AFC)

Age at First calving is the time of the beginning of a cow life for productive and contributing for both the reproduction and production life of the cow, directly through its effect on her life time calf crop and milk production and indirectly it is influence on the cost invested for up-bringing (Mukasa-Mugerwa, 1989) and it is affected by the time of outset (Perera, 1999). According to Perera (1999), the good enough and optimum performance of age at first calving of dairy cattle under better small holder production system in the tropics is less than 30 and 36 months, respectively Heritability of age at first calving is generally low, indicating that this trait is highly influenced by environmental factors such as feed and health (Mukasa-Mugerwa, 1989). The productivity indigenous cattle in Ethiopia are still lower than as compared to these exotic or cross breed ones. According to (Mukasa-Mugerwa and Azage 1991), they are known for produce their first calf not earlier than 35-53 months of age. The average ages at first service and at first calving in Tigray region were reported as 24.8 months (range 10 to 48 months) and 35.3 months (range of 21 to 57 months), respectively (Alem Selam B. et.al, 2015). The average age at 1st calving (AFC) was reported 3 years by Addis Getu (2015) which is shorter than Asaminew and Eyasu (2009), Niraj, (2914), National

Meteorological agency (NMA), (2011), and Snedecor, et.al, (1967) who reported that 39.4 AFC of 3.37, 1729.9 days (4.48 years), 47.16 months (3.9 years) reported. Marta kluszczynska, (2012) reported that Crossbred cows have earlier mean age at first calving and a shorter calving interval than local cows. From farmers' experience the pregnancy success rate is higher when the cow is mated naturally with a bull; usually there is no repeated breeding. Some farmers mentioned that they used a bull as an alternative option when cow did not conceive with AI. They also added that there is more repeated breeding during dry season. Environmental factors, especially nutrition, determine pre-pubertal growth rates, reproductive organ development, and onset of puberty and subsequent fertility.

2.4.2. Daily Milk Yield

Cows these are characterized as indigenous breeds are generally considered to have low performance in milk production. However, they are the major source of milk in Ethiopia that account for 97 % of the total milk production in the country (Abaye et al., 1991). As reported Zereu G and Lijalem T., (2016) daily milk yield performance of the local cows is significantly affected by due to agro-ecology effect, thus the value of average daily milk yield was significantly higher in mid land (2.127 ± 0.094) than low land (1.861 ± 0.084). Milk yield has remained extremely low with national average of 1.09 liter/day/cow (Dagenae and Adugna 1999). Similarly, Lemma et al. (2005) reported that the average milk yield of local Arsi cows was 1.0 liter/head/day. The average daily milk yield (DMY) performances of indigenous cows in PLWs were 1.85 liters/day, and ranged from 1.24 liters in rural lowland agro-pastoral system of Mieso to 2.31 liters in rural highland dairy production system of Fogera (Azage Tegegne, 2013). For Fogera cattle the overall average estimate lactation yield was 506.78 liters, which is very low due to poor genetic make- up and shortage of feed and poor management conditions (Mulugeta, 2005) and also shorter lactation length (Gebeyehu, 1999). Melku, (2017) reported that the average daily milk yield of local animal across the production system was 1.6±0.5, 2.3±0.4 and 3.2±2 in rural, peri-Urban and Urban, respectively. Milk production performance of crossbred cattle with different exotic blood level and indigenous dairy cows was affected by blood level, production systems and management practice (feeding practices, health care and housing) (Muluye et.al,2017). Milk production per day per head is very low and this is further affected by relatively short lactation length and extended post-partum anestrus resulting in low production efficiencies (Azage and Alemu 1997). Milk yield performance of cows as reported by farmers varies across the different dairy production systems in the study area, mainly due to differences in breed and management (Azage Tegegne, 2013). Milk yield and reproductive efficiency play major roles in determining the Profitability of a dairy herd (Britt, 1985; Arbel et al., 2001).

2.4.3. Calving Interval (CI)

Calving interval refers to the amount of period (days or months) between the birth of a calf and the birth of a subsequent calf, both from the same cow. When the length of gestation period is more or less stable for a specific breed, the number of days open becomes the solitary variable of calving interval of dairy cattle. If there are long open periods, and long calving intervals, it usually indicates management problems which is associated with management. Calving intervals have low heritability and can be improved through nutrition and early breeding (Mulugeta et al., 1990). This is truly supported by Olori VE. et.al, (2002) as a delay in conception due to poor fertility prolongs inter calving interval and causes a shift in calving pattern, which can lead to culling. To maintain maximum advantage of an economy with in more intensive dairy cattle production systems, it is ideal to accept that the CI should be around one year. However, practically in most tropical countries to achieve CI in a one-year is repeatedly difficult or impossible and, in some situation, even undesirable. Zebu cattle are commonly reared in highlands of Ethiopia’s through traditional management, calving interval averaged 26 months (Perera, 1999). The overall least squares mean for CI Tigray, Mekelle for indigenous and HF crossbreed cows in included in this study were estimated to be 453.5±88.3 days (Kumar N, Tuki K and Bisrat A 2014). The overall calving interval of cows in Oromia region is 18.6 months. In pastoral and agro-pastoral areas shorter calving intervals of 15.5 months and 19 months respectively have been reported (Workneh and Rowland, 2004). In Zebu cattle, calving interval is estimated to range from 12 to 22months (Mukasa-Mugerwa, 1989). The relative importance of factors that affect reproductive performance vary in the different smallholder farming systems. For instance, under extensive free grazing system nutritional fluctuation due to seasonal shortage cause delays in puberty and the post-partum cycle (Perera, 1999).

Calving interval was shorter in crossbred than indigenes under properly management of animals was practiced, as reported by Yifat et al. (2012) crossbreds of unknown exotic blood level have 622.6 days calving intervals in Tatesa Cattle Breeding Center and also another result was reported by, (Mulugeta and Belayneh 2013) and (Belay et al.,2012) in North Showa zone and Jimma Zone indicated that crossbreds of unknown exotic inheritance have calving interval of 660 and 640.8±3.84 days) respectively. On other hand Calving interval of crossbred born form indigenes cows with Holstein Frisian/HF with different exotic blood level of Ari XHF of 50%, 75% and 87.5% have Calving interval of 503, 464 and 525 days respectively and crossbred of Zebu XHF of 50%, 75% and 87.5% have Calving interval of 458, 475 and 525 days respectively (Gabriel et al., 1983). As well as crossbred of Borana X HF of 50%, 75% and 87.5% exotic blood level have Calving interval of 440, 471 and 493 days respectively and crossbred of Barka X HF of 50%, 75% and 87.5% have Calving interval of 415, 474 and 512 days respectively (Million and Tadelle,2003). Indigenous cows had the significantly longer average CI (453.22±71.81 days) than that of HF crossbred's cows (428.11±64.32 days) (Niraj Kumar, 2014). Calving interval is usually influenced by dam parity and year of lactation period (Yohannes G. 2003). However, the changes in late parity period could be attributed to periodical changes in feeds management and health situations. Similar effects were reported in studies conducted at Holettt D/Zeit and Asella (Million Tadesse et.al 2006).

2.5. Systems of crossbreeding

A crossbreed is an organism with purebred parents of two different breeds, varieties, or populations. Crossbreeding, sometimes called "designer crossbreeding", is the process of breeding such an organism, often with the intention to create offspring that share the traits of both parent lineages, or producing an organism with hybrid vigor. Cross-breeding native cattle, often of Bos indicus type, with exotic Boss Taurus cattle is now a widely used method of improving reproduction and production of cattle in the tropics (VanRaden and Sanders, 2003). Although indigenous cattle are well adapted to local production conditions, they usually mature late and have poor growth rates and low milk yields (Syrstad, 1988). According to Tadesse, B. (2002) reported that cross breeding of indigenous breed with superior genetic (exotic) cattle and selection has been considered as a practical solution to improve the low productivity of local cattle. Scientifically there are different types of crossbreeding systems. These are composite breeding, Grading up and rotational crossing. On breeding policy there are so many criteria's on how to select the appropriate breeding and crossing systems for one's country. Out of the cross-breeding types grading up is the most common strategy which employed in most parts of the tropics. Mating of indigenous female animal with an exotic male is usual activity. The first cross generation (F1) performs very well in productive and reproductive traits: it has higher milk yields; shorter CIs and the animals calve at a younger age than the indigenous stock. Further upgrading, however, usually leads to mixed results (McDowell, 1985; Rege, 1998).

The breeding program in Ethiopia commonly uses either artificial insemination (AI) or natural service. AI has been accessible at commercial level for more than 60 years and it is widely used in dairy cattle as compared to beef cattle breeding which is known as much less because of handling and labor costs. AI demands a selection of good genetic potential bulls which is measured by estimated breeding values (EBVs) for traits like ease of calving or growth rates. As overall husbandry management (proper nutrition and heat detection) are managed, the outcome will be satisfactory. The most reason for unsuccessful AI process is fail to achieve recognizing estrus timely. When cows are properly inseminated with good-quality semen at the proper time, 50%–60% may conceive on first service, the same percentage on second service.

2.5.1. Cross breeding in Ethiopia

Crossbreeding systems have been employed in Ethiopia to enhance livestock productivity, particularly in the dairy sector. These systems involve mating indigenous breeds with exotic breeds to combine desirable traits like disease resistance, adaptability, and high milk production. Historically, crossbreeding efforts in Ethiopia were initiated by Italy in the 1930s. Subsequently, organizations such as the Institute of Agricultural Research (IAR) and the Chilalo Agricultural Development Unit (CADU) expanded these efforts, using breeds like Holstein-Friesian, Jersey, and Simmental to cross with local cattle breeds like Horro, Borana, and Arussi. In recent decades, various strategies have been implemented to further improve the dairy sector. These include the establishment of dairy cattle improvement ranches and the distribution of crossbred heifers to smallholder farmers. Artificial insemination (AI) programs have also been instrumental in facilitating crossbreeding and improving genetic diversity. However, challenges remain in implementing successful crossbreeding programs. Factors such as the selection of appropriate breeds, the management of crossbred animals, and the provision of adequate feed and veterinary services are crucial. Additionally, careful consideration must be given to the potential impact of crossbreeding on the genetic diversity and adaptability of indigenous breeds.

2.5.2. Crossbreeding in dairy cattle

Crossbreeding has been a key strategy to enhance livestock productivity in Ethiopia, particularly in the dairy sector. This involves mating indigenous breeds with exotic breeds to combine desirable traits such as disease resistance, adaptability, and high milk production (Cunningham and Syrstad, 1987). Italy initiated crossbreeding efforts in Ethiopia in the 1930s. Subsequently, organizations like the Institute of Agricultural Research (IAR) and the Chilalo Agricultural Development Unit (CADU) expanded these efforts, using breeds like Holstein-Friesian, Jersey, and Simmental to cross with local breeds like Horro, Borana, and Arussi (Brannang et al., 1980; EARO, 2001). In recent decades, strategies like establishing dairy cattle improvement ranches and distributing crossbred heifers to smallholder farmers have been implemented to further improve the dairy sector. Artificial insemination (AI) programs have also played a crucial role in facilitating crossbreeding and enhancing genetic diversity (EARO, 2001; Kelay, 2002).

However, challenges persist in the successful implementation of crossbreeding programs. Factors like selecting appropriate breeds, managing crossbred animals, and providing adequate feed and veterinary services are critical. Additionally, it is essential to consider the potential impact of crossbreeding on the genetic diversity and adaptability of indigenous breeds (Addisu Hailu, 2013).

2.5.3. Crossbreeding as innovation

Crossbreeding in Ethiopia has been practiced for such a long timeso this may arise a question by some one crossbreeding can still assume by smallholders as an innovation in the country. For the purpose of this study crossbreeding is defined as practice perceived as new by either an individual or adoption unit (Rogers, 1983). So even though the technology has been around for a long time, crossbreeding can be defined as innovation for every smallholder in the tropics who starts using it on his own farm. Literature sees crossbreeding as innovation when attempts are made to find out why impediments retarding its widespread adoption exist. The few projects providing livestock services successfully reaching the poor in developing countries (de Haan, 1995) are surprising given advantages of crossbreeding technology discussed in the previous chapter.

2.5.4. The use of assisted reproductive technology

The productivity and re-productivity of cattle in urban and rural production system was low due to many factors including the poor or non-adoption of best practices, new finding of information using researched and dissemination of advanced technologies. The challenge was also arising from using of poor genetic potential of the animal by dairy producers. Assisted Reproductive Technologies (ARTs) mainly estrous synchronization and artificial insemination could be used to improve genetic potential of both local and their crossbreed in breeding programs. Additionally, ARTs can minimize the cost associated with buying and managing a bull, time and labor essential for heat detection in cow that graze in those areas with physical barriers such as mountains and bushes (Maqhashu, 2013; Nqeno et al., 2010). The adoption and use of these technologies by urban dairy farmers was more improved than these found in rural production system who had been laid their animal feed sources at communal grazing. Government have been tried to support the rural community by preparing accessible AI delivery system, However, the package was challenged by so many factors, such as feed shortage for animals, housing problem, disease and overall husbandry practices which was applied by the crossbreed beneficiaries.

2.5.5. Artificial insemination

Artificial Insemination (AI) has been a revolutionary tool in the advancement of animal genetics, particularly in the 20th century. It revolutionized animal breeding by allowing for the rapid dissemination of superior genetics across vast distances (Kurup, 2000). This technology has been widely adopted in both developed and developing nations, primarily for dairy cattle and other livestock species. AI offers numerous advantages, including the ability to utilize the genetic potential of elite sires to improve herd quality globally (Chupin & Schuh, 1993). Additionally, AI mitigates risks associated with natural mating, such as disease transmission and libido issues (Vishmanath, 2003; Thibier, 2005). Through cryopreservation, a single bull can sire thousands of offspring annually, maximizing its genetic impact (Funk, 2006). AI also plays a crucial role in Multiple Ovulation Embryo Transfer (MOET) programs (Saacke et al., 2000; Kanitz et al., 2002; Funk, 2006). While traditional AI techniques, such as uterine body deposition, have been effective, newer methods have emerged to enhance pregnancy rates, especially when using valuable semen like sex-sorted sperm (Hunter, 2003; Kurikyn et al., 2003; Verberckmoes et al., 2004). However, these advanced techniques require specialized skills and are limited to specific applications (Hunter, 2003). A significant challenge in AI is the variability in bull fertility, as accurate prediction remains elusive (Garner, 1997; Tanghe et al., 2002; Flint et al., 2003; Rodríguez-Martinez, 2006, 2007).

In Ethiopia, AI has been implemented for over six decades to enhance cattle genetics. However, progress has been hindered by various factors, including a lack of trained personnel, inadequate breeding policies, limited awareness among dairy producers, and insufficient resources (Desalegn, 2008). These challenges have limited the widespread adoption of AI and its impact on the genetic diversity of indigenous cattle breeds. While crossbred cattle constitute only a small fraction of the total cattle population (Workneh et al., 2002), it is crucial to assess the extent of genetic dilution and its potential impact on local breeds.

2.5.5.1. Advantages and Challenges of AI

Artificial Insemination (AI) is a significant advancement in animal breeding, offering numerous advantages. It enables the widespread dissemination of superior genetics from elite sires, maximizing their reproductive potential (Foote, 2002). AI facilitates the rapid introduction of new genetic material, reduces transportation costs, and allows for the use of frozen semen from deceased animals (Boa-Ambones & Minozzi, 2006). Additionally, it prevents the spread of infectious diseases, enables the use of older or injured bulls, and eliminates the risks associated with handling aggressive animals. However, AI also presents challenges. Accurate estrus detection is crucial for successful AI, as poor detection rates can lead to decreased fertility (Foote, 2002; Boa-Ambones & Minozzi, 2006). While technological advancements, such as radio telemetry and camera systems, have improved estrus detection, visual observation remains a valuable tool (Darnsfield et al., 1998; Peralta et al., 2005; Alawneh et al., 2006). Timed AI protocols, which bypass the need for estrus detection, can be effective in controlled settings but may be less efficient under field conditions (Tóth et al., 2006). Despite advancements in estrus detection and hormonal treatments, predicting ovulation remains a challenge. Various approaches, including progesterone measurement, behavioral analysis, and pedometer readings, have been explored (Velasco-Garcia & Mottram, 2001; Roelofs et al., 2005-2006). However, a reliable method for accurately predicting ovulation in cattle has yet to be developed.

2.5.5.2. Factors that affect adoption of ART in rural and urban production system.

Lack of resources

The challenges which associated with inadequate infrastructure were significantly dominated this category. Inadequate infrastructure merely takes away the limited incentives that are available to rural farmers (Nkosi and Kirsten, 1993). Gwala (2013) reported about the poor state of access roads and lack of transport facilities in rural Eastern Cape Province. Almost all the cattle infrastructure currently in existence in the Eastern Cape Province was built by the Department of Agriculture (Tada, 2012). According to Frisch (1999), in communities that have facilities, they were either in a poor state or nonfunctional because they were erected some 50-60 years ago and farmers have not been the cash to maintain them. The facilities make it easy for farmers to carry out the basic animal husbandry activities such as castration, animal identification, vaccination, animal treatment, artificial insemination, pregnancy diagnosis and live weight measurements. The lack of infrastructure could seriously deter development initiatives such as the implementation of ART in urban and rural production system.

AI technology has also led to one of the most successful smallholder dairy systems in the developing world (Stall et al 2008a). However, the use of AI has also failed in many situations in developing countries because of the lack of infrastructure and the costs involved, such as for transportation and liquid nitrogen for storage of semen or because the breeding program has not been designed to be sustainable (Azage et al 1995, Mpofu Rege 2002 and Philipsson et al 2005). Improper use of AI for crossbreeding indigenous cattle with exotics might be disastrous when, for example, a long-term strategy lacks information on how to maintain the appropriate level of exotic genes in an environment that couldn't support pure exotic breeds. The prospect and constraints of using AI should therefore be critically reviewed for each case before designing breeding programs. However, with the sudden change of policy and removal of public support, the AI system simply collapsed.

Policy and Recording System

Lack of appropriate livestock policies have been identified as one of the increasing key factors causing threats to Farm Animals Genetic Resource (FAnGR) in the developing world (Gibson et al 2006). At present, there were no legal framework in Ethiopia to regulate crossbreeding or to regulate the importation and distribution of exotic genetic materials (ESAP 2007). In an increasingly globalized market, the absence of breeding policies and regulations, as well as the absence of gene bank for animal genetic resource conservation, could put indigenous breeds at risk and endanger the future generations of livestock in Ethiopia and the rest of the world (Desalegn 2008).With the present increasing trend for high-out animals, unorganized crossbreeding program and absence of crossbreeding policies would put a threat to FAnGR of Ethiopia in the future (ESAP 2009).

The absence of coordinated systems for data collection and record keeping and the maintenance of databases for the livestock sector, including a mechanism for feedback and exchange among the stakeholders for development of livestock-related policies have been identified as a major constraint. Such data recording, even on a limited scale, were critical for genetic improvement. Success in genetic improvement to a larger extent depends, among others, on accurate recording of the farm operations and periodic analysis of the data to design future plans and take corrective measures as appropriate (Aynalem et al., 2011). Lack of record keeping and reporting by AI service providers and farmers has adversely affected national data analysis and decision making on progress and it was also highly believed to have increased the incidence of inbreeding in the country (Desalegn, 2011).

2.6. Achievements of cross breeding

Several studies have shown that crossbreeding local cattle with exotic breeds can significantly improve their performance. Melku Muluye et al. (2017) and E. Galukande et al. (2013) report that crossbred cattle exhibit enhanced reproductive and productive traits, including increased milk yield, shorter calving intervals, and lower age at first calving. However, the success of crossbreeding depends on factors like production systems and breeding strategies (Aynalem et al., 2009).

Studies by Abera (2016) and Shamsuddin et al. (2007) indicate that 50% crossbred cattle, particularly Friesian crossbreds, are well-suited for low-input production systems in Ethiopia. They demonstrate improved reproductive performance, longer lactation lengths, and higher milk yields compared to local breeds. Galukande et al. (2013) further highlight the positive impact of 50% Bos taurus crossbreeding on milk production, lactation length, and calving interval across various climatic zones.

2.7. Dairy product processing, Consumption and Marketing in Different Production System

In Ethiopia there is long standing and strong culture of consumption of dairy products. In addition to row milk, milk products, such as butter, cottage cheese, fermented milk (yogurt) and whey are also commonly consumed (Yoseph, 1999). Consumption pattern of milk and milk products produced at home varies depending upon the amount of milk produced per household, dairy production system and market access, season of the year, and fasting period (particularly for the followers of Orthodox Christian) Azage, et.al (2013). Ethiopian dairy products were directed to consumers through both formal and informal dairy marketing systems similar to these other African countries, such as Uganda and Kenya. The informal market involves direct delivery of fresh milk by producers to consumer in the immediate neighborhood and sale to itinerant traders or individuals in nearby towns. In the informal market, milk may pass from producers to consumers directly or it may pass through two or more market agents (Mohamed, 2003). Still, the proportion of total production being marketed through the formal markets remains small (Muriuki and Thorpe, 2001). According (BELETE, 2006) report showed that the type of milk marketing was informal type of marketing. It was a type of a monthly contractual agreement that means the producer and his client agreed on the amount to be delivered in a day and the price per litter as well and finally the producer received the money at the end of the month. Milk marketing in rural areas was characterized by poor linkage among producers, consumers and processors and other market agents due to many factors, like lack of market information, less processing units, absence of collection systems and insufficient credit facilities than of urban marketing system for milk. As many studies showed that improved and appropriate milk processing technologies like churner and cram separator should be accessible in place to improve milk processing for sustainable dairy production. Azage et al. (2013) reported that marketing of milk and milk products varies depending up on the source of the milk, access to market, and culture of the society, season and fasting period.

2.8. Factors influencing the reproductive and lactation performance of smallholder dairy cattle

The performance of animals depends not only on their genetic merits, but also on other factors such as nutrition, management, health, and environment. Many factors influence the reproductive performance of lactating dairy cows.

2.8.1. Artificial Insemination Service Facilities

The country has made significant efforts to improve the productivity of local breeds through artificial insemination (AI) programs, crossbreeding locally adapted cattle breeds with improved exotic dairy breeds (Zereu and Lijalem, 2016). AI technology has contributed to one of the most successful smallholder dairy systems in the developing world (Stall et al., 2008). However, AI implementation has faced challenges in many developing countries due to inadequate infrastructure, high costs associated with transportation and liquid nitrogen storage, and poorly designed unsustainable breeding programs (Azage et al., 1995, Mpofu and Rege, 2002, Philipsson et al., 2005). Improper crossbreeding of indigenous cattle with exotics can be detrimental, particularly when there's a lack of information to maintain optimal exotic gene levels for long-term strategies. As reported by Azage et al. (1995), Mpofu and Rege (2002), and Philipsson et al. (2005), crossbreeding efforts in Ethiopia often lack a specific breeding plan or policy to guide the selection of appropriate exotic breeds and monitor inheritance levels.

2.8.2. Diseases challenges and weak veterinary service

Animal health care and improved health management are major constraints in dairy development in Ethiopia, leading to poor performance across the production system. The prevalence of various diseases, including tick-borne diseases, internal and external parasites, and infectious diseases, impacts dairy development programs to varying degrees, depending on ecological zones and management levels (Guadu and Abebaw, 2016). Government staff often lack adequate mobile facilities, a limitation that the government is currently unable to address (Tafesse, 2001). Belete A. (2006) reports that trypanosomiasis and internal parasites (schistosomiasis, fasciolosis) were the most prevalent diseases in Fogera district. In a notable case, one processor closed its farms after losing five cows to animal disease, opting to operate solely as a processing plant by outsourcing milk (Getnet Haile, 2009).

2.8.3. Problem on Feed and feeding systems

Inadequate feed supply is a significant challenge in Ethiopia's dairy sector, especially during the dry season. Traditional grazing lands, often overgrazed and mismanaged, are the primary feed source. However, these lands are insufficient to meet the year-round nutritional needs of dairy animals. The limited availability of improved forage seeds and planting materials hinders the development of sustainable forage production systems. Furthermore, the use of agro-industrial byproducts is minimal, particularly in rural areas. Consequently, poor nutrition weakens dairy cows, making them more susceptible to diseases, stress, and reproductive problems. This leads to lower milk production, longer calving intervals, and reduced overall productivity. Addressing these challenges, including improving feed resource management, promoting the use of improved forages, and enhancing animal health care, is essential for the growth and sustainability of Ethiopia's dairy sector.

2.8.4. Lack of genetic improvements activities

Indigenous cattle breeds in Ethiopia, though well-adapted to harsh conditions, have limited milk production potential. Crossbreeding with exotic breeds offers a promising solution, but the lack of structured breeding programs hinders progress. Substandard feeding, poor healthcare, and uncontrolled breeding practices further compound the issue. To improve dairy productivity, it is essential to implement sustainable genetic improvement strategies tailored to specific production systems. This involves identifying the most productive and adaptable animals within each environment for breeding purposes. By addressing these challenges, Ethiopia can enhance its dairy sector's overall productivity and sustainability.

2.8.5. Lack of strong extension services

Dairy development depends on reliable inputs and services such as Artificial Insemination, health service and improved forage seeds supply (Muriukia, et.al, 2001). In Ethiopian context, most of extension works were facilitating and coordinating by government extension services, this in result for inaccessible complete input delivery system (AI, vet services and improved feed delivery), gap on skill management and other associated problems for dairy production. (Belete A., 2006) reported that some respondents did not grow improved forages in the homestead so as to alleviate the feed scarcity of the household. The interest gap between BoARD and the producers may increase in hesitating of producers even in other important services (Gebretnsae et al., 2017).

2.9. Opportunities of cross breed cows

2.9.1. Availability of large base populations

A significant portion of the world's cattle population, estimated at over two-thirds of the 1.4 billion, resides in tropical regions (Wint and Robinson, 2007). Most of these cattle are indigenous Zebu breeds, well-adapted to the harsh tropical environment. In Ethiopia, indigenous breeds constitute a staggering 99.26% of the total cattle population, while highly productive exotic breeds and their crosses account for less than 1% (CSA, 2011).

These indigenous breeds have evolved to withstand challenging conditions, including heat, low feed availability, and minimal management. To meet the rising demand for milk and milk products, genetic improvement of indigenous cattle has been proposed as a viable solution. However, studies like Getu (2015) have shown that farmers often prefer feeding crossbred cattle with industrial byproducts, such as those from breweries, over traditional roughages. This preference is linked to the perception that industrial byproducts can boost milk production.

The increasing demand for milk, driven by population growth and rising incomes, has also influenced the adoption of crossbred dairy cattle. However, challenges such as high feed consumption, handling difficulties, and a lack of training and awareness have hindered their widespread acceptance, particularly during early dissemination periods. Despite these challenges, the dairy industry holds a special position in the agricultural sector due to its potential for providing a regular income to numerous small-scale producers (Zereu and Lijalem, 2016).

3. Materials and methods

3.1. Description of study area

3.1.1. Geographical location

The study is carried out in Enda Mehoni Woreda, southern zone of Tigray region Ethiopia (Figure 2). Enda Mehoni district is located at 120 km from Mekelle city of Tigray region to the south and 660 km from Addis Ababa, the capital city of Ethiopia to the north (BoARD, 2017). The district is bordered in the north by Alaje district, in the east by Raya-Azebo district, in the south by Ofla district, and in the west by Amhara region (Kumasi and Okyere, 2011). Geographically, the district lies between 12°47' North latitude and 39°32' East longitude. The district's altitude is estimated to range from 1,700 to 3,925 m.a.s.l. and has an area coverage of 61,229.5 ha or 612.295 square kilometers (BoARD, 2017). The study tabias are in typical high land areas with an altitudinal range of 2,300–3,200 m.a.s.l. The administrative center of the district is Maichew town (Figure 1).

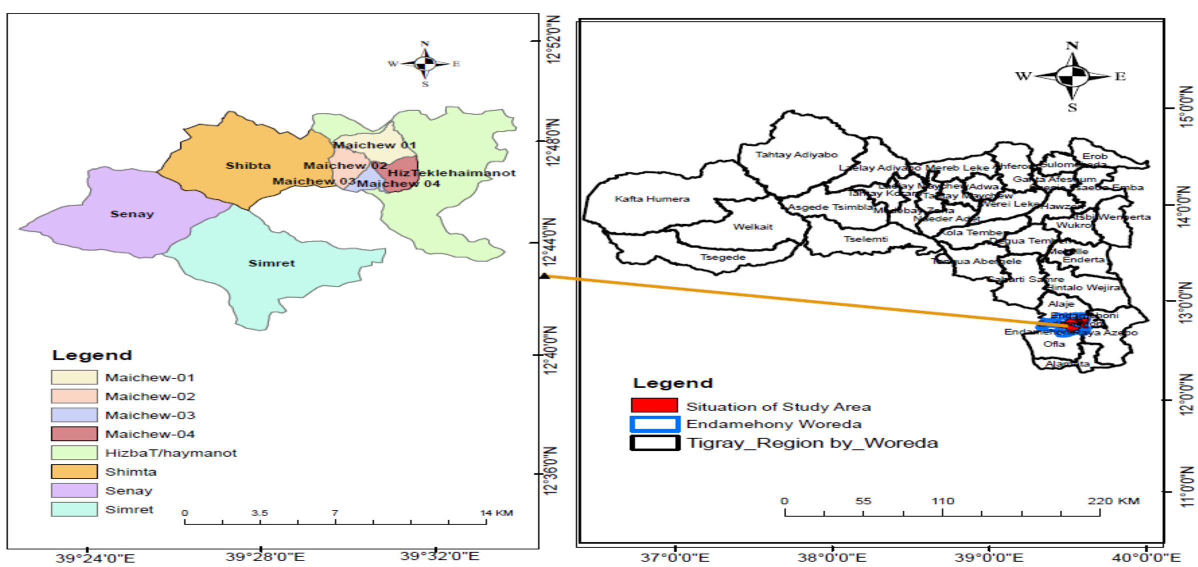

Figure 1: location of the study area (Endamehoni)

3.1.2. Topography and climate

The study district has generally a tropical, semi-arid climate (Mekuria and Yami, 2013). According to local classification system, which mainly relies on altitude and temperature, the district`s climatic zones are divided into Kola, Weyna-dega and dega. The three agro-ecological zones represent 5%, 30% and 65% of the district, respectively (Admasu et al., 2011).

Over the period 2012–2016, the mean annual temperature of the study area was 17.9°C with the mean annual minimum and maximum temperature of 11.5°C and 24.2°C, respectively (Figure2). Based on the data obtained from Ethiopian Meteorological Service Agency (2016), the hottest month of the district was April with a mean maximum temperature of 26.5°C, and the coldest month was December with a mean minimum temperature of 9°C.

The rainfall pattern of the study area was predominantly bimodal, with peak rainfall occurring in summer from June to September and a short and less rainy season between March and May. The mean annual rainfall was 799.3 mm with more than 78% of the annual rainfall received during the months of June, July, August and September (locally known as Kermet season), and about 15% during the month of March to May (Figure2.).

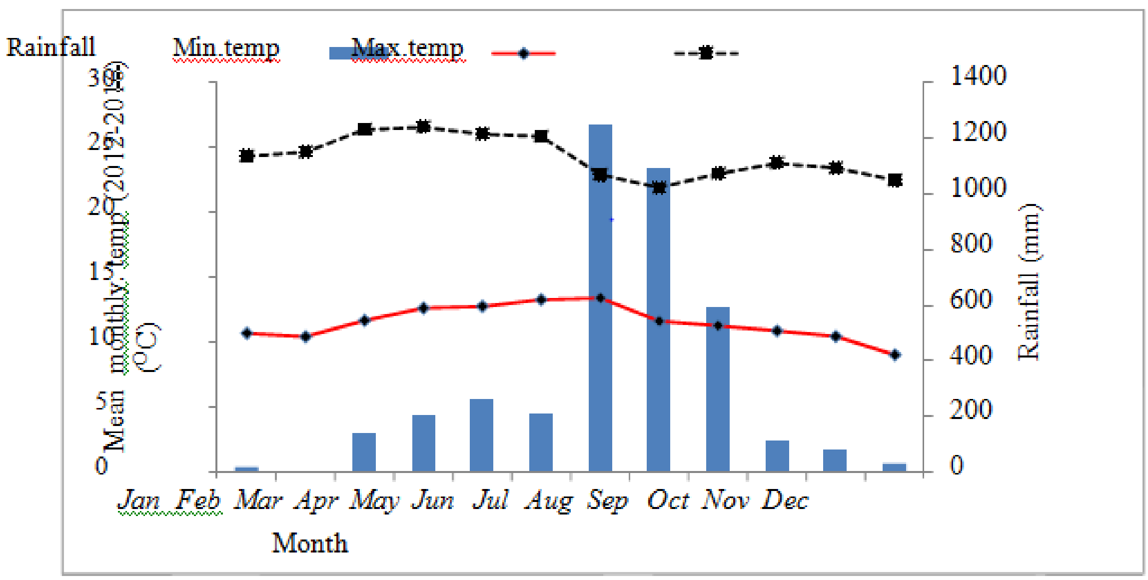

Figure 2: Mean monthly precipitation and temperature for Enda Mehoni district (2012-2016) Source: National Meteorological Agency

3.1.3. Soil

The major soil types of the study area are Leptosols, Eutric Cambisols, and Regosols. Eutric Regosols were associated with the steep slopes of the highlands in Enda Mehoni district (Feyisa, 2006). Generally, the soil types of the study area are characterized as shallow, moderately deep, and very deep. The soil textural classes in the study district were silt (43%), brown (25%), clay (19%), sand (7%), and Loam/"Baekel" (6%) (BARD, 2017).

3.1.4. Vegetation

According to the district office of agriculture and rural development and my personal observation, the dominant indigenous woody plant species in the study area are Juniperus procera, Acacia Abyssinia, Dodona angustifolia, and Maytenus ablutophilia. The dominant exotic woody species are Eucalyptus Globulus, Acacia saligna, Cupressus lusitanica, and Chamaecytisus Palmensis. The dominant grass species include Hyperrhenia hirta and Cynodon dactylon, while the dominant herbs include Trifolium species, Becium grandiflorum, Rumex nervosus, and Asystasia gangetica.

3.1.5. Human and livestock population

The total human population of the district was approximately 136,883, with 69,807 (51%) females and 67,076 (49%) males (BoARD, 2017). The total land area is about 61,229.5 hectares or 612.295 square kilometers, resulting in a population density of 220.13 persons per square kilometer. There are 24,850 farm households, with an average family size of approximately 6 (BoARD, 2017). According to the CSA (2012), the district has an estimated population of 57,905 cattle, 76,422 sheep, and 64,254 goats.

3.1.6. Farming system and land use

The study area, Enda Mehoni Woreda, is predominantly agricultural. Crop cultivation, including wheat, barley, sorghum, tef, maize, peas, and beans, is the primary economic activity, contributing significantly to local income. Wheat and barley are staple crops, while beans and peas are cash crops. Livestock rearing, particularly dairy and beef cattle, sheep, goats, poultry, and beekeeping, is another important income source. The region's diverse landscape includes cultivated land, grazing land, plantations, and marginal land. Natural forests, composed of indigenous trees, are distinct from plantations, which are human-planted forests. Marginal lands, characterized by low productivity and limited agricultural potential, account for a small portion of the total area.

Table 2: Land use of Enda Mekoni district source; (BoARD, 2017)

Land use type	Area coverage in hectare	Proportion in%
Natural forest	3124	5.1
Plantation	11633.61	19
Cultivated land	14695.08	24
Enclosures	8179.53	13.4
Grazing land	16348.28	26.7
Settlement	5154.5	8.4
Marginal land	2094.5	3.4
Total	61229.5	100

3.1.7. Production systems of the study areas

3.1.7.1. Rural dairy production system

The rural farming system is characterized by the use of a low level of inputs (such as feed and housing systems), low production levels of animal products, poor marketing linkages, and insignificant access to crossbreed animals. This type of production system is divided into two types of dairy farming.

The first one is the traditional dairy production system, which is based on indigenous breeds that have poor production performance and use low inputs. According to Ketema and Tsehay (1995) and Desta (2002), the traditional system is based on indigenous breeds, which have low production performance. This is supported by Falvey and Chantal Khana (1999), as the milk produced in the rural farming system is mainly used for home consumption, and the feed requirements are entirely satisfied from native pasture, crop residues, stubble grazing, or agricultural by-products.

3.1.7.2. Urban dairy production system

The second production system to consider is the Urban Dairy Production System. This system is developed in towns located in different agro-ecologies of Ethiopia. It comprises medium to large-sized dairy farms that have improved dairy cattle. The cattle have a chance to be housed in improved shelters made of locally available materials (Desta, 2002). This system is characterized by farmers having limited access to farming or grazing land, due to which livestock are given a chance to feed under stall-feeding conditions (Ayenew et al., 2008).

The study area, classified as a rural production system by the E/Mekoni district administration, doesn't seem to align with the FAO's definition of peri-urban livestock production. The FAO considers various factors for such classification, including farm types, livelihoods, farmer profiles, and livestock products. Peri-urban systems often differ from rural ones. They may involve partly mobile animals or soilless feeding methods. These systems are typically composed of specialized, independent units working together or within supply chains.

Livelihoods in peri-urban livestock production are often secondary, with farmers having part-time jobs. These systems face unique challenges, such as high land prices, land tenure insecurity, and potentially higher labor costs due to their proximity to urban centers. However, they may benefit from easier access to affordable commercial feed and inputs. These distinct characteristics differentiate peri-urban livestock production from both purely urban and rural systems.

3.2. Study methodology

3.2.1. Sampling technique and sample size

A purposive sampling technique was used to select the study sites. From the Southern Zone, the Endamekoni Wereda (district) was chosen due to its significant cattle population and the community's reliance on animal rearing for their economy. This district is known for crossbreeding efforts, both by the government and NGOs, to improve cattle performance. However, there was a lack of documented data on the community's major challenges related to these breeding programs. From the selected district, a total of four Kebeles (villages) and one administrative town were purposively chosen for the study: Hizba, Smret, Shimta, Senay, and Maichew Town. The Kebeles were selected based on factors such as their crossbred and local cattle populations, ease of access, and herd management characteristics. The selection also considered the dairy production system, whether rural or urban.

Table 3: Mechanisms used to characterize production systems of study area

No.	Differentiate Factors	Dairy production systems	
		Rural	Urban
1	Location	Far from town	Within town
2	Management	Extensive	Intensive
3	Marketing	Not access as much	Access to market
4	Feed source	Mainly pasture from pasture land	Purchased feed
5	Feeding system	Mainly grazing by own self	Zero grazing
6	Herd type	Local and crossbred of lower exotic blood level	Crossbred of higher exotic blood level
7	Herd size	Larger herd size	Lower herd size
8	Land size	Larger land size	Lower negligible land size
9	Objective of keeping animal	For multi- purpose	For specific objective
10	Milk production	To process and home consumption	To sell

Source: Reda et al. (2000)

3.2.2. Determination of Sample Size

Based on a purposive sampling approach, four rural sites (Hizba T/Haymanot, Shimta, smret and Senay) and one urban site (Maichew Town) were selected for the study. The total sample size of crossbred beneficiaries was calculated using the formula provided by Singh and Masuku (2014).

$$((\frac{N.Z^2.p.(1-p)}{(N-1).(e^2)+Z^2.p.(1-p)}))$$

Given a total population of 3059 (2079 from rural and 980 from urban), a standard error of 0.5%, and a confidence level of 95%, the total number of respondents was determined to be 150 households, with an equal distribution of 75 households in both rural and urban areas. In addition to the household samples, key informants were selected from animal experts, researchers, milk collectors, sellers, processors, and retailers, all chosen using a purposive selection procedure. Crossbred and indigenous dairy cow owners under smallholder conditions were also selected using the purposive sampling method.

The number of respondent farmers per selected Kebele was determined using a proportionate sampling technique. The formula used was:
W = [A/B] x No

Where:
W = Sample of farmers determined per single selected Kebele
A = Total number of households (farmers) living per a single selected Kebele
B = Total sum of households living in all selected sample Kebeles
No = the total required calculated sample size

The total number of households with both local and crossbred dairy cattle in each selected Kebele (Hizba T/Haymanot, Smret, Shimta, Senay, and Maichew Town) were 540, 589, 450, 500, and 980, respectively. The total households in the selected rural Kebeles were 2079, and 980 in the urban area. Out of these, approximately 1300 households owned crossbred animals. Accordingly, the number of households selected from each Kebele was 20, 21, 16, 18, and 75, respectively, for the rural and urban areas.

In summary, the study employed a purposive sampling approach to select the study sites, key informants, and crossbred/indigenous dairy cow owners. A statistical formula was used to determine the total sample size of 150 households (75 rural, 75 urban). The number of respondents per Kebele was calculated using a proportionate sampling technique.

Table 4: Sample Size of Study areas/ tabias

No.	Study areas/ tabias	Farming system/production system	No. of sample for respondents
1	Hizba t/haymanot	Rural	20
2	Smret,	Rural	21
3	Shimta,	Rural	16
4	Senay	Rural	18
5	Maichew	Urban	75
		Total	150

3.2.3. Data sources

3.2.3.1. Primary and secondary data

The research allows gathering of information about farmers' perceptions of their farming practices, occupation, and their real opinions about the production and reproduction performances of local and crossbred cows (low- and high-grade crosses) where they are beneficiaries in their own production system.

The main secondary data sources used in this research were both hard copies and online materials, such as published and unpublished articles, proceedings, project reports, and other data available at the Bureau of Agriculture and Rural Development, Kebele, districts, zonal, regional, national, and international levels.

To gather information on the reproduction and production of crossbred cows with different exotic blood levels and indigenous dairy cows, both primary and secondary data were used. Secondary data, such as certificates given for crossbred animals from research centers and the exotic blood level of sires/bulls from AI centers, were utilized.

Primary data were collected using a questionnaire on production and reproduction parameters (age at puberty, age at first calving, days open, calving interval, lactation length, and daily milk yield) and socioeconomic data, achievements, challenges, and opportunities for all household characteristics and input delivery data. In addition to the questionnaire, focus group discussions or key informant interviews were used to validate the data collected from the questionnaire.

3.2.4. Data collection methods

This study investigated dairy farming practices and cow performance in both rural and urban settings. The research involved interviewing farmers, collecting farm records, and conducting surveys to gather data on factors such as age at first calving, calving interval, lactation length, milk yield, feeding, housing, healthcare, and herd management. The study also explored the impact of crossbreeding on cow performance and farmer perceptions of crossbreeding practices. Additionally, the research delved into the use and adoption of assisted reproductive technologies (ARTs), such as artificial insemination, in both rural and urban areas. By combining data from various sources, including government records and existing research, the study aimed to identify factors influencing dairy cow performance and to understand the challenges and opportunities faced by dairy farmers in different settings.

Table 5: Mechanisms used to identify exotic blood level of crossbred cows/heifers

Probability of Dam exotic blood level certified from source and supplied for	**Probability of Sir/bull exotic blood level at AI /natural**				
	50%	62.5%	75%	87.5%	100%
	Estimated Offspring exotic blood level				
0%(Local)	25%	31.25%	37.5%	43.75%	50%
25%	37.5%	43.75%	50%	56.25%	62.5%
50%	50%	56.25%	62.5%	68.75%	75%
62.5%	56.25%	62.25%	68.75%	75%	81.25%
75%	62.5%	68.75%	75%	81.25%	87.5%
87.5%	68.75%	75%	81.25%	87.5%	93.75%
100%	75%	81.25%	87.5%	93.75%	100%

Source: Abera, (2016)

3.2.5. Data analysis

The data were subjected to statistical analysis using the Statistical Package for Social Sciences (SPSS) software, version 20.0 (SPSS, 2016). Descriptive statistics such as means, frequency distribution, and percentages were used. For quantitative data, the general linear model (GLM) was used to compute least square means (LSM), and statistical significance between variables was examined using P-values at a critical probability of $P<0.05$. For rank case Index calculation, the method described by Myers and Montgomery (1995) was used.

$Yijk=\mu+mi+bj+aik+fk+\epsilon ijk$

Where:

- ***Yijk***: Cow performance (dependent variable).
- ***μ***: Overall mean performance.
- ***mi***: Fixed effect of production system.
- ***bj***: Fixed effect of exotic blood level.
- ***aik***: Random effect of the EBV (Estimated Breeding Value) for cow *i* in production system *j* and exotic blood level *k*, capturing individual genetic variation.
- ***fk***: Fixed effect of family size, accounting for differences in performance based on the size of the family.
- ***ϵijk***: Residual error term.

This statistical analysis aimed to determine the effects of different fixed factors, such as production system and exotic blood level, on various performance parameters of crossbred and indigenous dairy cows.

4. Results and discussion

4.1. Result of Households survey study

4.1.1. Description of Household

The study found that rural households were significantly larger than urban households. About 30.6% of households were headed by women, while 69.3% were headed by men. The average age of household heads was 42.8 years in urban areas and 47.7 years in rural areas, indicating a prime working age for most households. The average family size in the study was 7.75 people, higher than the national rural average of 4.9 people. Rural and urban dairy production systems differed significantly. Rural systems relied more on natural resources and traditional practices, while urban systems relied on purchased inputs and intensive management. These differences have implications for the efficiency, sustainability, and profitability of dairy production in both settings.

Table 6: Household characteristics across the production system

Parameter	Production system				Total	P-value
	Urban		Rural			
	N (%)	Mean ±SE	N (%)	Mean ±SE	Mean	
Age	75(%)	42.8±1.15	75(%)	47.7±1.4	45.3±1.20	0.005
Household Size	75(%)	7.0±0.19	75(%)	8.4±0.25	7.7±0.16	0.001

Parameter		**Production system**			
		Urban		Rural	
		N	(%)	N	(%)
Household sex	Female	20	26.3	23	30.6
	Male	55	73.3	52	69.3

Education	Illiterate	2	2.6	12	16.0
	Primary School	17	22.6	32	42.7
	Secondary school	31	1.3	25	33.3
	College/ university	25	33.3	6	8.0

N= number of farmers, SE standard error

The study revealed significant demographic differences between rural and urban farmers in Ethiopia. Rural farmers were found to be older, with an average age of 47.7 years compared to 42.8 years for urban farmers. This age disparity was statistically significant (p-value < 0.005).

Additionally, rural households were larger, averaging 8.4 people, while urban households were smaller, averaging 7.0 people. This difference was also statistically significant (p-value < 0.001). Both rural and urban farming systems were dominated by male farmers. However, there were notable differences in educational attainment. Urban farmers were more likely to have higher levels of education, with 16% holding a college or university degree, compared to only 8% of rural farmers. In contrast, a larger proportion of rural farmers (32.7%) had only primary education, while this was the case for only 22.6% of urban farmers.

The study also found a correlation between education level and cattle ownership. Households with higher educational levels were more likely to own and manage crossbreed cattle. This suggests that education plays a crucial role in adopting modern farming practices and improving agricultural productivity.

These findings align with previous research, which has consistently shown that rural households in Ethiopia tend to be larger and have lower levels of education compared to urban households. Understanding these demographic disparities is essential for developing effective policies and interventions to support the agricultural sector and improve the livelihoods of farmers in both rural and urban areas.

4.1.2. Labor distribution of Household Members in Dairy Activities

Effective household labor distribution is key to maximizing profits in dairy farming worldwide, including in developing regions (Njuki and Sanginga, 2013). This is often achieved by improving animal handling practices across different production systems (Hemme and Otte, 2010). Households in dairy dependent communities typically prioritize dairy-related work over other farm or non-farm activities for income generation (Tangka et al., 2002).

Interestingly, larger dairy herd sizes have been shown to require less labor per animal for routine dairy tasks, thereby freeing up household time for other activities (Staal et al., 1997). Additionally, gendered roles often emerge, with women typically responsible for feed preparation and feeding, while men focus more on forage collection and other dairy-related chores (Njuki and Sanginga, 2013).

Importantly, factors such as land size and overall household income have been found to have minimal impact on the allocation of household labor for dairy activities, suggesting a dedicated focus on optimizing dairy operations regardless of these contextual factors (Tangka et al., 2002; Hemme and Otte, 2010).

Table 7: Participation of household members in dairying activities

	Production system							
	Rural				Urban			
House hold Family	Milking	Milk processing	milk transport(market)	husbandry activities	Milking	Milk processing	milk transport(market)	husbandry activities
	Freq (%)	Freq (%)	Freq (%)	Freq (%)	Freq (%)	Freq (%).	Freq (%).	Freq (%)
Men	28(37.3)	0(0.0)	6(8.0)	21(28.0)	20(26.7)	6(8.0)	20(26.7)	22(29.3)
Wome	36(48.0)	60(80.0)	28(37.3)	20(26.7)	14(18.7)	37(49.3)	14(18.7)	18(24.0)

n								
Children	5(6.7)	15(20)	36(48.0)	34(45.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Worker	6(0.0)	0(0.0)	5(6.7)	0(0.0)	41(54.7)	32(42.7)	41(54.7)	35(46.7)

Freq. = Frequency

Household Participation in Dairy Production

The way households participate in dairy production differs significantly between urban and rural areas. In urban settings, workers and men are the primary labor force for most dairy tasks. In contrast, women in rural areas play a major role, especially in milking (37.3%). Children, however, are not involved in dairy activities in either setting. This could be beneficial for rural children's education, as it frees them from labor responsibilities. However, rural women shoulder the burden of milk processing (80%) and transportation of milk and milk products (66.7%).

Rural households typically have larger families compared to urban households. This difference can be explained by various factors, including cultural norms, economic practices, and access to resources. In rural areas, larger families provide the necessary labor for agricultural activities, including dairy farming, which is crucial for their livelihood. Limited access to family planning services and education in rural areas can contribute to higher birth rates. In contrast, urban households generally have better access to education, healthcare, and family planning services, leading to smaller family sizes. Urban economic dynamics often favor smaller families due to higher living costs and reduced reliance on family labor for economic activities.

Urban households have a higher percentage of single-person households compared to rural households. Additionally, there are more working individuals in urban areas, although dairy production is not a common occupation among them. Traditionally, milk processing has been considered women's work. In rural households, a significant number of people are involved in milk production compared to other occupations. This aligns with previous research that found women and children to be primarily responsible for milk processing, transportation, herding, fodder harvesting, and feeding in rural production systems. These gender roles are often rooted in traditional beliefs and cultural norms that assign domestic duties to women, regardless of their contributions to agricultural production.

4.1.3. Cattle Herd size and Composition across production system.

In this study, higher herd size was recorded in the rural system (55.20 %) than urban (44.8 %) production system. The current result from rural production system revealed that female calves with mean number of 0.73±.08, heifer's 0.51±0.09, lactating cows; 2.33±0.29 and total herds of local cattle; 5.23±0.49 were observed.

Table 8: Cattle herd size and composition across production system

Cattle breed and type	production system				Total
	Rural		Urban		
	Mean ± SE	%	Mean ± SE	%	%
Total herd size	9.65±0.34	55.20	7.83±0.29	44.8	100
No. Local cattle	5.23±0.49	74.50	1.79±0.21	25.49	100
No. of crossbred	4.42±0.19	43.17	6.04±0.36	56.83	100
No. Local cattle					
Male calves	1.60±0.23	82.9	0.33±.09	17.1	100
Female calves	0.73±0.08	48.6	0.77±0.05	51.33	100
Heifers	0.51±0.09	100	0.00±0.0	0	100
Bulls	0.12±0.38	100	0.00±0.0	0	100
Lactate Cows	2.33±0.29	85.18	1.11±0.11	14.81	100
Dry cows	23±0.059	38.43	0.04±0.023	50	100

No. Crossbreed					
Male calves	1.00±0.0	50	1.00±0.00	50	100
Female calves	1.08±0.09	38.43	1.73±0.18	61.56	100
Heifers	0.19±0.05	25.67	0.55±0.01	84.84	100
Bulls	0.09±0.04	45	0.11±0.04	55	100
Lactate Cows	2.11±0.086	43.24	2.80±0.182	57.37	100
Dry cows	0.012±0.042	50	0.17±0.044	50	100

Distinct Cattle Raising Practices in Rural and Urban Areas

The data revealed distinct cattle raising practices in rural and urban areas. Rural areas had larger herds (average 9.65±0.34) with a higher proportion of local breeds (74.5%). This likely reflected ample space for grazing and a focus on preserving local breeds. Rural areas also raised more local male calves (1.60±0.23) compared to females (0.73±0.08), possibly for draft work like plowing.

In contrast, urban farms, with space limitations, maintained smaller herds (average 7.83±0.29) with a higher percentage of crossbred cattle (56.83%) known for greater milk production. This focus on maximizing milk yield was further evidenced by the presence of more crossbred lactating cows (2.80±0.182) in urban areas compared to rural areas (2.11±0.086). While both environments raised calves, urban farms likely sold male calves early (0.33±0.09) or avoided them altogether due to space constraints, keeping more female calves (0.77±0.05) potentially for future milk production. These insights suggest a clear adaptation of cattle raising practices to the specific challenges and opportunities of rural and urban settings.

4.1.4. Crossbred Genotype Composition

Based on the statistical significance reported in the analysis, the differences in exotic blood proportions between the urban and rural production systems can be considered significant in several cases:

Table 9: Genotype composition of crossbred cattle across the production system

Exotic blood level %		Production systems				Total		P-value
		Rural		Urban				
		Mean± SE	%	Mean±SE	%	Mean± SE	%	
Cow	<50%	0.31±.06	53.8	0.25±.05	46.2	0.43±0.05	100	0.46
	50%-62.5%	2.21±0.16	51.5	2.08±0.09	48.4	2.15±0.09	100	0.43
	>75 %	0.04±0.02	8.3	0.44±0.08	91.7	0.24±0.04	100	0.003
Heifer	<50%	0.38±0.05	62	0.35±.04	38	0.54±0.05	100	0.64
	50%-62.5%	0.03±0.02	63.8	0.17±.04	36.1	0.10±0.03	100	0.005
	62.5%-75%	0.13±0.05	40	0.27±.07	60	0.20±0.06	100	0.101
	>75 %	0.03±0.02	21.4	0.11±0.04	78.5	0.07±0.03	100	0.046
Bull	<50%	0.22±0.04	61	0.18±.03	39	0.29±0.16	100	0.42
	50%-62.5%	0.01±0.01	12.5	0.07±0.03	87.5	0.04±0.02	100	0.046
	62.5%-	0.13±0.05	43	0.17±.03	57	0.22±0.21	100	0.478
	>75 %	0.00±.0.00	0.0	0.04±0.02	100	0.02±0.01	100	0.046
Calf	<50%	2.01±0.01	73	0.29±.03	27	1.29±0.05	100	0.00
	50-62.5%	1.41±0.11	17.85	1.15±0.04	82.1	1.28±0.08	100	0.056
	62.5%-	0.87±0.08	29.2	0.97±0.10	70.8	0.92±0.09	100	0.406
	>75 %	0.07±0.03	22.0	0.47±0.08	78.0	0.27±0.05	100	0.001

The study delved into the distribution of exotic blood levels in cows, heifers, bulls, and calves across rural and urban livestock systems in Ethiopia. A notable trend emerged: rural areas exhibited a higher prevalence of animals with lower exotic blood levels (below 50%). This finding aligns with research by Zewdie (2010) and Tadesse et al. (2018), suggesting that rural systems often prioritize indigenous breeds, which are better adapted to local environmental conditions and resource constraints. In contrast, urban areas displayed a higher proportion of animals with elevated exotic blood levels (above 75%). This is consistent with studies by Gebrekidan et al. (2012), Negussie et al. (2016), Ashenafi et al. (2018), and the CSA (2020), indicating a preference for exotic breeds in urban systems. These breeds are often associated with higher productivity and better adaptation to intensive production systems. The study's findings highlight the significant influence of production environment on breed composition and have implications for livestock breeding and management strategies aimed at optimizing both productivity and resilience in Ethiopian livestock systems.

4.1.5. Exotic Blood Level Preferences of Farmers

Productive and reproductive performance of cattle was directly affected by exotic blood level they have. As presented in (Table10) farmers preferred high graded crossbreds to improve both productive and reproductive performance of dairy cattle like optimum daily milk yield, earlier age at first calving and short calving interval.

Table 10: Preference of cow/heifer's exotic blood level across production systems of study area.

Breed Blood level	**Production system**		
	Urban	Rural	Total
	Freq. (%)	Freq. (%)	Freq. (%)
Local	5(6.67)	18(24)	23(30.7)
<50%	13(17.3)	16(25.33)	29(48.7)
50%-62.5%	15(20)	19(21.33)	34(45.33)
62.5%-75%	18(24)	13(17.3)	31(51.3)
>75%	24(32)	10(13.3)	34(45.3)

This suggests that urban production systems tend to have a higher proportion of more intensified/commercial breeds, while rural production systems have a higher proportion of local and indigenous breed types. This was evident when comparing the percentages: local breeds make up nearly a quarter 18(24%) of the rural population compared to a mere 5(6.67%) in urban areas. The trend continues for breeds with less than 50% improved genetics, with a higher concentration found in rural areas 16(25.33%) compared to urban areas 13(17.3%).

This difference in breed distribution suggests a historical focus on distinct priorities between the two production systems. Urban systems appear to concentrate on breeds with a higher percentage of improved genetics. This focused-on breeds exceeding 62.5% improved genetics (24% in urban areas) suggests a prioritization of maximizing production through breeds specifically selected for high yields or other desirable traits.

The findings presented in the above are largely supported by the existing body of research on dairy cattle breeds in Ethiopia. Past studies have consistently noted a higher diversity of dairy breeds, especially local/indigenous breeds, in rural areas compared to urban production systems (Tesfaye and Chairatanayuth, 2007; Zewdie, 2010). This was evidenced by the prevalence of local dairy breeds in smallholder rural systems, in contrast to the dominance of crossbred and exotic breeds in urban/peri-urban dairies. Corroborating this, Tadesse and Dessie (2003) and Gebrekidan et al. (2012), also reported higher percentages of local Zebu cattle in rural dairy herds compared to urban/peri-urban settings, aligning with the finding that local breeds make up 18(24%) of the rural dairy population versus only 5(6.67%) in urban areas. Furthermore, the result suggestion that urban dairy systems focus more on breeds with higher proportions of improved genetics (>62.5%), prioritizing productivity, is consistent with studies like Belay et al. (2012), which evaluated the performance of crossbred dairy cows with varying levels of exotic Holstein-Friesian genetics in the urban production system of Jimma, Ethiopia.

They acknowledge the continued importance of local breeds in these systems, while also recognizing the potential for improved genetics to increase milk yield. Gebremedhin et al.

(2014) explore the genetic diversity of Ethiopian cattle breeds. While not directly addressing rural vs. urban distribution, their findings suggest a wider presence of local breeds across various regions.

4.2. Source of feed for dairy cattle

The findings show grazing as the most common feed type in rural communities with an index ranking of 0.188. This aligns with the research by Gizachew Assefa et al. (2017), who noted that Ethiopia's pastoral and agro-pastoral communities rely heavily on extensive natural pastures. The dominance of grazing lands and the strategic use of hay and crop residues are a direct response to the seasonal and environmental variability faced by farmers. The extensive grazing lands, covering over 60 million hectares, provide a critical resource for rural households, as confirmed by Lemma and Asfaw (2019).

Hay's prevalence in both rural and urban settings, with index rankings of 0.187 and 0.191, respectively, is supported by findings from Tegegne et al. (2010) and the Livestock Feed Resources Assessment conducted in 2022. These studies highlight hay's critical role during the dry season, particularly in the highland mixed farming systems.

Similarly, crop residues are crucial in bridging feed gaps, as noted by Tolera et al. (2012) and Gebremedhin & Mekuni (2018). These residues are especially vital post-harvest and are readily available to smallholder farmers. However, competition for land use and the need for crop residue in construction may have restricted their availability for livestock feed.

The lower index ranking of concentrates (0.164 in rural and 0.222 in urban areas) indicates their limited use, corroborating the findings by Desta et al. (2011) and Alemayehu (2011). The high cost of commercial concentrates makes them less accessible to smallholder farmers, restricting their use to supplementing other feed types rather than as a primary feed source.

The current observations on the limited use of green feed and mineral supplements are consistent with studies by Mengistu (2006) and Berhane et al. (2021). Green feed's availability is often limited by water resources, making it less common in rain-fed areas. The low index ranking for mineral supplements highlights a widespread issue of mineral deficiencies in livestock diets, likely due to both lack of awareness and the unavailability of mineral supplements.

In summary, Ethiopia's livestock feed practices are heavily influenced by the availability of natural resources. The dominance of grazing lands, the strategic use of hay and crop residues, and the limited use of concentrates, green feed, and mineral supplements reflect the farmers' adaptation to the seasonal and environmental challenges they face. (see appendix table 1)

4.3. Production and reproduction performance of local and crossbred dairy cows with different exotic blood levels

4.3.1. The production performance of local and crossbred dairy cows with different exotic blood levels

Table 11: Lactation length and milk yield of crossbred and local breeds

Parameters	Production system	Pure local	<50	50-75	>75
	system	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE
Lactation length (month)	Rural	8.89±.153	8.20±.057	9.05±.170	9.00±.577
	Urban	8.91±.149	8.81±.045	8.25±.479	9.92±.303
	Over all	8.90±.106	8.51±.044	8.92±.169	9.83±.281
			Average of all cross 9.08±.164		
	p-value	0.208	0.001	0.078	0.326
Milk yield (L)	Rural	2.24±.061	6.467±.622	10.90±.518	16.33±.333
	Urban	2.28±.059	7.840±.156	18.00±1.22	25.038±335
	Over all	2.26±.042	7.153±.102	12.08±.722	24.138±.584
			Average of all cross 14.457±.469		
	p-value	0.005	0.000	0.000	0.000
	Rural	522.55±17	1645.60±25	2512.50±11	3160.0±693.
	Urban	448.13±13	1764.20±43	2707.50±32	4776.9.6±41

Milk/lactation (L)	Over all	482.52±11 .376	1704.90±25	2545.00±10	4609.6±385.
			Average of all cross 2953.16±173.81		
	p-Value	0.109	0.021	0.520	0.207

4.3.1.1. Lactation length

The study examined the lactation length (LL) of dairy cows in different production systems and with varying levels of exotic blood. Interestingly, LL was not significantly influenced by either factor. Crossbred cows, regardless of their specific blood level, exhibited a slightly longer average LL (9.08 months) compared to local cows (8.90 months). This finding is consistent with previous research, which has generally reported similar LL for local cows in the region. However, a notable disparity exists in the reported LL for local cows in Ethiopia. Some studies have documented shorter LL (6.7-7 months), while others have reported longer durations (9.23 months). These variations likely stem from regional differences in factors such as breed characteristics, management practices, and feed availability. The relatively lower LL observed in the current study compared to certain previous research, such as Mulugeta & Belayneh (2013) and Kumar (2005), could be attributed to several factors. These include breed differences, milking practices, and potential limitations in feed availability within the study area.

Table 12: Milking frequency (day) of local and their crossbred across production system.

Exotic Blood level and Breed type						
Parameters	Production system	Pure local	<50	50-62.5	62.5%-75%	>75
	Rural	1.17±0.06	1.33±0.05	2.00±0.72	2.32±0.01	2.09±0.043
	Urban	1.36±0.07	1.79±0.04	2.00±0.81	2.10±0.55	2.19±0.634
	Over all	1.77±0.05	1.56±0.49	2.00±0.72	2.37±0.03	2.52±0.043

milking frequency(day)	Average of all crossbreed 2.04 ± 0.37					
	p-value	0.001	0.179	1.00	0.202	0.220

The study found a clear link between the level of exotic blood in dairy cows and milking frequency. Cows with a higher percentage of exotic blood were milked more frequently than those with lower percentages, regardless of whether they were kept in rural or urban settings. Cows with over 75% exotic blood were milked most often, averaging 2.52 times per day. In contrast, pure local cows were milked least frequently, averaging 1.77 times per day. This difference was statistically significant. The increased milking frequency for crossbred cows can be attributed to several factors. Genetic factors, such as those associated with higher milk production, may play a role. Additionally, physiological differences, such as faster milk production rates, could necessitate more frequent milking. These findings align with previous research that has shown a positive correlation between exotic blood level and milk yield. While the specific factors influencing milking frequency are complex and require further investigation, the current study provides valuable insights into the relationship between exotic blood level and milking practices in dairy cows.

4.3.2. Reproduction performance of local and crossbred

Table 13: Age at first service (AFS) and age at first calving (AFC) of all local and their crossbred (months)

Parameters	Production system	Exotic blood level and Breed type				
		Pure local	<50%	50%-62.5%	62.5%-75%	>75%
		Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE
Age at first	Rural	42.5±0.4	33.7±0.2	30.21±0.2	22.1±0.2	21.3±0.2

service	Urban	37.1±0.3	29.9±0.7	28.3±0.14	19.2±0.47	18.2±0.20
	Over all	39.6±0.3	31.8±0.5	29.2±0.18	21.6±0.3	18.5±0.74
			Average of all crossbreed 25.31±0.431			
	p-value	0.001	0.001	0.001	0.001	0.001
Age at first calving	Rural	51.53±0.3	46.9±0.29	38.7±0.3	31.1±0.23	30.3±0.33
	Urban	46.1±0.35	39.1±0.13	34.9±0.06	27.1±0.20	27.1±0.20
	Over all	48.6±0.37	43.0±0.11	36.8±0.5	30.6±0.30	27.5±0.25
			Average of all crossbreed 34.513±0.292			
	p-value	0.001	0.001	0.001	0.001	0.001

SE: Standard error

4.3.2.1. Age at first service

The study revealed a strong positive correlation between exotic blood levels and earlier age at first service (AFS) in cattle (p-value < 0.001). Crossbred cows with 50-62.5% exotic blood reached breeding maturity the earliest, with a mean AFS of 28.31 ± 0.14 months in urban areas and 30.21 ± 0.22 months in rural areas. Pure local breeds had the latest AFS at 42.5 ± 0.44 months and 37.1 ± 0.35 months in rural and urban settings, respectively.

These findings align with Abera (2016) who also reported lower AFS for crossbred cows with higher exotic blood levels. However, the current results contradict those of Haftamu et al. (2010), Belay et al. (2012), and Hunduma (2013), who reported lower AFS for general crossbreds (24.9 months, 24.07 months, and 24.30 months, respectively). Similarly, belay et al. (2012) and Addis et al. (2017) reported lower mean AFS for crossbred dairy cows (24 months and 24.5 months, respectively). Nevertheless, the current study's AFS for crossbreds was shorter than the 36.8 months reported by Gebeyehu et al. (2005).

The results suggest that crossbreeding with exotic breeds and improved management practices can significantly reduce the time taken for cows to reach reproductive maturity, especially in urban settings where cows mature slightly faster due to better nutrition and management.

4.3.2.2. Age at first calving

Age at first calving (AFC) is a crucial indicator of a cow's reproductive life and is closely linked to generation interval (Heinrichs, 2008). The study found a significant difference ($p < 0.001$) in AFC between pure local breeds and crossbreds. AFC varied significantly ($p < 0.05$) across different production systems and exotic blood levels. Cows in urban settings and those with higher exotic blood levels tended to calve earlier. This is likely due to improved management, nutrition, and the genetic potential of exotic breeds (Abebe et al., 2021). Pure local breeds had the latest average calving age at 51.53 months, while cows with over 75% exotic blood calved the earliest at 30.33 months. The current study's AFC values were lower than those reported by Mebrahtom et al. (2016), Abera (2016), and Kumar et al. (2017). For instance, Kumar et al. (2017) reported a higher AFC for all crossbreeds (25.33 months) compared to the current study (26.5 months). Similarly, the AFC for local breeds in this study was higher than those reported by Dinka (2012), Zereu and Lijalem (2016), Gebretnsae et al. (2017), and Gebre et al. (2021). This discrepancy could be attributed to factors like inadequate supplementary feeding, poor-quality forage, and suboptimal management practices common in smallholder settings.

4.3.2.3. Calving interval, Day open SN, and Longevity

The overall reported calving interval (CI, months), day open (days) of local and their crossbred cow's performance based upon the response of the farmers from the study area are presented in the below (Table 16).

Table 14: Calving Interval (CI), Days Open (DO), Service Number/Conception and Longevity (year) of indigenous and their crossbreds.

Parameter	Production system	Exotic blood level and breed type				
		local	<50%	50%-62.5%	62.5%-75	>75
		Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE
Calving interval (months)	Rural	22.3±0.12	17.1±0.22	16.1±0.11	14.5±0.15	13.0±1.00
	Urban	21.7±0.05	16.0±0.10	14.8±0.19	13.2±0.25	12.1±0.17
	Over all	22.0±0.07	16.5±0.16	15.4±0.12	14.3±0.17	12.2±0.18
			Average of all crossbreed 14.65±0.158			
	p-value	0.001	0.001	0.001	0.001	0.164
Day open (days)	Rural	206.5±1.5	201.2±0.12	188.2±0.32	104±0.56	103.3±21.8
	Urban	202.1±0.72	197.3±0.25	175.6±0.72	97.4±0.47	85.0±2.67
	Over	204.1±0.8	199.2±0.18	181.9±0.65	102.9±0.4	86.9±3.20
			Average of all cross 142.75±1.128			
	p-value	0.001	0.001	0.001	0.622	.0.083
Services number/ conception	Rural	2.31±0.10	1.96±0.021	1.72±0.052	1.67±0.67	1.50±0.170
	Urban	1.73±.092	1.53±0.069	1.39±0.06	1.25±0.25	1.04±0.038
	Over all	2.0±0.074	1.74±0.045	1.55±0.042	1.46±0.14	1.27±0.104
			Average of all crossbreed 1.506±0.179			

	p-value	0.001	0.001	0.000	0.539	0.009
Longevity(year)	Rural	9.95±0.17	9.05±0.14	8.89±0.11	9.65±0.34	10.6±0.145
	Urban	7.8±00.18	8.12±0.11	8.69±0.115	8.7±0.12	9.96±0.301
	Over	8.82±0.16	8.58±0.126	8.79±0.081	9.5±0.33	10.03±0.30
			Average of all crossbreed 9.22±0.210			
	p-value	0.001	0.012	0.218	0.328	0.484

4.3.2.4. Calving Interval

The study found a significant correlation between exotic blood level and calving interval (CI). Cows with higher exotic blood percentages consistently exhibited shorter CIs. This trend was observed in both rural and urban settings, with urban cows generally having shorter CIs than rural cows.

The shortest CI was observed in urban cows with over 75% exotic blood (12.15 months), while the longest was in pure local rural cows (22.36 months). These results suggest that both production system and genetic factors influence CI. While urban cows generally had shorter CIs, other factors like improved management practices might also contribute to this trend. Comparing these findings to previous research, the current study revealed shorter CIs for both local and exotic breeds. For instance, the CI for local breeds (22.16 months) was lower than the 24.6 months reported by Berhanu et al. (2021). Similarly, the CI for exotic breeds (14.65 months) was shorter than the 14.59 months reported by Tesfaye & Chairatanayuth (2007). However, some discrepancies were observed, such as the higher CI for local breeds compared to the 19.913 months found by Zereu et al. (2021). These variations likely arise from factors like breed genetics, management practices, and environmental conditions.

4.3.2.5. Day Open (days)

The study investigated Days Open (DO), the interval between calving and re-pregnancy in cows. It found that rural cows had a significantly longer DO (206.53 days) compared to urban cows (202.19 days) ($p < 0.001$). This difference is likely attributed to factors such as limited access to veterinary services and lower-quality feed in rural areas. Additionally, cows with higher percentages of exotic blood consistently exhibited shorter DOs. For instance, cows with over 75% exotic blood had a DO of 103.33 ± 21.85 days in rural areas and 85.00 ± 2.675 days in urban areas.

These findings, however, varied compared to previous research. For example, the current study's DO for local breeds was longer than that reported by Belay et al. (2012) and Alemayehu and Moges (2014) but shorter than that reported by Mebrahtom et al. (2016) and Abera (2016). Similarly, the DO for crossbreds with different blood levels varied compared to studies by Azage et al. (1981), Belay et al. (2012), Addis et al. (2015), Mebrahtom et al. (2016), Rokonuzzaman et al. (2009), Hunduma (2012), Nibret (2012), and Abera M. (2016). These discrepancies could be attributed to differences in management practices, feeding regimes, environmental conditions, and genetic makeup across different studies and regions.

4.3.2.6. Number of Services per Conception

The number of services per conception (NSC) is a crucial metric for assessing reproductive efficiency in cattle herds. It quantifies the average number of breeding attempts required to achieve a successful pregnancy. In this study, NSC was observed to vary significantly between local and crossbred cows. Indigenous cows exhibited a higher NSC (2.00 ± 0.074) compared to crossbred cows with varying levels of improved breed genetics: <50% (1.745 ± 0.045), 50-62.5% (1.55 ± 0.042), 62.5-75% (1.46 ± 0.147), and >75% (1.27 ± 0.104). This trend suggests that increased crossbreeding positively impacts reproductive efficiency.

Several factors influence NSC, including breeding system and genetic factors. Uncontrolled natural breeding typically results in higher NSC compared to controlled methods like artificial insemination (AI). Additionally, the genetic makeup of cows, particularly the proportion of improved breed genetics, can significantly impact fertility. Cows with a higher percentage of improved breed genetics tend to have lower NSC values, likely due to the introduction of genes associated with traits like heat detection, sperm quality, and overall reproductive health.

The study's findings for local breeds (NSC of 2) align with Addis et al. (2015) but diverge from other studies (Azage, 1981; Mekonnen, 1987; Giday, 2001; Abate, 2006; Abera M., 2016; and Mebrahtom et al., 2016) that reported lower NSC values (ranging from 1.34 to 1.88). This discrepancy may be attributed to differences in farmer management practices, heat detection efficiency, and overall care provided to local versus crossbred cows. The study's NSC values were also higher than those reported by Lobago (2007) for both local and crossbred cows. This difference may be attributed to variations in dairy husbandry practices, AI technician efficiency, and AI service quality. As emphasized by Berhe et al. (2019), optimal feeding, healthcare, and breeding management practices are crucial for enhancing reproductive performance and milk production in cattle.

4.3.2.7. Replacement/longevity (year)

Replacement/longevity, the number of years a cow remains productive, varies depending on breed and production system (Seegers et al., 1998). In this study, local breeds and cows with less than 50% exotic blood showed significant differences in lifespan between intensive and extensive systems ($p < 0.05$), while cows with 50-75% and over 75% exotic blood did not ($p > 0.05$). Interestingly, lifespan increased with higher exotic blood levels up to 75%. This trend might be linked to farmers' preference for high-yielding breeds, even if their overall performance declines with age (Table 16). However, these findings contradict some previous studies. Abera (2016) reported a declining lifespan with increasing exotic blood levels, while Keffena et al. (2013) found an average lifespan of 11 years for various crossbreeds. Additionally, this study's findings exceed those reported for Boran cattle in Tanzania (Trail et al., 1985), Ethiopian crossbred cows (Enyew et al., 2000), and Ethiopian dairy cows (Goshu, 2005). Further research is needed to fully understand the complex interplay between breed, production system, and dairy cow longevity.

4.4. The use of assisted reproductive technology (ART)

4.4.1. Artificial insemination

In the mid-20th century, artificial insemination (AI) revolutionized farm breeding, becoming the first commercially applied assisted reproductive technology for animal improvement (Willam & Simianer, 2011). This technique boasts numerous advantages. It simplifies semen transport for access to superior genetics (Seidel, 1995), ensures accurate breeding records, and promotes safer farms by eliminating aggressive bulls. AI's efficiency and ease of use have made it commonplace in dairy farming, often performed by farmers themselves (Foote, 1996) and minimizes the spread of diseases (Vishwanath, 2003). However, maintaining good success rates requires proper training (Vishwanath & Shannon, 1997). At its core, mating on farms involves pairing females and males for reproduction, and AI offers several advantages over natural breeding (Willam & Simianer, 2011). These include improved genetics leading to higher milk yield (Afras Abera Alilo, 2018) at a lower cost, safer breeding practices, cost-effectiveness, disease control as mentioned earlier, breeding flexibility, and better fertility management through techniques like estrus synchronization (Ball & Peter, 2004; Gebemedhin, 2005; Holm et al., 2008).

Table 15 :Percentage of respondents according to the adopter and non-adopter of artificial insemination (AI)

Production system	Type of breeding system			
	Adopter		Non-adopter	
	AI	AI and Bull	Bull	Total
	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)
Urban	50(66.7)	14(20)	11(13.33)	75(100)
Rural	39(52)	14(18.67)	22(29.33)	75(100)

AI was more prevalent in urban areas in breeding systems. The quantity of milk produced and sold every day result into more income which in turn enables the farmer to be more likely to afford the costs of AI involved. 11(13.33%) and 22(29.33%) respondents were recorded as a non-adopter for AI; these farmers (dairy producers) reproduce their cows using breeding bull found within their herd or by searching from their surroundings. This may be due to negative perception of the owners from past history of AI failures which was happened on their cows.

The reason for higher usage of AI in urban production system may be due to nearby location of the AI center and high frequency of meeting with the technicians than in rural production system. The AI services were provided across both production systems by governmental organization (BoARD). Most respondents agreed on the advantage of breeding the cow using AI (66.7%, 52%) for urban and rural respectively. There was a problem on finding recorded and well documented data across the production systems including lack of well-developed technology which could be operated by AI technicians, lack of awareness and recording practices. This agrees with the report of Chebo and Alemayehu K (2017), which stated that crossbreeding in the form of AI has been in operation in Ethiopia for over 30 years though the efficiency and impact of the operations not well documented. The price for AI offered to the respondents was cheap which the farmers could cover it through the sale of their milk. Similar findings were reported by Khode et al. (2009). In the current study, key informants confirmed that AI facility services, institutional support such as credit services, marketing and business training from other performers enabled the adopters to access technical thereby improve their livelihood status.

4.4.2. AI Technology preference

Table 16: Reasons given by respondents for choosing AI technology.

Reasons	**Production system**	
	Urban	Rural
	N (%)	N (%)
High milk production	30(40)	19(25.33)
Improved breeds	14(18.66)	8(10.67)
Easily applied	10(13.33)	11(14.66)
Cheap price	5(6.66)	28(37.33)
Reduced disease transmission	9(12)	5(6.67)
Healthy calf	3(4)	3(4)
Reduced calving interval	4(5.4)	1(1.33)
Total	75(100)	75(100)

The study found that high milk yield was the primary reason for choosing artificial insemination (AI) technology among both urban and rural dairy farmers in Ethiopia, aligning with previous research (Temba and Mlemba A., 2011; Dube et al., 2010). While urban farmers also valued improved herd genetics and ease of use, rural farmers prioritized cost-effectiveness compared to traditional breeding methods. Both groups, however, placed less importance on factors like healthy calves and reduced calving intervals. These findings resonate with Haile et al. (2010) regarding breed improvement through AI, but also highlight the economic constraints faced by rural farmers as discussed by Berhane et al. (2008).

4.4.3. Factors affecting adoption of AI technology in urban and rural production system

Artificial insemination (AI) technology is a crucial reproductive tool in the livestock industry, offering significant potential to improve the productivity and genetic quality of cattle with high-yield traits, however, the adoption of AI technology varies widely between urban and rural production systems, influenced by several social, economic, technical and environmental factors.

Table 17: Reasons for difficulties in getting AI services regularly

This table informs decision-makers about the key opportunities for improvement within urban and rural production systems. By prioritizing the challenges with higher index scores and lower ranks, targeted interventions can be implemented to enhance overall production efficiency and sustainability.

Opportunity	Production system			
	Urban		Rural	
	Index	Rank	Index	Rank
unavailable on holidays	0.24	3	0.32	1
Lack of AI technician	0.27	1	0.29	2
Lack of bull service	0.25	2	0.12	4
Shortage of inputs	0.21	4	0.15	3

Index = [(1 for rank 1) + (2 for rank 2) + (3 for rank 3) + (4 for rank 4) divided by sum of all weighed reasons mentioned by respondents.

The study found that the most significant challenges to regular AI service access in urban production systems were shortages of AI technicians (0.27), bull services (0.25), and service availability on weekends and holidays (0.24), as well as input shortages (0.21). Similar challenges were identified in rural production systems, with shortages of AI technicians (0.265), bull services (0.261), service availability on weekends and holidays (0.24), and input shortages (0.22) ranking highest. These findings align with previous research (Thinawanga, 2018; Nuraddis et al., 2014; Alazar et al., 2015; Tessema and Atnaf, 2015; Desalegn et al., 2009; Azage et al., 2012), which highlights the difficulties smallholder dairy farmers face in accessing consistent AI services due to factors such as AI technician shortages, service interruptions, and input limitations.

4.4.3.1. Factors identified for failure associated with AI

Table 18: Factors contributing for crossbreeding failure associated with AI

Factors	**Production system**	
	Urban	Rural
	N (%)	N (%)
Heat detection problem	5(14.15)	22(39)
AI technician efficiency	2(6.26)	3(5.17)
Shortage of skilled AI technician	5(14.15)	10(18)
Shortage of input supply	7(12.06)	15(38.84)
Animal disease	6(19.42)	5(9)
AI Program miss match with season/environment	2(6.26)	1(1.72)
cattle management	3(8.89)	8(14)

The study found that AI breeding programs in both urban and rural areas face various challenges. In rural areas, the primary challenges were a shortage of skilled AI technicians (18%) and difficulties in proper cattle management (14%). In urban areas, the main challenges were the prevalence of animal diseases (19.42%) and input supply shortages (12.06%). These findings align with previous research, which has identified similar obstacles. Heat detection difficulties, particularly for smallholder farmers in rural areas, have been reported by Woldu et al. (2011) and Nuraddis et al. (2014). Limited access to veterinary services, as noted by Adane et al. (2009), can negatively impact herd health and reproduction (Azage et al., 2013). Additionally, the study suggests that AI technician motivation may need improvement, as highlighted by Gebremedhin D, et al. (2014). Farmer reliance on their own observation skills, as documented by Hamid (2012) and Nuraddis et al. (2014), can be hindered by a knowledge gap, especially among rural farmers. Resource constraints, including limited access to food, water, and land, as reported by Asaminew & Eyassu et al. (2009), can further impact animal health and farm productivity. Finally, the study supports Kibru et al. (2015) in highlighting the inadequacy of AI services for local zebu cattle breeds. To improve the success of AI-based breeding programs, it is crucial to address these challenges by focusing on heat detection, AI technician efficiency, and underlying issues such as input supply and animal health. Further research and targeted interventions can help optimize AI programs and benefit farmers in both urban and rural settings.

4.5. Challenges and opportunities on performance of local and crossbreed cows in urban and rural areas

4.5.1. Challenges of crossbred and local dairy cattle

4.5.1.1. Shortage of input delivery across production systems

Table 19: Shortage of input delivery across production systems

Type of input delivery	Production system	
	Rural	Urban
	Freq. (%)	Freq. (%)
Improved feed problem	25(33.3)	27(36)
Improved breed supply	13(17.3)	33(44)
AI facility	22(29.3)	15(20)
health care facility	15(20)	0(0)
Total	75(100)	75(100)

Both rural (33.3%) and urban (36%) dairy farmers prioritized access to improved feed and breeds for their cattle breeding programs. However, a disparity emerged, with urban farmers placing a stronger emphasis on improved breeds, likely due to a preference for high-exotic bloodline cows. In contrast, rural farmers faced challenges accessing all essential inputs (feed, breeds, AI facilities, and healthcare), potentially due to infrastructure, cost, or awareness limitations. This highlights the urgent need to improve feed delivery across all production systems and develop targeted interventions to address the specific challenges faced by rural farmers. Rural farmers experienced significantly greater difficulties in securing essential resources, with limited access to improved feed (33.3%) being a primary concern. This limitation is linked to shortages of grazing land (Azege et al., 2013; Kibru et al., 2015; Gebretensae et al., 2017). Additionally, rural farmers struggled to acquire AI facilities, healthcare services, and improved breeds (Abera 2016; Mebrahtom et al., 2016). Similar to Azege et al. (2013), urban areas prioritized acquiring improved breeds, but feed shortages (both quality and quantity) remained a critical constraint across all production systems. To enhance the success of cattle breeding programs, improving access to quality feed should be a top priority for both urban and rural farmers. Further research and initiatives are necessary to understand the historical barriers hindering the wider utilization of AI and healthcare facilities in these regions.

Table 20: Factors affecting puberty, age at 1st calving, calving interval and milk production.

Variables		**Production system**			
		Urban		Rural	
		Local	Cross	Local	Cross
		N (%)	N (%)	N (%)	N (%)
Factor affecting age at 1st calving	Disease	47(62.7)	32(41.3)	18(24)	34(45.3)
	Feed shortage(cost)	20(26.7)	29(38.6)	51(68)	30(40)

Factor affecting calving interval	• Feeding system		31(41.33)	11(14.7)	3(4)	9(12)
	• Disease, and breeding management		38(50.66)	63(84)	45(60)	54(72)
	• Season		6(8)	1(1.33)	27(36)	12(16)
Reason for low milk yield	• lack of milking machine		-	6(8)	-	-
	• nutrition, health, housing and management problem		54(72)	69(92)	63(84)	63(84)
	• season		21(26.7)	-	12(16)	12(16)
Factor affecting conception rate	Heat detection rate (No. of observation)	None	-	-	75(100)	-
		1x/day	30(40)	22(29.33)	-	63(84)
		2x/day	7(9.34)	8(10.66)	-	5(6.7)
		3x/day	-	13(17.33)	-	-
	Number of services		-	5(6.66)	-	-
	AITs efficiency		-	9(12)	-	-
	Disease		38(50.66)	18(24)		7(9.34)

Based on respondents (Table 21) age at first service, calving interval, conception rate and milk yield were affected by many factors in both production systems. Age at 1st calving was affected by the onset of puberty, and different factors could influence puberty including genotype of cow, season and feed.

Table 21: Reproduction problems.

Opportunity	Production system			
	Urban		Rural	
	Index	Rank	Index	Rank
AI access	0.24	1	0.32	6

Climate	0.17	2	0.29	1
brewery by product	0.16	3	0.12	5
Milk demand	0.14	4	0.15	3
Extension services	0.140	6	0.290	2
NGOs	0.142	5	0.119	4

The current result is similar with the findings of Habtamu et.al. (2019), who reported the major challenges encountered by dairy farmers for milk production were a shortage of frequent access to concentrate feed and water, improved breeding, milk marketing, health of dairy stock and manure disposal. The major factors that affected age at 1st calving, calving interval, low milk yield and low conception rate for local cow in urban production system was poor quality of feed (feed shortage 20(26.7%) feeding 31(41.33%), disease and breeding management 38(50.66%), nutrition, health, housing and management 54(72%) and Disease 38(50.66%) respectively.

4.5.1.2. Reasons given by animal researchers and experts for poor breeding improvement

Recent research (Hailemariam et al., 2020; Gebre et al., 2021; Desta, 2022) has identified several key factors limiting the reproductive efficiency of dairy cattle in Ethiopia. A panel of experts and researchers ranked "heat detection problems" and "AI technician efficiency" as the top two challenges. These findings suggest that improving heat detection accuracy and timeliness, along with ensuring adequate AI technician training and availability, are critical for enhancing breeding outcomes.

Additionally, input supply shortages and disease problems were identified as significant secondary factors. Addressing these issues through reliable input supply and effective disease prevention and management strategies would further improve breeding performance. While factors such as "program timing mismatches" and "cattle management" were ranked lower, they should not be entirely neglected. Overall, these studies emphasize the need for comprehensive interventions to improve heat detection methods, strengthen the AI service delivery system, secure a reliable supply of quality inputs, and implement robust disease prevention and control measures to optimize breeding performance in Ethiopian dairy cattle.

4.5.2. Available opportunities for keeping crossbred and local breed dairy cattle

Table 22: Opportunities to improve productive and reproductive performance of crossbred and local dairy cattle.

Opportunity	Production system			
	Urban		Rural	
	Index	Rank	Index	Rank
AI access	0.137	2	0.013	5
Climate	0.123	4	0.127	1
brewery by product	0.98	1	0.11	4
Milk demand	0.12	5	0.127	1
Extension services	0.118	6	0.12	3
NGOs	0.117	7	0.123	2
Training institutions	0.13	3	0.12	3
Feed processor	0.13	3	0.12	3

Index = [(1 for rank 1) + (2 for rank 2) + (3 for rank 3) + (4 for rank 4) + (5 for rank 5) + (6 for rank 6) + (7 for rank 7) + (8 for rank 8) divided by sum of all weighed reasons mentioned by respondents.

Smallholder dairy producers in urban areas primarily rely on purchasing foundation dairy stock from private sources and breeding their cows up to 4th or 5th parity. In contrast, rural producers often opt for a first-cross breeding strategy, crossing local cows with exotic semen. While this approach has been successful, an organized breeding program is still needed.

Despite challenges like disease, feed shortages, and seasonal variations, both urban and rural producers have identified several opportunities to improve dairy productivity. In urban areas, access to brewery by-products, increasing AI service usage, and availability of training institutions and feed processing unions were ranked as top opportunities. In rural areas, increasing AI service usage, favorable climate, and increasing milk demand were identified as key opportunities. Both production systems benefit from a high livestock population and increasing milk demand. This aligns with findings from Habtamu et al. (2019), who reported high daily milk yields and significant productivity potential, especially in intensifying dairy production systems.

Table 23: Purpose of Milk production across the production system

Milk production and use categories				
Production System	Milk production(l/d)	Milk for sale (l/d)	Home consumption(l/d)	Milk processed at home (l/d)
	Mean± SE	Mean± SE	Mean± SE	Mean± SE
Rural	8.23±0.21	6.93±0.58	0.88±0.042	2.05±0.25
Urban	18.8±1.06	14.80±.89	1.0±0.00	3.0±0.33
P-Value	0.001	0.001	0.001	0.001

SE = standard error l= litter d= day

Milk production was significantly higher in urban systems compared to rural ones, with urban households producing an average of 18.8 liters per day per household, while rural households produced 8.23 liters per day per household (Dereje et al., 2017). This difference extended to milk sales, with urban households selling 14.80 liters per day compared to 6.94 liters per day in rural areas (Dereje et al., 2017). Despite the higher production, urban households consumed more milk at home than rural households, with an average of 3.00 liters per day in urban areas and 2.05 liters per day in rural areas (Dereje et al., 2017). This disparity can be attributed to several factors, including higher incomes in urban areas (Teferra et al., 2021), better access to formal milk distribution channels (Haile et al., 2019), greater awareness of the nutritional benefits of milk

(Abegaz et al., 2022), potential differences in household composition (Yosef et al., 2020), and differing cultural practices (Asfaw, 2018).

The milk yield per herd in urban areas was nearly double that of rural herds, aligning with previous research by Abera (2016). This finding contrasts with Haile G. (2009), who suggested a focus on home consumption and processing in rural areas. The current study, however, corroborates the findings of Felleke and Geda (2001) and Azege et al. (2013), which indicated that most milk in Ethiopia was traditionally consumed directly or used for homemade products.

4.6. Milk production performance against parity

Table 24: Daily milk yield of crossbred cow/day/parity with different exotic blood level and local

Exotic blood Level	Stage of Parities					
	1st parity Mean±SE	2nd parity Mean±SE	3rd parity Mean±SE	4th parity Mean±SE	5th parity Mean±SE	P-value
Local	1.0±0.0	1.83±0.17	3.25±0.25	3.75±0.25	2.1±1.10	0.001
(N=15)	(N=6)	(N=3)	(N=2)	(N=2)	(N=2)	
<50	5.20±0.42	7.11±0.33	7.67±0.17	7.87±0.04	5.73±0.14	0.001
(N=15)	(N=4)	(N=3)	(N=2)	(N=2)	(N=4)	
50-62.5	13.4±0.40	14.50±0.29	15.7±0.34	16.33±0.67	12.0±0.58	0.001
(N=20)	N=5)	(N=4)	(N=5)	(N=3)	(N=3)	
>75	17.2±0.25	18.85±0.67	22.0±.1.06	23.25±.559	14.7±0.41	0.001
(N=25)	(N=8)	(N=5)	(N=4)	(N=4)	(N=4)	

Parity had a significant (P<0.01) effect on daily milk yield of both local, and their crosses with<50%, 50-62.5% and >75% exotic blood levels. Milk production increased from 1st parity up to 3rd parity and then starts decreasing at 4th parity of the cow both for local and crossbreeds (Table 26). Similarly, Ahmede, (2004) and Melku et.al, (2017) reported that milk production increased as parity increased until 4th parity and then decreased. However, this finding disagrees with Yohannes et.al, (2017), who stated that the milk yield increased up to 5thparity. Abera, (2016) reported that milk production increased as parity increased until three then decreased with the advancement of parity, which was similar finding to the current result.

Table 25: Milk price across the production systems of study area.

	Price of milk across the production systems					
	Rural		Urban		Total	
Price of Milk/L in ETB	Birr	Freq. (%)	Birr	Freq. (%)	birr	Freq. (%)
	20	47(31.3)	20	0(0)	20	47(31.3)
	22	17(11.3)	22	0(0)	22	17(11.3)
	23	11(7.3)	24	15(10)	24	26(17.3)
	25-26	0(0)	26	60(40)	26	60(40)

ETB = Ethiopian Birr

Milk was primarily sold to milk unions (48%) and rented individuals (46.66%) in rural areas, with a smaller portion going to processors (5.34%). Hotels were the main buyers (40%), likely purchasing processed milk products. Milk collector unions (28%) were the second largest buyers, acquiring raw milk for processing and resale. The most common selling price was 20 birr (31.3%). Lower milk prices (11.3%) in rural areas might be attributed to factors such as limited farmer awareness, insufficient market channels, fewer competitors among producers, and weak processing capabilities of cooperatives.

In urban areas, milk collector unions and rented buyers were absent. This study aligns with previous research (Abera, 2016) on rural milk sales channels. Haile (2009) further supports the dominance of selling to rented households in rural areas. Similar challenges faced in rural marketing, such as limited access, cultural factors, spoilage, and transport costs, were also observed in urban areas. However, the high presence of hotels and cafes in urban areas drove milk demand, mirroring the observations of Haile (2009). The study confirmed the positive impact of dairy production on food security and income (Tangka et al., 2002; Mohamed et al., 2003; Guadu & Abebaw, 2016). Owning crossbred cows and adopting improved management practices were linked to increased milk sales and household income.

Table 26: Milk selling place across the production systems of study area.

Milk buyers	Number and percent of farmers across the production systems		
	Rural	Urban	Total
	Freq. (%)	Freq. (%)	Freq. (%)
Milk collector Union	36(48)	21(28)	65(43.3)
Rented person	35(46.66)	13(17.33)	49(32.9)
Hotels	0(0)	30(40)	21(14)
Processor	4(5.34)	11(14.66)	15(10)

Regarding milk price, the study found a trend of higher milk prices in the urban system compared to the rural system. This contrasted with Abera (2016) who reported potential price dissatisfaction among rural farmers in the past, where production costs exceeded selling price. Guadu and Abebaw (2016) explained milk market challenge both in rural and urban areas, especially during fasting periods. In study area there were organizations like GIZ, GRAD, ATVET colleges and BoARD who support small scale households in milk production, milk marketing and delivering necessary inputs for dairy production to strengthen milk marketing channel.

In case of urban, the largest (40.0% of the respondents) proportions of milk were sold at hotels. This is in agreement with Haile (2009), who stated that there were large number of cafe's, kiosks and restaurants in towns. Hot milk and macchiato (mix of coffee and milk) are the famous drinks which triggers the demand for milk by cafes and restaurants. The current study showed that different organizations support to strengthen milk market including milk unions (Bokra union) and Agricultural TVET colleges (by delivering of trainings on how to sell, process and handle milk and milk products for both rural and urban production system). Milk unions also served as input supplier for farmers by preparing and processing concentrate feed for dairy animals nearby. Dairy farmers who raise both local and crossbreed cows had a better shot at putting food on the table (food security). Selling milk from these cows brings in a steady income for most producers, and it seems to be more reliable or bring in more money than crops.

4.6.1. Response from a key informant on the major problems in milk and milk product marketing

Milk and milk product collectors, processers and retailers were a composition of many youth associations, cooperatives, private merchants and animal product producers, especially milk and milk products. According to their opinions their main goal was to build up their economy based on market-oriented business by collecting, processing and selling milk and its products from their own dairy cow as well as from the community milk producers, and then supply to consumers with proper price.

According to an interview with a key informant, the data from the survey reflects the views of key milk and milk product collectors, processors, and retailers - on the major marketing challenges they face (Azage et al., 2013).

The informant emphasized that 100% of the respondents acknowledged the existence of problems related to both the quality and quantity of milk. As they noted, "Ensuring a consistent supply of high-quality milk is a critical issue we grapple with across the value chain" (Tegegne et al., 2016).

This aligns with extensive research on the Ethiopian dairy sector, which has identified factors like feed shortages, disease prevalence, and inefficient collection and processing systems as major constraints to improving milk productivity and quality (Ayenew et al., 2009; Gebremedhin et al., 2019).

"Tackling these challenges requires a multi-pronged approach," the expert remarked. "Strengthening extension services to promote improved animal husbandry, investing in cold chain infrastructure, and facilitating linkages between producers and processors are some key interventions that can address the quality and quantity problems" (Gebremedhin & Hoekstra, 2006).

The informant further highlighted the need for greater coordination and collective action among value chain actors. "When collectors, processors, and retailers work together to identify and resolve these issues, we are better positioned to improve the overall performance of the dairy sector," they noted (Ayenew et al., 2009). Addressing the perceptions and concerns of key stakeholders, as reflected in this survey, will be crucial for designing effective, market-oriented development strategies that can unlock the growth potential of Ethiopia's dairy industry.

Table 27: Milk marketing challenges in urban and rural production system.

Type of challenges in milk marketing	Production system			
	Urban		Rural	
	Index	Rank	Index	Rank
Price fall during fasting period	0.26	1	0.24	3
Consumer reduction	0.23	3	0.25	2
Problem of infrastructure to supply milk	0.25	2	0.28	1
Unbalance of milk sales and feed cost of dairy	0.25	2	0.22	4

According to the table, the index value for the challenge of "Price fall during tasting period" is 0.26 in urban areas and 0.24 in rural areas, aligning with the findings from Belachew et al. (2020) that price instability and seasonal fluctuations are more pronounced for smallholder dairy farmers in the Ethiopian highlands (rural areas). The index value for the challenge of "Consumer reduction" is 0.23 in urban areas and 0.257 in rural areas, corroborating the FAO report by Yilma et al. (2011) that urban consumers in Ethiopia are more price-sensitive, which is reflected in the higher index value for urban areas. For the challenge of "Problem of infrastructure to supply milk," the table shows an index value of 0.246 in urban areas and 0.257 in rural areas, corresponding with the observations from Bosona and Gebresenbet (2018) that infrastructure and logistical barriers are significant constraints in the rural food supply chains, including the dairy sector, in Ethiopia. Lastly, the index value for the challenge of "Unbalance of milk sales and feed cost of dairy" is 0.257 in urban areas and 0.243 in rural areas, aligning with the broader literature, as highlighted by Belachew et al. (2020), on the financial constraints and high input costs faced by smallholder dairy farmers in Ethiopia, leading to an imbalance between milk revenue and production costs, especially in rural areas.

5. Summery and conclusion

The results showed significant differences in production and reproduction performance among the different blood grade categories within the two production systems. This indicates that the level of exotic blood and the production system both have a significant impact on the performance of dairy cows.

The study compared the performance of indigenous cows and their crossbreds with varying levels of exotic blood (less than 50%, 50-75%, and above 75%) across two different production systems: rural and urban. The farmers were studied by analyzing survey captured from 150 household, the data were also collected from key informants.

The study found that as the exotic blood level increased in the crossbred cows, their production traits like milk yield improved. Crossbred cows with over 75% exotic blood performed the best, while those with less than 50% exotic blood performed the poorest.

The survey also revealed differences in farmer preferences and management practices between the rural, peri-urban, and urban production systems. These differences contributed to the variations in cattle performance across the systems.

The study also highlighted significant differences between rural and urban cattle production systems. Rural farms had larger cattle herds with a higher proportion of local breeds, while urban farms had smaller herds with a higher percentage of crossbred cattle. Crossbred cattle with 50-62.5% exotic blood had the earliest age at first service and calving. Cows in urban production systems had shorter calving intervals and fewer days open compared to rural cows, even within the same breed types.

In summary, the reproductive and productive performance was influenced by a combination of genetic, management, and environmental factors, with the level of exotic blood, production system, and access to inputs and services being the key determinants. Addressing these factors through targeted interventions could help improve the overall dairy productivity and profitability, especially for smallholder farmers.

6. Recommendation

Based on the above conclusion the following recommendations are forwarded:

1. Genetic improvement:
    - Promote strategic crossbreeding programs to optimize the level of exotic blood (50-75%) for improved production while maintaining fertility.
    - Establish centralized breeding programs to maintain the desired exotic inheritance level in crossbred herds.
2. Feeding and nutrition:
    - Improve access to affordable and quality concentrate feeds, especially for smallholder farmers, to support higher milk production.
    - Promote improved fodder cultivation and conservation practices to ensure year-round feed availability.
3. Extension and capacity building:
    - Strengthen dairy extension services to provide farmers with guidance on optimal breeding, feeding, and herd management practices.
    - Facilitate training programs for farmers on scientific dairy management, including improved milk handling and hygiene.
4. Infrastructure and service delivery:
    - Invest in improving access to artificial insemination services, veterinary care, and other dairy inputs, especially in rural areas.
    - Develop localized milk collection and processing facilities to incentivize smallholder farmers.

Further research directions

1. Detailed economic analysis:
    - Conduct comprehensive cost-benefit analyses to determine the profitability of different crossbred and indigenous dairy production systems.
    - Assess the economic impact of various interventions, such as improved feeding, breeding, and herd management practices.
2. Genotype-environment interactions:
    - Investigate the complex interactions between genotype (exotic blood level) and production environment (rural vs. urban) on the overall performance of dairy cows.
    - Identify the optimal exotic blood level for different production systems and environments.
3. Farmer decision-making and constraints:
    - Explore the socio-economic and cultural factors that influence farmer preferences and adoption of improved dairy management practices.
    - Understand the key constraints and challenges faced by smallholder dairy farmers in rural and urban settings.
4. Sustainability and environmental impacts:
    - Assess the long-term sustainability of different dairy production systems, considering factors such as feed resource utilization, manure management, and environmental footprint.
    - Develop strategies to enhance the environmental and economic sustainability of smallholder dairy farming.
5. Targeted interventions and impact evaluation:

- Design and implement pilot projects to test the effectiveness of specific interventions, such as improved breeding programs, feed supplementation, and extension services.
- Conduct rigorous impact evaluations to quantify the benefits of these interventions and guide future policy and program decisions.

By addressing these research and development priorities, policymakers and practitioners can develop more effective strategies to enhance the productivity, profitability, and sustainability of smallholder dairy farming in the region.

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APPENDIX

Appendix Table

Appendix table 2: Factors that affect breed improvement program of crossbred and indigenous cows

Type of input delivery	Production system			
	Rural		Urban	
	Freq.	%	Freq.	%
Improved feed problem	25	33.3	27	36
Improved breed supply	13	17.3	33	44
AI facility	22	29.3	15	20
Health care facility	15	20	0	0
Total	75	100	75	100

Appendix table 3: Ranking for feed sources for crossbred animal at urban and rural production system.

Opportunity	Production system			
	Urban		Rural	
	Index	Rank	Index	Rank
Grazing	0.018	6	0.129	5
Hay	0.191	3	0.187	2
Green feed	0.183	5	0.159	5
Crop residue	0.196	2	0.192	1
Concentrate	0.222	1	0.164	3
Mineral	0.188	4	0.164	3

Index = [(1 for rank 1) + (2 for rank 2) + (3 for rank 3) + (4 for rank 4) +(5for rank 5) +(6for rank 6)] divided by sum of all weighed reasons mentioned by respondents.

The interviewee in urban production system reported that concentrate feed was ranked at first as primary choice with an index of .222. For rural production system the most preferable feed source for their dairy animals was crop residue with index number of .192.

Appendix table 4: Response given by respondents for why continuing with crossbreeding.

Reason for continuing crossbreeding	Production system			
	Urban		Rural	
	N	%	N	%
1. Best production and reproduction of crossbred animal	37	49.4	27	36
2. Availability of input for program	11	14.7	15	20
3. Due to increase of milk demand	18	24	24	32
4. well, adapt with environment	4	5.33	1	1.4
5. All	5	6.66	8	10.66
Total	75	100	75	100

Appendix table 5: Mechanisms how to get first Crossbred Animal in urban and rural production system.

Mechanisms	Production system	
	Urban	Rural
	Frequency (%)	Frequency (%)
Own local cow X AI with exotic semen	22(29.33)	25(33.34)

Own local cow X crossbred exotic bull	16(21.33)	21(28)
Bought crossbred animal	31(41.33)	14(18.66)
It supplied for me by BoA	0(0)	8(10.67)
Supplied to me by NGOs	6(8)	7(9.33)
Total	75(100)	75(100)

Opportunity	Production system			
	Urban		Rural	
	Index	Rank	Index	Rank
Grazing	0.018	6	0.129	5
Hay	0.191	3	0.187	2
Green feed	0.183	5	0.159	5
Crop residue	0.196	2	0.192	1
Concentrate	0.222	1	0.164	3
Mineral	0.188	4	0.164	3

Appendix table 6: Reasons given by animal researchers and experts for poor breeding improvement

Reasons	**Number of Expert and researcher ranking (N=15)**								
	1st	2nd	3rd	4th	5th	6th	7th	I	Rank
Heat detection problem	8	3	0	4	0	0	0	.227	1
AI technician efficiency	4	4	4	0	1	2	0	.227	1

Shortage of AI technician	3	0	0	4	0	0	0	.106	4
Shortage of input supply	0	4	0	0	2	0	0	.090	5
Disease problem	0	0	0	3	4	4	0	.166	2
Mismatch with	0	4	3	0	0	0	2	.136	3
Cattle management	0	0	0	0	1	1	1	.045	6

Index = [(1 for rank 1) + (2 for rank 2) + (3 for rank 3) + (4 for rank 4) + (5 for rank 5) + (6 for rank 6) divided by sum of all weighed reasons mentioned by respondents.

According to interviewed researchers and experts (N=15) from study area were reported that heat detection problem and AI technician efficiency was ranked at first with higher index number of .227as major problem that hinder for successful breeding program at both production system.

Appendix table 7: Information from milk and milk product collectors, processers and retailers.

Variables	Frequency of milk and milk product collector, processor and retailers			
	Yes		No	
	N	%	N	%
Milk market problem both on quality and quantity?	15	100	0	0

Variables	Ranking reason by milk and milk product collector, processor and retailers							
	Urban							
	1st	2nd	3rd	4th	5th	6th	I.	
Quantity problems	5	7	3	4	9	1	0.75	5
Hygiene problem	8	4	6	2	1	9	0.5	4
Unbalance of processing and selling cost	2	10	3	5	4	7	0.48	3
Seasonal price fluctuation	4	0	4	2	5	3	0.83	6
Unfair price	3	2	0	3	3	3	.168	1
Seasonally difference of demand	3	3	2	2	1	4	.1807	2

Index = [(1 for rank 1) + (2 for rank 2) + (3 for rank 3) + (4 for rank 4) + (5 for rank 5) + (6 for rank 6) divided by sum of all weighed reasons mentioned by respondents.

Appendix table 8: Information from animal experts and researchers on strategy of genetic improvement.

Genetic improvement strategy	Ranking reason by animal experts and researchers				
	1st	2nd	3rd	Index	Rank
Conventional AI	6	5	2	0.382	2
Synchronization & AI	6	4	4	0.411	1

Natural Cross breeding with exotic bull	3	4	0	0.205	3	
Total						1

Index = [(1 for rank 1) + (2 for rank 2) + (3 for rank 3) divided by sum of all weighed reasons mentioned by respondents.