COLLEGE OF AGRICULTURE SCIENCES

DEPARTMENT OF ANIMAL SCIENCES

ASSESSMENT OF REPRODUCTIVE PERFORMANCE OF HF CROSS BRED DAIRY COWS AND ARTIFICIAL INSEMINATION SERVICES EFFICIENCY UNDER SMALLHOLDER DAIRY PRODUCTION SYSTEM IN SELECTED DISTRICTS OF NORTH WOLLO, ETHIOPIA

By

Mekonnen Worie Alemu

September, 2024

Mersa, Ethiopia

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Mekonnen Worie Alemu

A Thesis Submitted in Partial Fulfillment for the Requirements of the Degree of Master of Science (MSc) in Animal Production

Major Advisor: Tassew Mohammed (PhD)

Co- Advisor; Nurlign Mohammed (Assistant professor)

September, 2024

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THESIS APPROVAL SHEET

The thesis requires significant changes to the data analysis, the impact of cross breeding (jersey and HF), the agro ecology and districts, and, if data is available, the effect of parity should be incorporate in the analysis. The parameters examined by SAS and SPSS in the data analysis under material approaches should be mentioned in detail. The only purpose of Microsoft excel 2010 are data entry and data clearance. For additional parameter analysis, the data needs to be exported to SPSS. The paper has to be edited throughout, and the grammar will be reviewed.

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I hereby certify that I have supervised, read and evaluate this thesis titled “ASSESSMENT OF REPRODUCTIVE PERFORMANCE OF HF CROSS BRED DAIRY COWS AND ARTIFICIAL INSEMINATION SERVICES EFFICIENCY UNDER SMALLHOLDER DAIRY PRODUCTION SYSTEM IN SELECTED DISTRICTS OF NORTH WOLLO, ETHIOPIA” by Mekonnen Worie prepared under my guidance. I recommend the thesis be submitted for oral defense.

Tassew Mohammed (PhD) ……………………… ……………………………..

Advisor’s Name Signature Date

Nurlign Mohammed (Assistant professor) ……………………… ……………………

Co-Advisor’s Name Signature Date

DECLARATION

This is to certify that this thesis entitled ASSESSMENT OF REPRODUCTIVE PERFORMANCE OF HF CROSS BRED DAIRY COWS AND ARTIFICIAL INSEMINATION SERVICES EFFICIENCY UNDER SMALLHOLDER DAIRY PRODUCTION SYSTEM IN SELECTED DISTRICTS OF NORTH WOLLO, ETHIOPIA submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in Animal production to the Graduate Program of College of Agriculture Sciences and Department of Animal Sciences, Woldia University by Mekonnen Worie is an authentic work carried out by him. The matter embodied in this project work has not been submitted earlier for the award of any degree or diploma to the best of our knowledge and belief.

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STATEMENT OF THE AUTHOR

I hereby, declare that this thesis is my authentic work and that all sources of materials used for this thesis have been appropriately acknowledged. The thesis has been submitted in partial fulfillment of the requirements for an advanced M.Sc. degree in Animal production at Woldia University and is deposited at the university library to be made available to borrowers under the rule of the library. I soberly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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ABBREVIATIONS OR ACRONYMS

AFC	Age at First Calving
AFS	Age First Service
AI	Artificial Insemination
AIT	Artificial Insemination Technicians
ANOVA	Analysis of Variance
ANRS	Amhara National Regional State
CCI	Calving to Conception Interval
CI	Calving Interval
CR	Conception Rate
CRFS	Conception Rate First Service
CSA	Central Statistical Agency
CV	Coefficient of variation
DA	Development Agent
EC	Ethiopian Calendar
FAO	Food and Agriculture organization
GLM	General Linear Model
GOV	Governmental Organization of Ethiopia
HH	House Hold
IBC	Institute of Biodiversity Conservation
ILRI	International Livestock Research Institute
MASL	Meter Above Sea Level
NRR	Number of Response Rate
NSPC	Number of Service per Conception
SAS	Statistical Analysis Software
SD	Standard deviation
SE	Standard error
SPSS	Statistical Package for Social Science
SIDA	Swedish International Development

ABSTRACT

This study was conducted to assess the reproductive performance of HF cross bred dairy cows, artificial insemination service efficiency in urban and peri-urban areas of selected districts of North Wollo, Ethiopia. The study involved cross sectional survey, and retrospective study. The study was conducted at two production systems (peri-urban and urban). For this study, three woredas and six kebeles were selected purposively. A total of 198 respondents (119 from peri-urban and 79 from urban) were selected systematically random sampling from the six kebeles included in the study. he survey data was collected using a structured and semi-structured questionnaire whereas the retrospective study data were collected from the recorded book of the AITs centers covering the period from 2020 to 2022. The data were analyzed by using Statistical Package for Social Sciences (SPSS v.23) and statistical analysis system (SAS 9.4). The result showed that about 39.9% and 60.1% of urban and peri-urban beneficiaries, respectively, were literate. Mean herd size of crossbred dairy cows for urban and peri-urban households were 1.198± 4.4 and 1.501± 4.79, respectively. The major feed resources overall in the study area were grass hay(1st), Agro-industrial by product (2nd), crop residue (3rd) and improve forage (4th). The mean age at first service (AFS), age at first calving (AFC), calving interval (CI), day open (DO), Inter service interval (ISI)l, conception rate to first service (CRFS), number of service per conception (NSPC), and calving rate (CR) for urban and peri- urban dairy system were 24.51 ± 0.10, 26.94 ± 0.08, 34.10 ± 0.10, 36.94 ± 0.08, 12.12 ± 0.04, 14.21 ±0.30 months,70.27 ± 0.09, 83.14± 0.11, 24.34 ± 0.18, days, 64.79 ± 0.11, 64.33 ± 0.09 percent, 1.4 ± 0.05, 1.75 ± 0.04 numbers, and 55.5 ±0.12, 55.49 ± 0.1percent respectively. Both year and production system exerted significant ($p<0.05$) effect on AFS, AFC, CI, ISI, CRFS, and NSFC. Whereas year and season had significant effect ($P<0.05$) on CRFS and CR The overall reproductive performance of dairy cows in the current study was below the optimal level. Crossbred dairy cows in peri-urban systems had lower reproductive performance compared to urban. In the present finding the dairy farmers were able to heat detect their cows/heifers based on physical observing estrus signs namely, swollen red vulva (16.28%), mounting (15.1%), clear mucus discharge (20.81%), restlessness (15.84%), bellowing (15.84%) and loss of appetite (16.13%). time of insemination (1st), shortage of AITs (2nd), heat detection practices (3rd), Management practices (4th), lack of AIT skill (5th), farmer awareness (6th), a long distance from the center (7th), infertility (8th), shortage of AI inputs /semen and nitrogen (9th), and diseases and parasites (10th,. were the major constraints hindering AI service delivery system in the study area. therefore, *concluded that the reproductive performance of crossbred dairy cows in the area should be improved through appropriate heat detection, improved feeding system, introduction of proper data recording system, improved level of husbandry, and improved capacity of AI technicians.*

Keywords*:-Artificial Insemination determinants, Artificial Insemination efficiency, Crossbred dairy cows (HF X Zebu), Production systems, Reproductive performance*

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1. INTRODUCTION

1.1 Background and Justification

Ethiopia has the largest indigenous livestock population in Africa. The total cattle population of the country is estimated to be about 70.29 million constituting of male (43.78%) and female (56.22%) and 97.4% alone accounted for local breeds and remaining as exotic breeds (0.3%) and cross bred cows (2.3%) as reported by (CSA, 2022). Despite the large livestock population, the contribution of the Ethiopian livestock sector in general and the dairy sector, in particular, is below its potential at both the national and household level due to poor animal productivity, the low genetic potential of animals, and the prevalence of animal diseases, feed shortage in terms of quantity and quality which are considered as the major factors that hinder sustainable development of the livestock sector in Ethiopia (FAO, 2018). The reproductive performance of the breeding female is probably the single most important factor that is a pre-requisite for sustainable dairy production system and influencing the productivity. Crossbred is an animal that having best reproductive performance and AI service efficiency compared to indigenous animal, which mainly due to recombination and hetrosis effect. Genetic improvement of indigenous breeds is possible by way of selective breeding and/or strategic crossbreeding, some effort has been exerted to date to improve any of the indigenous breeds (Azage *et al.,* 2012). Increase in milk yield in the F1 generation (50% exotic blood level), compared with local stock, crossbreed females reach age of puberty (age at first service) at a much younger age and also calved at younger age than their local herd mates.

In Ethiopia, genetic improvement of indigenous breeds through crossbreeding and upgrading, and the accelerated production of crossbred cows from farmers' indigenous breeds through artificial insemination (AI) started more than 40 years ago following the establishment of the National Artificial Insemination Center (NAIC). However, the number of improved breeds in the country is still too small to transform the current subsistence-based smallholder dairy system to market-oriented commercial dairy production and boost milk production to meet current and predicted future domestic demands (CSA, 2019). Currently, however, NAIC distributes semen to nine sub-centers: two in Oromia (Nekemt and Asella), two in SNNP (Wolaita and Wolkite), two in Amhara (Bahir Dar and Dessie), two in Tigray (both in Mekele), and one in Harari (Harar). These places are selected for their strategic locations and all the semen is sent on request to the

Regional Agricultural Bureaus, which are responsible for distributing liquid nitrogen and semen to sub-centers in their respective regions (Zelalem, 2014). At the end of 2016, additional four semen production and processing centers were established regionally at Bahir Dar, Nekemt, Hawassa, and Mekele using Holstein Friesian bulls imported from the Netherlands and Jersey young bulls recruited from South Africa. These regional AI centers are established to coordinate the AI service delivery at their respective regions, and input supply systems.

Reproduction and productivity of cross breed dairy cattle are believed to be higher than that of local zebu, but the performance status of different exotic blood level crossbreed and local dairy cows in different farming system of Ethiopia highland both in production and reproductive traits are not well under stood. However, there are limited and not well organized systematic under the smallholder dairy farmers in the country as a whole including urban and peri-urban area of North wollo area. It is, therefore, important to generate relevant information on reproductive performance of crossbred dairy cows and efficiency of AI service, which are instrumental for the profitability of dairy production. Accurate evaluation of the reproductive efficiency of the already introduced Holstein Frisian Crossbreds in different production systems of the study area is essential for the development of appropriate breeding strategies. The information generated from the current study can assist to formulate pertinent strategies towards dairy development in the study area.

1.2 Statement of the Problem

The major problems were lack of specific information on the various production systems, lack of information on reproductive performance of the various breed types (local and different exotic crosses) under the different production systems. For the research to be effective and to meet the need of the farmers, identification of problems and understanding of the existing dairy production, reproductive performances and artificial insemination (AI) services efficiency in the study area is vital to devise appropriate development interventions. Currently, the major cattle breeds kept by farmers in the study area are local (Zebu) animals, unidentified indigenous animals and local (Zebu) Friesian crossbreed.

AI application is success throughout the developed world, while the success rate in Ethiopia is still low. However, under current study area there was no conducted or there was no documented information on reproduction performance of crossbreed and AI service efficiency and its determinants success or failure. Therefore, the study was used as a bridge to give information on the study area from crosses breeds under the different production systems (peri-urban and urban). For this research, to be effective and to meet the need of the farmers, understanding the existing reproductive performance of cross breeds, CR and its determinants were a crucial issue in the study area to advise appropriate development interventions. Therefore, this study was conducted to assess reproductive performance of crossbreeds, AI efficiency and its determinants by searching the AI determinants that affect reproductive performance and AI efficiency in Meket, Gubalafito and Raya Kobo districts, Ethiopia.

1.3 Objectives

1.3.1 General objective

- To assess the reproductive performance of cross breed dairy cows and artificial insemination services efficiency under smallholder dairy production system of in study areas

1.3.2 Specific objectives

- To assess the reproductive performance of cross breed dairy cows in the study areas
- To evaluate the efficiency of artificial insemination services in the study area
- To know smallholder dairy farmers' knowledge about estrus manifestations as a reason for AI services
- To assess the major constraints that influence efficiency of artificial insemination services in the study areas

1.4 Research Questions

This study tries to answer the following questions;

- How was the reproductive performance of cross breed dairy cows in the study area?
- How was the efficiency of AI services in selected dairy cows in the study area?
- What were the most common estrus signs observed by the dairy cows during the heat period?
- What were the major factors that affect the efficiency of AI services in the districts?

2. LITERATURE REVIEW

2.1 Reproductive Performance of Crossbred Dairy Cattle

The ultimate goal of dairy industry is to operate an economically efficient production system and this depends up on high reproductive efficiency of the cow. Reproductive efficiency is defined as a measure of the ability of a cow to conceive and maintain pregnancy when it is served at appropriate time in relation to ovulation Evelyn, 2001 Poor fertility decreases the profit margin due to loss in milk yield, cost of replacing culled cows and decreased calf sale per cow (Stoat *et al.*, 1999). According to Haileyesus (2006), reproductive performance is trait of outstanding importance in dairy cattle enterprises. The size of the calf crop is all important for herd replacement and the production of milk depends heavily on reproductive activity. Possible genetic improvement in almost all traits of economic importance is closely tied to reproductive rate. Reproductive traits describe the animal's ability to conceive, calve down and suckle the calf to weaning successfully (Davis, 1993) These traits are important since they affect the herd size and off take.

The reproductive performance of breeding female is probably the single most important factor influencing herd/flock productivity. This is so because, all forms of output (milk, meat, traction, wool and hides) depend on it, and it is the determinant of output, which varies mostly between flocks/herds within a population (ILCA, 1990). Therefore**,** reproductive performance influences efficiency of milk production, rate of genetic progress in both selection and crossbreeding programs (Mukasa *et al.*, 1991)

Reproductive efficiency of cattle is measured mainly by considering parameters such as age at first service, number of service per conception and conception rate (Mukassa, 1989). Gaines (1989) also indicated that, first service pregnancy rate, and inter-service interval (ISI) are used to evaluate the efficiency of AI service and the reproductive performance of dairy cows.

2.1.1 Age at first service (AFS)

Age at first service (AFS) is the age at which heifers attain body condition and sexual maturity for accepting service for the first time (Giday, 2001). AFS signals the beginning of the heifer's reproduction and production, and influences both the productive and reproductive life of the female through its effect on her lifetime calf crop. Studies on reproductive performance of Holstein Frisian (HF) cows and their crosses (HF x Zebu) conducted under different production systems in Ethiopia demonstrated that, the overall mean value for AFS ranged from 22 to 28 months. According to Belay *et al.*, (2012) the mean AFS for (HF x Zebu) crossbred cows in Jimma town was 24.3.

Table 1 AFS of HF×Zebu cattle in urban and peri-urban areas of Ethiopia

Breed type	Production system	Months	Location	Source
HFXZebu	Peri urban	25.8±3.9	Asella town	Hunduma (2012)
	Urban	24.9±3.8		
HF X Zebu	Peri urban	22.6±0.3	Mid-rift	Chalchissa *et al.*, (2014)
	Urban	20.6±0.2	valley	
HF X Zebu	Peri urban	25.4±8.2	Jima town	Belay *et al.*, (2012)
	Urban	24.30±8.2		
Hf X zebu	Peri urban	24.3±0.9	Gondar town	Nuraddis *et al* (2011)
	Urban	23.2±0.8		

FH = Frisian Holstein

2.1.2 Age at first calving (AFC)

Age at first calving (AFC) marks the beginning of cow's reproductive cycle. It is the period between birth and first calving and influences both the productive and reproductive life of the female, directly through its effect on her lifetime calf crop and milk production

Table 2 AFC of FH ×Zebu cattle in urban and peri-urban areas of Ethiopia

Breed type	Production system	Months	Location	Source
HF X Zebu	Urban	32.1±0.16	Ziway	Giday (2001)
HF X Zebu	Peri-urban	35.8±4.2	Asella town	Hunduma (2012)
	Urban	34.8±4		
HF X Zebu	Per- urban	40.3±7.5	Addis Ababa	Mekonen *et al.*,
	Urban	39.2±7.5	milk shade	(2010)
HFX zebu	Peri-urban	33.5±0.8	In and around	Nibret
	urban	32.4±0.7	Gondar	(2012)
HF X zebu	Urban	36.50±1.64	Jimma town	Belay *et al.*,*(*2012)

FH = Frisian Holstein

2.1.3 Calving interval (CI)

The gap between two successive calving is called calving interval (Mulugeta and Belayeneh, 2013). The overall mean, crossbreed cows calving interval was shorter and better than local cows (Mulugeta and Belayeneh, 2013) in North Shoa zone. Calving interval is an important factor in measuring the breeding efficiency and directly correlates with the economics of milk production. Reproduction in dairy cows with regular and shorter calving interval (365-420 days) is a key feature for the rapid multiplication of the breeding stocks. The long mean calving intervals result into low calf crop and low level of production.

Table 3 Means (± SE) of reproductive traits in breed

AFC= Age at First Cervices; CFSI = Calving to first services interval; CCI = Calving to conception interval; NSC = Number of service per conception; DALC= Days after last calving.

Breed	AFC (months)	CFSI (days)	CCI (days)	NSC	Source
FH X zebu	34.5(±0.5)	220(±6.9)	257(±9.2)	1.58(±0.05)	Tiwari *et al.,* (2013)
FH X zebu	-	-	428.11b±64.32	1.5b±0.3	Niraj *et al.,* (2014a)

2.1.4 Days open (DO)

An increase in the number of days between calving and conception (De Vries, 2005), also known as days open, is typically associated with reduced profitability in dairy cows. This reduction is partly caused by factors such as increased breeding cost, increased risk of culling and replacement costs, and reduced milk production (De Vries, 2005). On the other hand, (Hailemariam and Goshu, 1996) reported a mean DO of 151±13 days for the Fogera breed which was significantly lower and (Niraj *et al.,* 2014a) reported DO of indigenous cow 148.33a±38.44 and HF-cross breed 93.11b±43.87. (Giday, 2001: Ababu, 2002) reported 215 days and 250 days of DO for highland and lowland zebu cows, respectively.

2.1.5 Inter service interval (ISI)

Inter service interval (ISI) is the number of day’s between two successive inseminations. According to Gaines (1989) for a well-managed dairy farm 60% of the cows should have

ISI lying within the range of 18 to 24 days. ISI is a reproductive index used to determine the efficiency of AI service and the reproductive performance. ISI may be obtained by recording the interval between successive inseminations of the same cow provided that the cow has not been served and that the second insemination was successful (Gebergziabher *et al*., 2003). Mean ISI of 29.2 and 25.1 days was reported for Fogera cattle and for F_1 Friesian x Zebu heifers by Fikru, (1994) and Alberro, (1983) respectively .On the other hand, Mekonnen *et al*., (2010), Samsson (2001) and Gebergziabher *et al*., (2003) reported higher ISI values of 33.5, 39.8 and 49.1 in and around Arsi-Negel, around Addis Ababa and Bako Agricultural Research Centre for the same breed, respectively. This high ISI may be related to the fact that either fertilization did not take place, even though the cow was in estrus, or fertilization did take place, but the embryo failed to survive or the cow was not on heat when served. If estrus detection is accurate, the inter-service intervals should be either 18 to 24 days or 38 to 45 days and at least 60% of second estrus should be in these intervals. If not then the presumption is that at least one of the two cycles was incorrectly detected or early embryonic death has occurred (Gebregziabher *et al*., 2003). Longer ISI were associated with improper heat detection, missed or silent heat, the presence of ovarian cyst or embryonic mortality, climate (higher ambient temperature) and nutritional factors (Mekonnen *et al*., 2010). Therefore, this indicates that depending on the management followed and other genetic and non-genetic factors, determination of the inter-service intervals will serve as a guide to improve the herd reproductive efficiency.

2.1.6 Conception rate to first service (CRFS)

The conception rate to first service (CRFS) is the percentage of females actually pregnant after first breeding or the ratio of animals confirmed pregnant at the first service to the number of cows bred (Mekonnen *et al*., 2010). CRFS is a reproductive index used to determine the efficiency of AI service and the reproductive performance of the herd. The recommended conception rate to first service ranges from 45-60% (Gaines, 1989 It is a measurement that combines the effect of semen quality, fertility of the cow, timing of insemination, semen handling and insemination techniques as well as factors such as high environmental temperature and stress (Nebel, 2005). The CRFS for crossbred dairy cows in Ethiopian central high lands ranged from 41.9% to 44.7% (Yoseph *et al*., 2003). Mekonnen *et al*., (2010) reported that out of 168 first inseminated heifers/cows; pregnancy to first service was 34.5% in and around Arsi-Negelle. Emebet

(2006) reported that the overall mean CRFS for crossbred dairy cows in commercial farm in Dire Dawa was 45.9%. Similarly, Samsson (2001) and Belachew, (2003) reported 46.7 and 46.6% CRFS for crossbred dairy cows in and around Addis Ababa and Abornesa ranch respectively.

2.1.7 Number of services per conception (NSPC)

Number of services per conception (NSPC) is the number of services (natural or artificial) required for successful conception (Giday, 2001). It is calculated by dividing total number of services by total cows pregnant. The number of inseminations required to produce a live calf is one of the most useful parameters of reproductive efficiency, which mainly depends on the breeding system used. NSPC expresses the fertility level of the dairy herds. It is higher under uncontrolled natural breeding than hand-mating (Mukassa, 1989. Many factors contribute to the difference such as poor heat detection skills of farmers and improper timing of AI service whereas cows mated naturally conceive earlier because bulls have a natural advantage of stimulating estrus activity and detecting heat in cows. Though several studies estimated NSPC in Ethiopia, the results are variable due to various reasons. Nuraddis *et al*., (2011) reported mean NSPC of 1.29 for crossbred dairy cows in North Gondar town. A comparable value of 1.56, 1.62 and 1.73 NSPC were reported by Belay *et al*., (2012), Gebeyehu *et al*., (2005) and Demeke *et al*., (2004) for crossbred dairy cows in Jimma, Andassa ranch and Holetta Research Center, Ethiopia, respectively. However, Emebet (2006) reported higher mean NSPC of 2.2 for crossbred cows in commercial farm in Dire Dawa. NSPC greater than 2 is regarded as poor (Mukassa, 1989). On average, crossbred dairy cows kept in urban and peri-urban areas of East Africa conceive after 1.6 to 2.6 services (Mukassa *et al*., 1991). These values are higher than the minimum value of 1.3 NSPC recommended in the tropics. According to Cassell (2001), heritability values of NSPC is low and most of the variation is attributable to environmental factors such as quality of semen, skill of the inseminator, proper time of insemination and cows related factors. Management, nutrition and climate conditions may also affect the success of insemination or services (Melaku *et al*., 2011).

Table 4 NSPC of different cattle breeds in Ethiopia

Breed type	Production system	Months	Location	Source
HF X	Peri-urban	1.97±0.07	Zeway and its	Yifat *et al*., (2009)

Zebu	urban	1.67±0.03	surrounding	
HF	Peri-urban	1.40±0.03	Alage agricultural college	Haile (2014)
HF X Zebu	Urban	1.52±0.9	Asella town	Hunduma (2012)
HF X Zebu	Peri-urban	1.5±0.09	Gondar	Nibret (2012)
	Urban	1.4±0.01		
HF X Zebu	Peri-urban	1.29±0.02	North Shewa	Belayneh (2012)

2.1.8 Calving rate (CR)

Calving rate (CR) is defined as the number of calves born per 100 services (Evelyn, 2001). From biological point of view, calving rate is the most appropriate measure of fertility (Peters and Ball, 1995). Similar to other measures of reproductive efficiency, calving rate is influenced by several factors which included environmental, genetic, disease and management factors (Mukassa, 1989). The same author also reported that calving rate of Zebu cattle is generally low. Emebet, (2006) revealed that the overall mean calving rate of crossbred dairy cows in different dairy production system in Dire Dawa was 63.4%.

Table 5 Reproductive traits of crossbred dairy cows (HF X Zebu)

AFC= Age at First Calving; NSC= Number of Service per Conception; CI= Calving Interval.

Town/ City	Location	AFC (months)	CCI (days)	NSC (no)	CI (days)	Source
Ziway	Urban	31.9	130	1.62	406	(Yifat *et al.*, 2009)
Fitche	Urban	-	186	1.60		(Fikrie *et al.*, 2007)
B/dar and Gondar	Urban	46.0		1.9	555	(Ayenew *et al.*, 2009)
Addis Ababa	Peri-urban	-	177	1.7	456	(Gebeyehu *et al.*, 2007)
Holetta	Urban	36.7	154	1.7	462	(Yoseph *et al.*,2003)
Dare-Dawa	Peri-urban	36.2	218	2.2	534	(Emebet and Zeleke, 2008)
Addis	Urban				-	(Lemma and

Ababa		33.2	176.8	2.0		Kebede, 2011)
Holetta, Stell	Peri and Urban	39.2	148	1.8	446	Tadesse *et al.*, 2010)

2.2 Artificial Insemination (AI)

Artificial insemination (AI) or the introduction of semen in the female genital tract using instruments is the first generation of reproductive biotechnologies which was feasible in cattle. It is a process by which sperm is collected from the male, processed, stored, and artificially introduced into the female reproductive tract for conception (Temesgen *et al.,* 2017). Semen is collected from the bull, deep-frozen, and stored in a container with Liquid Nitrogen at a temperature of minus 196 degrees Centigrade and made for use. Artificial insemination has become one of the most important techniques ever devised for the genetic improvement of farm animals. It has been widely used for breeding dairy cattle as the most valuable management practice available to the cattle producer and has made bulls of high genetic merit available to all (Temesgen *et al*., 2017).

2.3 History of artificial insemination in Ethiopia

In Ethiopia, genetic improvement of indigenous breeds through crossbreeding and upgrading, and the accelerated production of crossbred cows from farmers' indigenous breeds through artificial insemination (AI) started more than 40 years ago following the establishment of the National Artificial Insemination Center (NAIC). However, the number of improved breeds in the country is still too small to transform the current subsistence-based smallholder dairy system to market-oriented commercial dairy production and boost milk production to meet current and predicted future domestic demands (CSA, 2019). In Ethiopia, AI was introduced in 1938 in the northern part of Ethiopia, which was interrupted due to the Second World War and restarted in 1952 (Yemane *et al.,* 1993). It was again discontinued due to unaffordable expenses of importing semen, liquid nitrogen, and other related inputs requirement. In 1967 an independent service was started in the then Arsi Region, Chilalo Awraja under the Swedish International Development Agency (SIDA). The first AI center in the country is Asella Artificial Insemination Center (AAIC), which was established in 1972 by Chilalo Agricultural Development Unit (CADU) with ten Friesian bulls imported from abroad to collect semen. This indicates that Ethiopia started crossbreeding activity far behind its neighboring Kenya where formal breeding started in 1903 with the establishment of the government-owned dairy experimental farm and AI was introduced in 1935. In the country, the national artificial insemination service mainly focuses on cattle to boost milk production and uses exotic and local semen as appropriate. Exotic semen includes Friesian and Jersey, while the indigenous include Fogera, Horro, Boran, and Begait (Azage *et al*., 2016).

2.4 Artificial Insemination Efficiency from Regular AI Services

Table 6 CRFS in some parts/regions of Ethiopia (HF X Zebu)

Note = CRFS Conception rate for the first service

Site of research done	CR (%)	Sources
Amhara	64.6	Kassahun *et al*., (2020)
Oromia	72.6	Kassahun *et al*., (2020)
SNNP	58	Kassahun *et al*., (2020)
Tigray	52j2	Kassahun *et al*., (2020)
At national level	27.1	Dessalegn *et al*., (2009)
Tigray	32.08	Ashebir *et al*., (2016)
SNNP (Siltie zone)	48.1	Hamid (2012)
Bahir-dar	13.7	Adebebay *et al*., (2013)
Amhara	20.3	Dessalegn *et al*., (2009)
North West of Ethiopia (Fogera Woreda)	32.07	Tewodros *et al*., (2015)

2. 5 Conception Rate of Hormone Treated Dairy Cows/heifers

According to all authors (Destalem, 2015; Tadesse, 2015; Bainesagn, 2015; Samuel, 2015), there had been high variation between conception rates under the action research and the regular extension services. The average conception rates across regions were 39.3% and 59.2% under the regular service and research conditions, respectively. However, conception rates of estrus synchronized and inseminated cows/heifers did not show considerable variation among breeds. In the Amhara region, conception rates of hormone-treated and inseminated Holstein Friesian, Jersey crosses, and local cows/heifers were 70.4%, 78.2%, and 71.5%, respectively, (Samuel, 2015). Similarly, the conception rates of Holstein-Friesian, Begait local, and non-descript local cows/heifers in the Tigray region were 38.4%, 39.7%, and 37.7%, respectively, (Destalem, 2015). In the SNNP region, exotic crosses had also a higher (68.4%) conception rate than local cows/heifers (53.3%). However, in the Oromia region, the local cows/heifers had a higher (77.4%) conception rate than the exotic crossbred cows (68.8%) (Bainesagn, 2015), some authors (Destalem, 2015; Bainesagn, 2015) reported that, conception rate of hormone-treated and inseminated cows/heifers affected by the skill of AI technicians, bull efficiency and age of cows.

Table 7 Oestrous response and CR from estrous synchronization

NB: OR Oestrus Response; CR Conception Rate

Studied site/area	OR (%)	CR (%)	Source
Ethiopia	82	83.3	Merga *et al.*, (2005)
Bahir-Dar	89.3	13.2	Adebebay *et al.*, (2013)
Fogera districts	98.9	31.29	Tewodros *et al.*, (2015)
West Shoa zone	72.3	52.29	Bainesagn *et al*., (2015)
Sidama zone of SNNP	90	58.4	Debir (2015)
Hawassa Dale Milk shed	97.7	57.7	Azage *et al.*, (2012)
Tigray	97.5	78.2	Alemselam *et al*., (2016)
Central Tigray	84.9	37.95	Destalem (2015)
Adigrat Milk shed	100	61.7	Azage *et al.*, *(*2012)
Wukro Kilte Awulaelo	92.17	32.17	Girmay *et al*., (2015)
Mizan Aman	63.64	24.69	Tegegn and Zelalem (2017)

2.6 Estrus Sign Detection and Behavior in Cattle

Worldwide some reports indicate a low rate of service in artificially inseminated cattle, mainly due to problems in the detection of estrus. While few cows are detected in heat losses occur in significant herd reproductive efficiency and commitment of the artificial insemination program. This commitment is even higher in Bos indices cattle, whose breeding behavior has special features of the heat of short duration with a high percentage of expression during the night (Costal, *et al.*, 2012). The cow is a non-seasonal polyestrous animal. The estrous cycle is on average 21±3 days. The different stages are pro-estrus (18 to 20 days), estrus (0 days), met-estrus (1 to 5 days), and di-estrus (6 to 17 days of the cycle) of the estrous cycle. Three distinct patterns are observed during estrus including male like mounting, rise in spontaneous activity, and mating responses. Secondary behavioral sign observed before real standing heat includes, frequent urination, separation from herd, chin resting, back rubbing, nervousness, restlessness, walking along fences, bawling, aggression, arching of the back, loss of appetite, and sudden drop in milk production. Other supportive signs include licking, sniffing, head lift, lip curling, and Lehman's reaction (up curling of lips by female or male after touching the genitalia of raged animal). Physical signs of estrus include the tumefaction of the vulva; reddening of the vulva (bright cherry pink color) and excess mucus discharge and tone in the uterus. Closeness in animals coming into heat usually congregates and form small groups of three to five animals called sexually active group (SAG). It is easy to detect heat if sexually active groups exist in the herd. The period of receptivity lasts for 18-24 hrs. A bloody discharge at the cessation of behavioral estrus usually indicates a missed heat.

According to Jane *et al.,* (2009) standing heat can occur any time in 24 hours. However, the most likely time for a cow or heifer to show heat signs is at night but the season of the year can influence this, with more cows showing heat at night in hot weather and more showing heat during the day in cold weather. Hot weather, high production, crowded conditions, and high-stress environments may reduce mounting activity. Observers must distinguish among cattle coming into heat, in standing heat, and going out of the heat. Females that are in standing heat, were in standing heat yesterday, or will be in standing heat tomorrow are the most likely herd mates to mount other cows or heifers in heat (Jane, *et al.,* 2009).

2.7 Factors Affecting Reproductive Performance of Dairy Cows

Reproductive performance of dairy cows is influenced by several factors, which included genotype, nutrition and management.

2.7.1 Genotype

In Ethiopia crossbreeding exotic sire with indigenous dams has been practiced with encouraging results, apparently better conception rate and less number of services per conception for crossbreds compared to local breeds (Haileyesus, 2006). The F_1 crosses can produce up to three fold milk yield, and have longer lactation and shorter calving intervals than the local breeds (Tadesse and Tadelle, 2003). According to Azage (1981) crossbred cows required fewer (0.12 and 0.24) numbers of inseminations per conception than local breed cows in the highland and lowlands of Ethiopia respectively. The same author indicated that, Zebu cattle exhibited less intensive symptoms of heat and remained in estrus for shorter period than temperate breeds may be the reason for poorer CR and NSPC of local cows. However, a strictly controlled breeding program has not been practiced and there has been no complete dairy herd recording scheme at national, regional and even at districts level (Tesfaye, 1990). From the 65.35 million cattle populations of Ethiopia, only 1.92% is crossbreds and 0.32% is exotic dairy cows (CSA, 2019). The draft policy of Ethiopia livestock development master plan recommended that the blood level of exotic animals to be from 50-62.5% to avoid adaptation related problems. However, the current crossbreeding work in Ethiopia, unfortunately, is not based on a clearly defined breeding policy with regard to the level of exotic inheritance and the breed type to be used.

2.7.2 Effect of nutrition

Environmental factors especially nutrition, determines pre-pubertal growth rates, reproductive organ development, onset of puberty and subsequent fertility. Substantial evidence revealed that dietary supplementation of heifers during their growth will reduce the interval from birth to first services and calving probably because heifers that grow faster cycle earlier and express clear estrus, which results in more economic benefit in terms of sales of pregnant heifers and/or more milk and calves produced during the lifetime of the animal. In general, low fertility rates of cattle in the tropics compared to temperate regions are probably related to environmental differences including inadequate nutrition, prevalence of diseases and parasites as well as the interaction between genotype and environment (Mukasa, 1989). According to Saha *et al*., (2014), management and environmental factors account for 96% of the variation in conception rates. The remaining 4% of variation in conception rates is due to genetic factors with 3% for the cow and 1% for the service bull. Factors associated with a negative energy balance have been suggested as causes of reproductive failure. Heifers fed inadequate amounts of energy reach sexual maturity later. Lower conception rates and an increased incidence of silent heat have been considered to be the results of energy deficiency (Otter by and Linn, 1981). Among minerals, phosphorus has been most commonly associated with decreased reproductive performance in dairy cows. Inactive ovaries (anestrus) and delayed sexual maturity and low conception rates have been reported when phosphorus intake was low.

2.7.3 Effect of management

According to Yoseph *et al*., (2003), management factors such as accuracy of heat detection, timing of insemination, proper insemination techniques, semen quality, proper semen handling and skills in pregnancy diagnosis have been reported to decrease the NSC. Gebeyehu *et al., (*2007) added that proper heat detection; feeding and postpartum reproduction management may reduce NSPC. Furthermore Emebet (2006) and Habtamu *et al*., (2010) revealed that the changes in management system and environmental condition from year to another year delays age at first service and calving.

Mekonen *et al*., (2010) and Gebergziabher *et al*., (2003), indicated that ISI is affected by poor management practice such as improper heat detection, missed or silent heat, the presence of ovarian cyst or embryonic mortality, climate (higher ambient temperature) and nutritional factors. Possible causes of low conception rates at first service may fall into different categories: problems related to heat detection: not servicing a cow that is in heat, Improper timing of service, misidentification of cows leading to errors in records; Problems related to artificial insemination.

2.8 Factors Affecting Efficiency of Artificial Insemination

2.8.1 Interrupted AI service delivery

According to many authors (Alazar *et al.,* 2015; Nuraddis *et al.,* 2014; Tessema and Atnaf, 2015), most smallholder dairy farmers in many places of Ethiopia expressed no/low satisfaction for AI services delivery systems. The most important reason for this was smallholder dairy farmers had not got the service regularly (without interruption) due to unavailability of AITs, discontinuation of the service on weekends and holidays, and lack of inputs (Azage *et al*., 2012; Nuraddis *et al.,* 2014; Alazar *et al.,* 2015; Tessema and Atnaf, 2015). In addition, the absence of incentives and rewards to motivate AI technicians had contributed to a very high turnover of AI technicians all over the country (Azage et *al*., 2012). Some farmers have to move their cows for long distances in search of AI services. This is happening in many areas and the reason is AI technicians are unable to get transport facilities like motor bicycles, fuel, etc. AI is known to be a time-dependent activity, in which during this long journey/waiting time, the heat period is passed away before the service has been given (Alemayehu, 2010).

2.8.2 Appropriate time of heat detection and time insemination

In Ethiopia, heat detection has been performed and reported to AITs by dairy cattle owners during observing signs of heat like mounting on other animals, vulva discharge, bellowing, swelling, redness, and mucus discharge of the vulva, restlessness, and nervousness (Nuraddis *et al.,* 2014). Hamid (2012) reported that observation of the estrus signs and bringing the animals for AI solely rests on dairy cattle owners. However, Woldu et *al.,* (2011), indicated that smallholder farmers are engaged in various farm activities, and is quite difficult for them to detect the proper time of heat. The dairy owners could detect the heat time but it might not match with the appropriate time of insemination. This leads to the heat period of the cows and heifers passing away before the AI service have been given or an inappropriate time of insemination that causes failure to conception.

Furthermore, Alemayehu (2010) revealed that, since AITs are unable to get facilities and services like motor bicycles and fuel, farmers trek their cows for long distances (more than 28 km round trip) to fetch for AI service. In contrast, Azage *et al.,* (2016), indicated that cows that show heat are reported to the AI technicians by the owners and the technicians usually visit the farm to inseminate the cow. Knowledge of estrus behavior and the estrus to ovulation interval is essential for estimating the best time to artificially inseminated cattle. According to Tegenu and Feyera (2016), Heat detection is basic to reproductive success in artificially bred herds.

Table 8 Showing proper timing of insemination

Source: (Tegenu and Feyera, 2016)

Cow show estrus	Should be inseminated	To be late for a good result
In morning	The same day	Next day
In afternoon	Moring of next day or early afternoon	After 3 pm the next day

2.8.3 Shortage of AI technicians and low efficiency

In Ethiopia, AI is undertaken by one or two AI technicians at the districts level. They are mainly providing services for dairy cows in urban and/or peri-urban areas. Little or no AI services are available in rural areas (Azage *et al*., 2016). According to Khan, (2008), the site of semen deposition has been an important factor in the success of AI in cattle accurate placement is important for achieving good conception rates. Faulty insemination technique is the major factor causing low conception rate in many herds accurate insemination to detail, a clear understanding of reproductive anatomy, and the ability to identify the target area and properly position the insemination road.

2.8.4 Semen handling and insemination technique

Animals showing signs of true heat should inseminate using frozen semen thawed at 37^0C for 30 seconds. Typically, of the 20–30 million sperm that are required in each insemination dose, 6-7 million survive freezing, which is generally regarded as the minimum dose compatible with acceptable fertility. Regarding depth and time of insemination, (Morell, 2011) recommends that very deep insemination can enhance sperm delivery. However, the site of insemination was found to make only small increases in sperm per egg. Deep insemination should be used only when the sperm dose is below the threshold, or if sexed semen is being used. Also, hygiene, thawing methods, temperature maintenance between thawing to insemination do play a factor in achieving pregnancy (Morrell, 2011). Rectal palpation and ultrasound examinations should be considered safe procedures when performed correctly, and recent evidence does not indicate that ultrasound examination is detrimental to the embryos.

2.8.5 Factors related to management

Fluctuation in the season which affect the availability of feed, high environmental temperature, and other environmental factors, cause stress and the challenge of high disease risk in cross breed cows that contribute to the high number of services per conception, late age at first calving, and first service, and longer calving interval. Therefore, energy status is generally considered to be the major nutritional factor that influences reproductive performance. Nutrition affects the quality of follicles, oocytes, and embryos (Funston, *et al*., 2009)), briefly described blastocyst formation as a key developmental process in the growth of an embryo. Dietary intake and diet type can alter the expression of transcripts of genes involved in early embryo development. Nutrient requirements for optimum follicle growth and embryo development may be quite different. Hence, the importance of diet around the time of mating and in particular the significance of extreme underfeeds post-mating in regulating pregnancy rate becomes evident. According to (Xu *et al*., 2010), reported that the peak of embryo death occurs during the first month of pregnancy and controlled feed intake is important to reduce the mortality of embryos. Housing conditions can also affect the distribution of heat during 24 hours. Estrous behavior expression at any housing arrangement that allows cattle to interact throughout the day provides more opportunity for mounting and standing behavior to be expressed which enables to identify estrous cow easily.

2.8.6 Factors related to the cows health

Post-partum problems including endo merits have been reported to harm fertility i.e. first service conception rate is poor and primiparous cows have higher conception rates than older cows under the use of two timed breeding protocols (Rahim, and Asghar, 2007). High reproductive efficiency is dependent on obtaining normal uterine involution, early resumption of ovulation, high efficiency of estrous detection, and high conception rates per service (James, *et al*., 2009). The presence of uterine infection prolongs uterine involution and resumption of ovulation. Some evidence indicates cows suffering from metabolic disorders, like milk fever, may have a higher incidence of reproductive disorders and lower conception rates (Rahim, and Asghar, 2007).

2.8.7 Factors related to dairy cows breed

Negative energy balance (NEB) is indicated by a loss in BCS (body condition score) because the cow has mobilized body fat stores to meet the energy demand for milk production in early lactation (Culmer, 2012). The interval after calving to first ovulation has been demonstrated to be longer in primiparous cows than multiparous cows. This relationship is associated with greater nutritional deficiency being imposed on younger cows due to the requirements for growth other than lactation. In a recent finding, under good management, the first ovulation after calving in primiparous cows was delayed as compared to multiparous cows (Tanaka, *et al*., 2008). The use of AI as a tool to enhance production efficiency in cattle (Holm *et al.,* 2008) and the successful use of artificial insemination (AI) as a means of animal breeding relies upon three major premises: firstly, that spermatozoa can survive outside the body; secondly, that they can be reintroduced into the female genital tract in a way that results in an acceptable conception rate and thirdly, that the fertile period of the female can be identified (Manabí, 2011).

3. MATERIALS AND METHODS

3.1 Description of the Study Area

The study was conducted in Meket, Gubalafito and Raya Kobo districts which are located in North Wollo Zone of the Amhara National Regional State.

3.1.1 Meket districts

Meket is one of the districts of North Wollo Administrative Zone. It is situated at an altitude ranging from 1458-2990 meters above sea level and has area cover age of 142, 567.93 ha. The minimum and maximum daily temperatures of the area are 17^0 and 28ºC, respectively. The livestock populations were accounted as bovine, 160,906, from these 1,377crossbreed, ovine, 81,843, Caprine, 79,518, equine, 19,314 and poultry, 108,707 from these 64,494 crossbreed (Meket woreda livestock office, 2022).

3.1.2 Gubalafito district

Gubalafito is one of the districts of North Wollo Administrative Zone. It is situated at an altitude ranging from 1700-2300 meters above sea level and has area coverage of 90,049 ha (CSA, 2022). The farming system in the area is mixed type (crop- livestock production). The area receives an average annual rainfall ranging from about 990 to 1030 mm. The minimum and maximum daily temperatures of the area are 21^0 and 25ºC, respectively (Gubalafito Agriculture Office, 2022). The major crops grown in the area are wheat, barley, teff, sorghum and maize (Gubalafito Agriculture Office, 2022). Based on the (CSA, 2022), a survey of the land in this districts shows that 41% is arable or cultivable, 15% pasture, 18% forest or shrub land, and the remaining 26% is considered degraded or other and has 34(rural = 21, peri-urban = 10 and urban = 3) kebeles. This district has a total population of 172,818, of whom 87,027 are men and 85,791 women and 22,635 or 10.7% and 15,975 or 7.55% are peri-urban and urban inhabitants were reported respectively. The livestock population of the area is estimated to be bovine, 199,524 from these 1344 crossbreed, ovine, 39537, Caprine, 39369, equine, 28616 and poultry, 149,035 from these 2909 crossbred (Gubalafito Livestock Resource Office, 2022).

3.1.3 Raya Kobo district

Kobo is one of the districts of North Wollo Administrative Zone. The districts are located at altitude ranging from 1552 to 3535 m.a.s.l. Its area coverage is about 200,157 ha (CSA, 2022). The average annual rainfall is 1270mm and also the minimum and maximum daily temperatures of the area are 10^0 and 32ºC, respectively (Kobo

Agriculture Office, 2022). The farming system in the area is mixed type (crop- livestock production). Based on the (CSA, 2022) this district has a total population of 301,102, of whom 151,541 are men and 149,561 women; 22,635 or 10.7% and 15,975 or 7.55% are peri-urban and urban inhabitants were reported respectively. Based on the (CSA, 2022), a survey of the land in this districts shows that 47% is arable or cultivable, 14% pasture, 13% forest or shrub land, and the remaining 26% is considered degraded or other and has 44 (rural = 37, peri-urban 4= and urban = 3)kebeles. The livestock population of the area is estimated to be bovine, 123,440 from these 1586 crossbreed, ovine, 79,217, Caprine, 11,471, equine, 24,904 and poultry 88,439 from these 7680 crossbred (Kobo Livestock Resource Office, 2022).

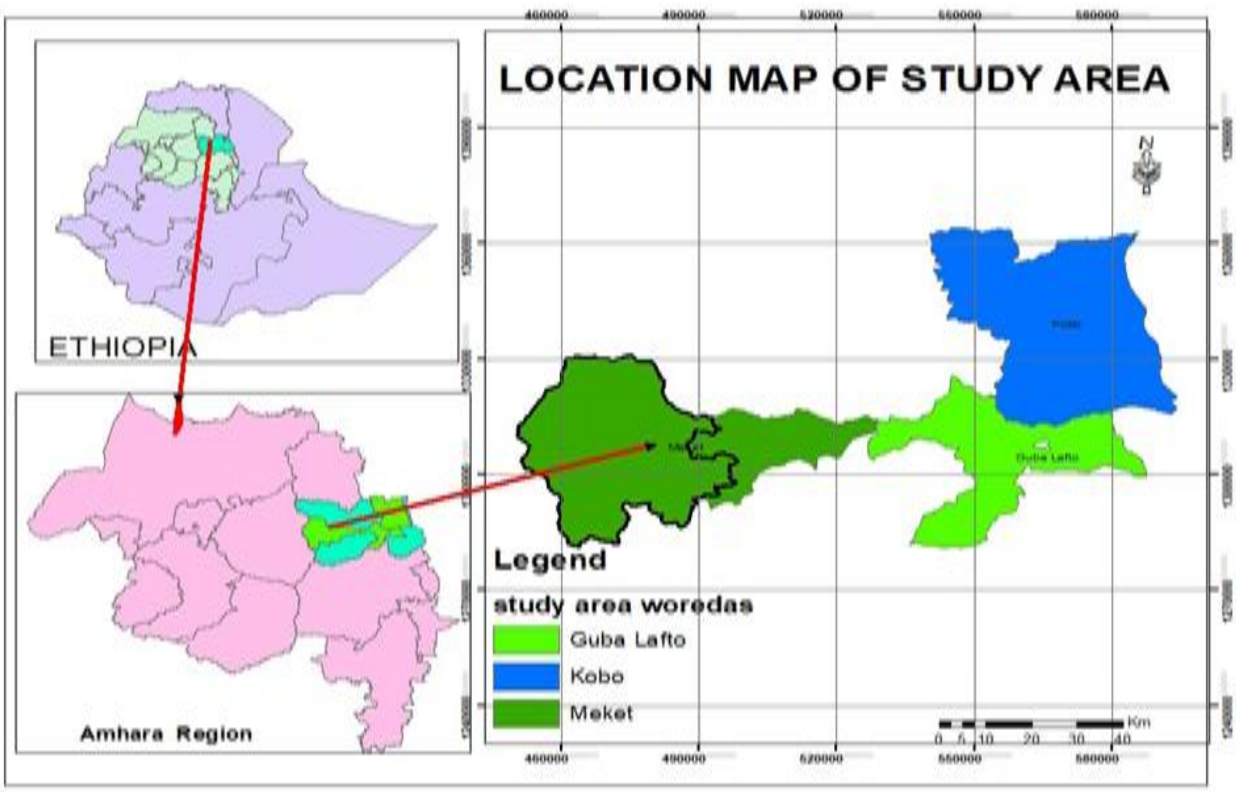

Figure 1 Map of the study area

3.2 Study Population

The study populations was conducted from 198 HHs in both production systems (peri-urban = 119 HHs and urban =79 HHs), and from a total number of 2296 Artificial Inseminated crossbreed dairy cows and/or heifer (HF X Zebu) which were taken from recorded retrospective data from AITs offices.

3.3 Sampling Size and Sampling Technique

This research work involved survey and retrospective study to evaluate the reproductive performance of crossbred dairy cows and artificial insemination service efficiency. During this research, systematic random sampling, stratified and purposive sampling methods was applied. Meket, Gubalafito and Raya Kobo district were selected purposively based on the availability of long lasted artificial insemination service, infrastructures, and population of crossbred dairy cows. The study area was further stratified in to urban and peri-urban dairy production systems. In this study, peri- urban dairying refers to the production systems located at the outskirts of the town at approximately 10 km radius from the municipality boundary of the city. Whereas, urban refer to keeping of dairy cows within the town.

A list of households with Holstein Frisian cross bred animals were taken from urban and peri-urban livestock development offices for urban and peri-urban production systems respectively. From the list collected, households possessing herd record were identified. After all smallholder dairy farmers were properly registered, a systematic random sampling technique is applied to choose at 198 respondents in selected six kebeles by giving proportional chance for those farmers with different cattle number, cattle management system, infrastructures, access of AI services.

The sample size was calculated by using 15% - 20% of the AI user at the study site, according to the formula given by Roberts (Roberts, 1985).

N = 15%-20% x n; Then, 20% *990 (from recorded data at different woredas) = 198

Where;

- ✓ N= number of sample size
- ✓ n= Number of all AI beneficiaries in the 3 years (from July 2020 to July 2022)

Based on this formula, the recorded data of retrospective from AITs office shows that the total numbers smallholder dairy farmers in the consecutive 3 years (from July 2020 to July 2022) were found 198 smallholder dairy farmers, thus 20 % of these AI beneficiaries were taken for sample size determination as follows: 990 x 20% = 198, thus 198 smallholder dairy farmers were included in the study areas. Therefore, based on recorded of retrospective data the contribution of sample size from each districts were in Meket (64) out of 320 AI users, Gubalafito (78) out of 390 AI users and Raya kobo (56) out of 280 AI users, according to their proportions.

Data on retrospective study were collected from each selected districts livestock resource office AI service center, which was the only center for both urban and peri-urban production systems in the area. The records used for the analysis covered the period 2020 to 2022. A total of 3835 AI service records were used for analysis of the number of service per conception (NSPC), while 2296 were used for the estimation of conception rate at first service.

Table 9 Sample size of inseminated dairy cows from retrospective data

Breeds	Age (years)			Production systems		Total number of cows
	3-5	6-8	>9	Peri-urban	Urban	
HF X Zebu	612	912	772	769	1527	2296
Total	612	912	772	769	1527	2296

3.4 Data Collection Methods

In each of the study kebeles two types of data collection methods was applied. First, crossbreed dairy cow owner farmers were discussed in groups on what they considered as most important regarding breeding objectives and selection decisions. General information about household characteristics, cattle holdings and performances of crossbreed dairy cow was generated from crossbreed dairy cow owner farmer groups and individual interview. A total of six ‘kebele’ were selected, which were found in (Meket) two kebele (64), (Gubalafito) two kebele 78), and (Kobo) two kebele (56) were selected; based on their proportion households who owned crossbreed AI cows, a total of 198 household were selected purposively. Livestock population were taken from reviewing different documents like credible reports, Central Statistics Agency of Ethiopian reports, files, books, journals, published and unpublished thesis and articles, government policy and national artificial insemination center documents, livestock research institutes and other sources that have been written about the study area.

3.5 Cross-Sectional Survey

A cross-sectional survey was carried out across the three districts, for the primary and secondary data collection. Structured and semi-structured questionnaires survey were developed and pre-tested to check for its appropriateness and clarity of the questionnaires on key informants. During the interview process, every respondent included in the study was briefed about the objective of the study before presenting the actual questions. Then the questions were presented to the respondents and farmers were convinced to come for the meetings at their respective houses for few days before the actual dates of interview conducted. Then after, the adjusted questionnaire was administered to the sampled households to collect information on the following attributes, such as main focus on feed resource availability, breeding constraints, and health, cross dairy breed reproductive and production performances for each interviewing owner of dairy cow households. Moreover, information on livestock structure, function for delivery of improved genetics (AI); feed availability reproductive performance, AI service efficiency and constraints for formal household's interview, development agents were used as enumerator. The enumerators were trained and practiced interviewing each other to ensure that they correctly understood each question and administer the interview. They were also supervised by the researcher throughout the survey period.

3.6 Methods of Data Collection

3.6.1 Field survey

A field survey was conducted on 198 AI beneficiary households by using systematic random sampling techniques from 990 AI users; Meket (64), Gubalafito (78), and Kobo (56), from both production systems (urban =79 and peri-urban =119) on reproductive performance and major determinants that influence the success of AI efficiency in the study area based on recorded data/information from AITs. The questionnaires are administered by a team of enumerators recruited and trained for this purpose with close supervision of the researcher. Pertinent data were collected on dairy cattle production systems, management practices, reproductive performance, reproductive management, efficiency and effectiveness of AI service and its constraint in the study area. Key informants' were selected purposively and interviewed to enrich the data reliability. The key informants were each kebele administrators (1), livestock experts (1), health experts (1), and AITs (1) who know the general situation about the study context and program. Totally in the districts, 24 key informants' were involved. Focus group discussions (FGD) were also used to verify the information given by individual farmers during the survey and to grasp an important issue. Twelve members (two in each kebele) focus group discussions were arranged. FGDs included livestock experts (1), health experts (1), AITs (1), youths (1), women group (1), and innovative/model farmers (3) (in each kebele) and were organized with eight members in a group. The group members were selected purposively based on their better position related to especially AI services. Totally in the districts, 48 members were involved.

3.6.2 Retrospective study

In the retrospective study, pertinent data were collected from AI certificates and inseminator's record book from each selected districts livestock resource office of AI service center and record book of the dairy HHs for both urban and peri-urban areas.

Data recorded from 2020 up to 2022 were used for the study. Meanwhile, only cows with complete information were included in the analysis (3835 crossbreed dairy cows). From this recorded data, the following parameters were estimated:

- Age at first service (AFS) was determined by computing average age of heifers when they have got AI service for the first time
- Age at first calving (AFC) was determined as the difference between the date of birth and the date of first calving of heifers.
- Inter service interval (ISI) was obtained by determining the interval of days between two successive services.
- Conception rate at first service (CRFS) was estimated as the percentage of cows/heifers that become pregnant at first service.
- Number of services per conception (NSPC) was determined as the number of services required for successful conception.
- Calving rate (CR) was determined as the proportion of the number of calves dropped to the number of cows mated per year.

3.7 Data Management and Statistical Analysis

Qualitative and quantitative data from the cross-sectional survey, and retrospective data, which were collected in the local language (Amharic), were translated and data were cleaned, edited, coded, and entered into Microsoft Office Excel 2010. The same software was used for data edition, management, computation of percentages, frequency and presentation of results in the form of charts and tables. Data was transported to and analyzed using the descriptive statistics of statistical package for social sciences (SPSS version 20.0, 2007) software and The General Linear Model (GLM) procedure of Statistical Analyzed (SAS, 2013) Version 9.4 software was used for analysis of men and men separation was done using DUNCAN multiple test.

Model 1. Retrospective Study

$$Y_{ijkl} = \mu + B_i + k_j + L_k + e_{ijkl}$$

Where:

yijk= dependent variables (NSPC, ISI, CRFS , AFS, AFC, CR) of cow in i[th] production system, j[th] year of insemination and calving, k[th] season of first service conception rate.

- ✓ µ = the overall mean
- ✓ B_i= the effect of the i[th] production subsystem (i= 2; urban and peri-urban)
- ✓ K_j = the effect of the j[th] year (j= 3; 2020, 2021 and 2022)
- ✓ L_k = the effect of k[th] season (k=2; Rainy and Dry season)
- ✓ E_{ijkl}= random residual error

Conception Rate (%) = $\frac{\text{No.of cow or heifers Pregnant}}{\text{No.of cows or heifers inseminated}} \mathbf{X100}$

4. RESULT AND DISCUSSION

4.1 Socio-Economic Characteristics of the Respondents

The household characteristics of the respondents were shown in Table 10, of these 198 respondents, about 169 (85.3%) were male while 29 (14.7%) were female. This result was disagreed the report of Haile A, (2014), in Hawassa city with the value of 70% and 30% for males and females, respectively. The difference might be due to the level of the low ratio of single once in the study area. The majority of the household head were found in the age group of 46-60 years old 107 (54.1%) followed by 30-45 years old 64 (32.3%), >60 years old 25 (12.6%), and <30 years old 2 (1%). The overall mean family size per household in the study area was 4.93 ± 1.48 and 5.02 ± 1.461 in urban and peri-urban areas, respectively. The overall family size in both production systems was 4.99 ± 1.465. The average household size observed in this study was in lined with that reported by (Azage T, *et al.,* 2013), who was reported a mean family size of 4.9 in Yirgalem, with (Tesfaye Mengistie, 2007), who was reported an overall mean family size of 5.7 persons in Metema districts in Northwest Ethiopia whereas smaller than with that reported by Azage T, *et al.,* 2013, who was reported 7.2 in Hawassa. This variation might be due to urbanization and the level of education. The educational level of the households was assessed to reflect the level of new technology adoption. Thus, about 14.6% illiterate, 45.5% read and write, 22.2% primary school, 6.1% secondary school, and 11.6% college and above had been educated. The majority of the household head could read and write in the study areas. The percentage of illiteracy in this study was lower than that reported by Adebabay K, (2009), in the Bure districts (50%). The difference might be due to the level of urbanization and access to schools in the study area.

Table 10 Household's characteristics of the study area

Parameters		Production Systems		Overall (N=198)	P
		Peri-urban (N=119)	Urban (N=79)		
Sex (%)	Male	52.5	32.8	85.3	0.319
	Female	7.6	7.1	14.7	
Age (%)	<30	-	1	1	0.037
	30-45	19.7	12.6	32.3	
	46-60	35.4	18.7	54.1	
	>60	5	7.6	12.6	
Family size (%)	<3	10.1	7.5	17.6	0.902
	3.5	39.9	26.3	66.2	
	6-8	10.1	6.1	16.2	
Educational status (%)	Illiterate	10.1	4.5	14.6	0.000
	Read and write	35.4	10.1	45.5	
	Primary	14.6	7.6	22.2	
	Secondary	-	6.1	6.1	
	College and above	-	11.6	11.6	

4.2 Cattle Herd Size and Composition per Household Level

Average cattle holding size by production system is presented in (Table 11). The overall mean cattle holding per household in the present study was 4.65 ±1.394. Peri-urban areas had more cattle per head (4.79±1.501) than urban (4.44±1.198). The overall mean number of cross lactating and pregnant cows per household was 1.1±1.302 and 1.41±1.556 from both production systems which were agreed with reported from Adebabay K, (2009), who reported 1.45± 0.069 in the Bure districts whereas less than reported from Melku M, (2016), who reported 2.187±4.365 in west Gojam zone. This difference might be due to awareness of households to use crossbreds by crossing their local cows and urbanization. The average herd size per household of the study area was smaller due to the shortage of grazing land in which most of the available land was used to produce cash crops, expansion of settlement, and shortage of land due to population pressure. The result of the current study showed that urban and peri-urban dairy producers prefer to retain lactating (1.15±0.36, 1.07±0.251) and pregnant (1.46±0.649, 1.37±0.484) cows respectively than the rest of dairy animals. The higher number of crossbreds in the urban production systems could be due to better market opportunities for milk and milk products, availability of AI services, production system is also specialized type which was different from peri-urban beneficiaries who had additional breeds rather than milk and milk products for different agricultural activities and could be difficult for them to manage more improved cross breed animals. Therefore, introduction of crossbreds has to be supported with other interventions such as better feeding, housing, health care, and extension services in order to exploit the genetic potential of the animals and thereby improve income of dairy producers. (Azage T, *et al.,2013).*

Table 11 Average cattle herd size and composition in the study Area (N= 198)

Types of cross cattle	Dairy production system		Overall
	Peri-urban	Urban	
	Mean ± SD	Mean ± SD	Mean ± SD
Total cross cattle/household	1.501± 4.79	1.198± 4.4	1.394± 4.65
Herd structure	-	-	-
Lactating cows	1.07± 0.251	1.15± 0.361	1.1± 0.302
Pregnancy cows	1.37± 0.484	1.46± 0.649	1.4± 0.556
Dry cows	1	1.09± 0.302	1.04± 0.2
Male calves	1	1	1
Female calves	1	1	1
Heifers	1.29± 0.455	1	1.22± 0.413
Bull calves	1	1	1
Bulls	1	1	1

4.3 Dairy Production and Management Practices

4.3.1 Dairy Management Practices

In the study area, the sample size were taken from peri-urban and urban dairy production was carried out which were contributed 119(60.1%) and 79(39.9%), respectively. Urban dairy cattle production systems are seen in towns for the production and sale of milk, with little or no land resources, only making use of the human and capital resources made available mainly for specialized dairy production under stall feeding conditions (Azage T et al., 2013). Based on their location, urban producers are not foreseen 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 Y, 2003).

Peri-urban dairy systems are located mainly in rural areas or at the edge of the urban areas having relatively better access to urban centers in which dairy products are highly needed (Azage T, et al., 2013). These systems contribute enormously towards filling the large demand-supply gap for milk and milk products in urban centers where dairy products consumption is unusually very high and are known to be the leading suppliers of raw milk to the processors of different scales (Zelalem Y, et al., 2011). Urban and peri-urban systems are intensified through the use of crossbred dairy cows, purchased and conserved feed, and stall-feeding (Azage T, et al., 2010). In the survey result, the average head of crossbred cows was very high in urban than that of peri-urban dairy cattle production system and the total cattle heads which include cross and local breeds. Similarly, grazing landholding and land allocated for forages were higher in the peri-urban production system.

4.3.2 Cattle housing and facility

Cattle were often housed at night and the type of housing provided varied depending upon the classes of milking animals, agro-ecology, production system, physiological stage of dairy animals (Berhanu G, *et al*., 2013). The types of houses provided, in general, varied from roof to a simple corral/pen with no roof. In the study area, almost all respondents (88.38%) were used traditional or free housing systems whereas 11.62% who had modern barn without individual cattle pen. A free stall with a feeding trough was commonly employed in the study area. From the total interviewed households, 22.73% of respondents were kept their cattle under the same barn with a human house while 77.27% of households housed their cattle in a separate house shown in Tabl 12. This result was higher than Teka F‘s (2015) results reported for respondents kept their cattle in a separate house (11%) This result was also contradicted with Melku M, (2016), who reported housing attached with the residing/open house in peri-urban (5%) and urban (1.67%) in selected districts of West Gojam zone. This variation might be due to agro-ecology, dairy farmer awareness, and production systems. The purpose of housing in the study area was to protect cattle from enemies, from extreme weather conditions, and feeding management. According to the respondents, the closed house was dominants in highland districts due to protect the animals from cold weather. Facilities of the cattle house play an important role to offer the dairy cows clean feed and water within the house. The result indicated that 72.73% of the farmers had feed trough, 13.13% had both water and feed trough, 4.04% had water trough and 10.1% had no facilities in the barn as shown in Table 12. This result was contradicted with Teka F, (2015), who was reported 22% have fed through, 5% have water trough, 47% have both feed and water trough and 28% have no facilities in Aleta Chukko districts, Southern Ethiopia. In the study area, both feed trough and water trough were available at the same place only in the urban production system 13.13%. This difference might be due to production systems, infrastructures, level of income, and dairy owner’s awareness. The floor of the house was compacted soil

(79.29%) and concrete (20.71%) shown in Table 14. This indicated that farmers in the current study area might have a good option and understanding about livestock production and also there may be a good provision of training and extension advice. Dairy producers in group discussions (FGD) told that the major problems of dairy farms in urban areas of selected districts regarding housing were lack of sufficient space to grow some homestead forages and to remove dairy waste disposals and lack of financial capacity for expansion of their dairy farm. Unlike urban systems, space was not a major problem in the peri-urban dairy production system. There was a significant difference in all parameters across the production systems except dairy housing system. The difference might be due to the level of urbanization/ infrastructures, the income of the dairy owner, delivery of extension services, and dairy awareness.

Table 12 Housing system of dairy cattle in the study area

Parameters		Production systems			P
		Peri urban (N=119)	Urban (N=79)	Overall (%)	
Type of housing	Traditional barn (free stall with closed)	112	63	88.38	0.000
	Modern barn without individual cattle pen	7	16	11.62	
Housing system	The same house with households	43	2	22.73	0.424
	Separate house from households	76	77	77.27	
Types of floor	Hardened soil	109	48	79.29	0.000
	Concrete	10	31	20.71	
Type of roof	Rainy proof	119	79	100	
	Not rainy proof	-	-	-	
Facility house	No facility	19	1	10.1	0.000
	Feed through	100	44	72.73	
	Water through	-	8	4.04	
	Both feed and water through	-	26	13.13	

4.3.3 Feed resources and feeding system

In the study area, the quantity and quality of feed resources for the livestock varied with season and production systems. The total interviewed household respondents revealed that grass/hay (1^{st}), crop residue (2^{nd}), improved forage (3^{rd}), and IBP /agricultural industrial by-products (4^{th}) in peri-urban production while grass/hay (1^{st}), crop residue (3^{rd}), improved forage (4th) and IBP /agricultural industrial by-products (2rd) in urban production in the districts. Totally, the overall feed sources in the study area from both production systems was grass/hay (1st), crop residue (2nd), improved forage (4th), and IBP /agricultural industrial by-products (3rd) as shown in Table 13. This result was in lined with Teka F, (2015), who found that the major feed resource in Ethiopia is 1st grass, 2nd crop residue, 4th industrial by-products, and 3rd improved forage in Aleta Chukko districts, Southern Ethiopia from peri-urban production whereas contradicted with Misganu A, (2018) who reported natural pasture (1st), crop residue (2nd), Agro-industrial by-product (3rd) and 4th improved forage in Jimma Zone South Western Ethiopia from both production systems.

Table 13 Major Cattle feed sources in the study district

Parameters		Production systems				Overall (N=198)	
		Peri-urban (N=119)		Urban (N=79)			
		Index	Rank	Index	Rank	Index	Rank
Feed sources	Crop residues	0.27	2	0.21	3	0.247	2
	Grass/hay	0.3	1	0.31	1	0.311	1
	AIBP	0.15	4	0.27	2	0.238	3
	Improved forage	0.25	3	0.19	4	0.203	4
Total		1		1		1	

IBP/AIBP: Agro-industrial by product

The common feeding systems in the study area were communal grazing (2nd), private grazing (1st), and stall feeding (3rd) in peri-urban and communal grazing (2st), private grazing (3rd), and stall feeding (1nd) from the urban production system. The overall from both production systems was communal grazing (2st), private grazing (3rd), and stall feeding (1nd) as shown in Table14. This finding was in lined with Teka F, (2015), who reported communal grazing (1st), private grazing (3rd), and stall feeding (2nd) in Aleta Chukko districts, Southern Ethiopia from both urban production systems.

Table 14 Major Cattle feeding systems in the study area

Parameters		Production systems				Overall (N=198)	
		Peri-urban (N=119)		Urban (N=79)			
		Index	Rank	Index	Rank	Index	Rank
Feeding system	Communal grazing	0.31	2	0.34	2	0.336	2
	Private grazing	0.41	1	0.31	3	0.335	3
	Stall feeding	0.28	3	0.35	1	0.339	1
Total		1		1		1	

4.3.4 Water sources and frequency

Pond, river, and tape (pipe) water were the source of water in the study area as indicated in Table 15. From the total respondents, 52.02% of the household were used pipe water for cattle whereas a few respondents (45.45%) and 2.53% were used pond and river water as the source of water for cattle, respectively. This result was contradicted with Teka F, (2015), who reported that pipe water (5%); river (59%) and pond/well (13%) in Aleta Chukko districts and this difference might be due to access of infrastructures, level of incomes and dairy awareness In this study, the water sources are accessible at home (63.32%), < 1 km distance (5.05%), and 1-5 km distance (31.32%). This finding was contradicted with Misganu A, (2018) who reported at home (1.7%), <1 km 63.3%, and 1-5 km 35% in Jimma Zone, South-Western Ethiopia. Major dairy cattle had got water at home in the study districts due to access to infrastructure and urbanization. During the dry season most of the farmers gave water for cattle twice a day (57.07%) and 41.41% once a day while during the wet season, the frequency of watering was once a day (100%). This might be due to the consumption of green pasture which has high water content and prevailing low environmental conditions during the wet season. The result was in line with Kibru B, *et al.,* (2015), who was reported water frequency once a day during the wet season, 100%, and in the dry season, 62% of gave water twice a day in Aleta Chukko districts, Southern Ethiopia. 58.59% of the respondents revealed the absence of water shortage in all seasons of the year which was higher than Kibru B, *et al.,* (2015), who reported 48% of the respondents revealed the absence of water shortage in all seasons of the year in Aleta Chukko districts. There was a significant difference in all parameters from the different production systems. This could be due to the types of the dairy production system, season of the years, and the development of infrastructures.

Table 15 Water sources and watering frequency of dairy cattle in the study area

NR: Number of Respondents; DS: Dry season; WS: wet Season

Parameters		Production system				Overall		P
		Peri urban (N=79)		Urban (N=119)				
		NR	%	NR	%	NR	%	
Water Source	Pond	99	83.19	11	13.92	110	45.45	0.000
	River	-	-	5	2.53	5	2.53	
	Pipe water	20	16.81	83	83.55	103	52.02	
Watering distanc in km	At home	60	50.42	65	82.28	125	63.13	0.000
	< 1 km	-	-	10	12.66	10	5.05	
	1-1.5 km	59	49.58	4	5.06	63	31.82	
Frequency (DS)	Once a day	59	49.58	26	32.91	85	42.93	0.02
	Twice a day	60	50.42	53	67.09	113	57.07	
Frequency (WS)	Once a day	119	100	79	100	198	100	
	Twice a day	-	-	-	-	-	-	
Wate shortage	Yes	89	74.79	27	34.18	116	58.59	0.000
	No	30	25.21	52	65.82	82	41.41	
Season	Dry	89	74.79	27	34.18	116	58.59	
	Wet	-	-	-	-	-	-	

4.3.5 Dairy cows/ heifers reproductive problems in the study area

Out of 198 respondents in the study area with retained repeated breading 1st, fetal membranes 2nd, milk fever 3rd and abortion/stillbirth 4th in peri-urban and milk fever 1st , retained fetal membranes 2nd, repeated breeding 3rd, and abortion/stillbirth 4th were affected dairy cows/ heifers in the urban production system as shown in Table 16. The overall major health problems from both production systems were retained fetal membranes 1st, milk fever ^{2nd}, repeated breeding 3rd, and abortion/stillbirth 4th. This result was contradicted with (Abunna F, *et al.*; 2018), who were reported that retained fetal membranes (1st), repeated breeding (3rd), and abortion/stillbirth (2nd) in and around Bishoftu town from peri-urban and urban. This variation might be due to all over management practices, extension services, skills of AITs, dairy farmer awareness and access to animal health centers.

Table 16 The major animal health problems in the study area

Parameters		Production systems				Overall	
		Peri-urban (N=119)		Urban (N=79)			
		Index	Rank	Index	Rank	Index	Rank
Dairy cow health problem	Retained Fetal membrane	0.29	2	0.28	2	0.296	1
	Repeated Breeding	0.33	1	0.23	3	0.249	3
	Abortion	0.17	4	0.18	4	0.174	4
	Milk fever	0.21	3	0.31	1	0.281	2
Total		1		1		1	

4.3.6 Reasons for dairy cows culling by smallholder dairy farmers

In this study districts, culling reasons of dairy cows were infertility problem /repeated breeding (1st) less production (3rd), feed shortage (5th), disease and parasites (7th), inadequate space (6th), the financial requirement (2nd), and old age of dairy cows (3rd) in peri-urban and less production (7th), feed shortage (3rd), disease and parasites (6th), inadequate space (1st), the financial requirement (5th), infertility problem /repeated breeding (2nd) and old age of dairy cows (3rd) in the urban production system as shown in Table 17. The overall reasons for culling from both productions were less production (6th), feed shortage (1st), disease and parasites (7th), inadequate space (2nd), the financial requirement (5th), infertility problem /repeated breeding (3rd) and old age of dairy cows (4th)

The result was contradicted with Abunna F, (2018), who reported in Debre Zeit Bishoftu Town the reason for dairy cows culling could be reproductive/ infertility problems (2nd), feed shortage (4th), old age (6th), health problems (5th), financial requirement (3rd) and inadequate space (1st) and with Misganu A, (2018), who was reported reproductive problems (1s),), sickness (2nd) and productive problems (3rd), in Jimma Zone, South-Western Ethiopia. Therefore, the main reason for culling in the study area was due to inadequate space in urban different activities such as, forage development, housing and to avoid wastage from the dairy site and infertility problem was occurred in peri-urban production due to management problems, heat detection practice and time of insemination.

Table 17 Reason for culling dairy cows in the study area

Parameters		Production systems				Overall (N=198)	
		Peri-urban (N=119)		Urban (N=79)			
		Index	Rank	Index	Rank	Index	Rank
Culling reasons	Less production	0.14	3	0.11	7	0.124	6
	Feed shortage	0.13	5	0.14	3	0.175	1
	Disease and parasites	0.11	7	0.12	6	0.118	7
	Space problem	0.12	6	0.16	1	0.159	2
	Financial requirements	0.15	2	0.13	5	0.136	5
	Infertility	0.17	1	0.15	2	0.147	3
	Old age	0.14	3	0.14	3	0.141	4
Total		1		1		1	

4.4 Reproductive Performance of Crossbreed Dairy Cows

4.4.1 Age at first service (AFS) based on retrospective study

The least square mean of age at first service (AFS) in urban and peri-urban dairy production systems in the study area was summarized in (Table 18). The overall mean AFS based on retrospective data across peri urban and urban production systems were 26.94 ± 0.08 and 24.51 ± 0.10 months, respectively. The result obtained in the present study for the HF X Zebu breed was in agree with the values of 24.30±8.01, 24.9±3.8, 25.2±1.1 and 25.6 months reported by Belay D, *et al.* (2012), Hunduma (2012), Emebet and Zeleke. (2007), in Jimma, Asella, Mekele and Dire-Dawa respectively, but the current result lower than 27.5 and 30.3 months reported by Zewdie *et al.* (2011), and Aregawi (2013) for HF X Zebu breed dairy cows in Debre-Birhan, Jimma, Sebeta and in Eastern Zone of Tigray. Similarly, about 23.2 and 15.4 months of AFS were reported by Nuraddis *et al.* (2011) and Nibret (2012), in Gondar Town and in and around Gondar respectively. Age at first service for crossbreds was significantly ($p<0.0001$) affected by production system where cows in peri-urban area had longer AFS than those in urban (longer by 2.43 month). This could be attributed to better nutrition in the urban than peri urban production system since dairy cows in urban were supplemented with agro-industrial by products. Consistent with the current findings, Belayneh (2012) reported that well-fed heifers grow faster, served and conceive earlier compared to their contemporaries managed poorly. Similarly, Aregawi (2013) also reported that AFS was longer for crossbred cows in peri-urban areas than in urban areas. AFS was significantly ($p<0.0004$) influenced by year of birth. AFS was shorter for heifers born in the year 2021, and 2022 than in 2020. The variation could be attributed to progressive change in herd management such as improved feeding, housing, health, accuracy of heat detection, and reproductive management during the latter than earlier years. Heifers need to be fed adequately for better growth performance, early initiation of estrus and younger age at first service and calving. Different factors contribute to delayed age at first service. Environmental factors, especially nutrition, determine pre-pubertal growth rates, reproductive organ development, and onset of puberty and subsequent fertility (Emebet and Zeleke 2007). Evidences shows that dietary supplementation of heifers during their young age will reduce the interval from birth to first services (Azage T, 1989) probably because heifers that grow faster cycle earlier and permit easier estrus detection.

Table 18 Mean (±SE) AFS cross breed cows in the study area

Variables	AFS (months) based on retrospective study	P
Overall mean	25.96 ± 0.88	
Effect of production system		
Peri urban	26.94 ± 0.08	<0.0001
Urban	24.51 ± 0.10	
Effect of year		
2020	26.07 ± 0.11	
2021	25.43 ± 0.11	0.0004
2022	25.68 ± 0.11	

4.4.2 Age at first calving (AFC)

The overall mean for age at first calving (AFC) in this study was 35.79 ± 0.89 months (Table 19). While the least square mean age at first calving (AFC) were 26.94± 0.08 and 24.51 ± 0.10 prei-urban and urban dairy production systems in the study area respectively. This result was low compared to the reports of Aregawi (2013), Beleyneh (2012), Haileyesus (2006), and Emebet and Zeleke (2007) who reported 39.6±0.4, 39.83±0.18, 36.41±0.9, and 36.2±1.03 months, for the HF X Zebu breed in Eastern Zone of Tigray, North Shewa Zone, North Gonder Zone, and Dire-Dawa Ethiopia, respectively. However, longer values than the current finding were reported by Nibret (2012), Nuraddis *et al.,* (2011) and kelay (2002) in and around Gondar, Gondar town and Selale, and Addis Ababa with the corresponding values of 32.4, 23.1and 30.14 months, respectively. Production system had significant ($p<0.0001$) effect on age at first calving (AFC) in the study area. Dairy heifers in urban production system had shorter AFC than those in peri-urban. This could probably be due to the difference in management and feeding systems between urban and peri-urban production systems.

In the current study, the effect of year was significant ($p<0.0001$) where cows calved during the year 2020 had longer AFC than the others calved during the other years (2021 and 2022). Cows calved in the year 2021 had shorter AFC. The variation could be attributed to change in herd management and awareness of households in nutritional management of dairy cows and might be the variation of the environment on the availability of feeds. According to Hammoud *et al.,* (2010) the reduction in AFC will minimize the raising costs and shorten the generation interval and subsequently maximize the number of lactations per head.

Table 19 Mean (±SE) AFC of crossbred cows in the study area

Variables	AFC (months) based on retrospective study	P
Overall mean	35.79 ± 0.89	
Effect of production system		
Peri urban	36.94 ± 0.08	<0.0001
Urban	34.10 ± 0.10	
Effect of year		
2020	36.38 ± 0.12	
2021	35.05 ± 0.11	<0.0001
2022	35.14 ± 0.11	

4.4.3 Calving Interval (CI)

CI was significantly ($p<0.0001$) higher in peri-urban than urban production system. These were due to good management practice in urban production system than peri-urban. The result of this study showed that the calving intervals (CI) of cross breed cows were 14.05±0.03 and 12.12 ± 0.04 months for peri-urban and urban production system. While the overall mean for both production system were 13.29± 0.32 (Table 20). Year and season of calving, nutrition and age of cow are known to have significant effects on calving interval (Mukasa-M, 1989). CI crossbreed cow was comparable to the value 13.26±0.29 reportedby Zemenu Y, *et al*., 2014, for Markos urban production system. Similarly the value 406 days (13.53 months) and 446 day (14.87 months) reported by Yifat D, *et al*.,2009 and Tadesse *et al*.,2010 for Zeway urban and Holleta urban and peri-urban production system respectively. Shorter CI in crossbreed cow was reported by Ayenew A, *et al*.,2009 555 day (18.5 months) Bahir dar and Gondar urban and peri-urban production system respectively, and also Emebet and Zeleke 2017 reported that 534 day (17.8 months) CI for Dare-Dewa peri-urban production system. The current result also comparable to the value 456 day (15.2 months) reported by Gebeyehu G,*et al*,.2017 for

Adis Abeba peri-urban production system and the value 462 day (15.4 months) reported by Yoseph S, *et al.*, 2003 for Holleta urban production system. The variation observed in different study results might be due to poor management, poor feed quality, environmental difference, difficulties in estrous detection, genetic variation, and silent heat, long DO, timely insemination and difference in forage production.

Table 20 Mean (±SE) calving interval of crossbred cows in the study area

Variables	CI (months) based on retrospective study	P
Overall mean	13.37± 0.34	
Effect of production system		
Peri urban	14.21 ± 0.30	<0.0001
Urban	12.12 ±0.04	
Effect of year		
2020	13.35 ± 0.04	
2021	13.06 ± 0.04	<0.0001
2022	13.08 ± 0.04	

4.4.4 Day Open (DO)

An increase in the number of days between calving and conception, also known as days open, is typically associated with reduced profitability in dairy cows. This reduction is partly caused by factors such as increased breeding cost, increased risk of culling and replacement costs, and reduced milk production (De Vries, 2005).

DO in cross bred was significantly (p<0.0001) longer in peri-urban than urban production system. These were due to good management practice in urban production system. Days open for cross breed cow in the study area was 83.14± 0.11 and 70.27 ± 0.09 days for per-urban and urban production systems respectively (Table 21). The overall mean of DO of cross breed cows in the study area were 75.34 ± 0.98 days which was shorter than the findings of DO of crossbreed 93.11b±43.87 days (Ni- raj Kumar *et al.,* 2014). The shorter DO recorded were due to good management practice in the household level than station and differences of blood level.

Table 21 Mean (±SE) day open of crossbred cows in the study area

Variables	DO (days) based on retrospective study	P
Overall mean	75.34 ± 0.98	
Effect of production system		
Peri urban	83.14 ± 0.11	<0.0001
Urban	70.27± 0.09	
Effect of year		
2020	76.63 ± 0.12	
2021	76.64 ± 0.12	0.2807
2022	76.84 ± .12	

4.4.5 Inter service interval (ISI) based on retrospective

The mean inter service interval (ISI) based on retrospective study in urban and peri-urban areas of selected districts was indicated in (Table 22). The overall mean inter service interval (ISI) of crossbred dairy cows from the retrospective study was 25.46 ± 1.58days. The value was shorter than 39.8 and 27.8 days reported by Mekonen *et al.,* (2010) and Aregawi (2013), for crossbred cows in and around Arsi-Negelle and Eastern Zone of Tigray, Ethiopia, respectively. Year and production system had shown significant ($p<0.05$) difference on inter-service interval (ISI) in the area. Longer value for ISI was obtained in the years 2020 and 2022, which might be due to lack of awareness of beneficiaries on prior heat detection, shortage of AI technicians, lack of proper feeding, health and overall management problem in compared to the recent years. Whereas the unexpected longer value of ISI for the year 2022 in the study area could be due to the shift from conventional to estrus synchronization and mass AI (OSMAI) program. The new program was introduced and piloted in the region in 2011 through the IPMS (Improving Productivity and Market Success of Ethiopian Smallholders) project of ILRI, Amhara Agricultural Research Institute (AARI), and Amhara Regional Bureau of Agriculture. During this year, less attention was given for the regular AI service than OSMAI, which resulted in lack of attention on proper time of insemination, communication gap between AI technicians and producers, lack of service on weekends and holidays. Production system had also significant ($p<0.05$) effect on ISI. Thus, animals in peri-urban production system had longer ISI than those in urban. The reason might be due to difference in awareness and skill on heat detection, nutritional management, access to AI center and communication gap with AIT, better awareness on feeding system, health and reproductive management when compared to peri- urban areas.

Table 22 Mean (±SE) Inter service interval of crossbred cows in the study area

Variables	ISI (days) based on retrospective study	P
Overall mean	25.46 ± 1.58	
Effect of production system		
Peri urban	26.20 ± 0.15	<0.0001
Urban	24.34 ± 0.18	
Effect of year		
2020	25.24 ± 0.20	
2021	25.00 ±0.20	0.0434
2022	25.57± .0.20	

4.4.6 Conception rate to first service (CRFS) and effect of season

The overall mean conception rate to first service was 64.33 ± 0.09 and 64.79 ± 0.11 for peri urban and urban production respectively, (Table 23). The result obtained from the current study on the same breed was almost in line with the value (65%) reported by Hunduma (2012) at Asella town and 61.7% (Azage *et al.,* 2012) reported for estrus synchronized cows in Adigrat and Mekelle milk shed. But it was higher than the values 58.6% and 54.15% for the same breed in urban and rural areas of Adami Tullu and North Gondar Zone reported by Woldu *et al.*, (2011) and Haileyesus (2006) respectively. There was significant (P<0.05) difference in conception rate at first service between the production systems. And also, year had significant (P<0.01) difference on CRFS. High conception rate to first service (CRFS) was found in the years 2020 and 2022, whereas lower (CRFS) were recognized during the year 2021. This differences might be attributed to inefficiency of AI service in the study area which could be associated to several factors such as improper insemination technique, timing of insemination, accuracy of heat detection, quality of semen and proper semen handling, availability, efficiency and effectiveness of AI technicians, improper feeding, and management conditions in the earlier year. Whereas in the year 2021, CRFS was exceptionally lower than the recent year and even lower than the previous service years. The reasons for low CRFS in the year 2021was due to the shortage of AI technicians for on time insemination, communication gap with AI technicians, and lack of services on weekend and holidays as the AI technicians were engaged on synchronization programs in and out of their woredas.

This study also demonstrated that CRFS was higher (p<0.05) for cows inseminated/served during the rainy season compared to dry season. The reason for the difference between dry and rainy season in CRFS was due to availability of better quality feed and water.

According to Mukasa-M, (1989), Zebu and crossbreed cows tended to be in peak reproductive activity during the rainy season when grazing conditions and nutrient availability is optimal. However, in urban subsystem, there was as such no observed difference in CRFS between dry and rainy season. This might be due to the reason that urban beneficiaries were mostly dependent on purchased crop residue, concentrate and hay as they lack own farmland for forage, pasture and crop residue production.

Table 23 Means (±SE) CRFS of crossbred cows in the study area

Variables	CRFS based on retrospective study (n=1500)	P
Overall mean	64.52 ± 0.95	
Effect of production system		
Peri urban	64.33 ± 0.09	0.001
Urban	64.79 ± 0.11	
Effect of year		
2020	64.68 ± 0.12	
2021	61.20 ±0.12	<0.0001
2022	67.82 ± 0.12	
Effect of season on CRFS		
urban production	65.48 ± 0.00	
Rainy season	66.50 ± 0.00	<0.0001
Dry season	64.45 ± 0.00	
Peri-urban production	62.97 ± 0.00	
Rainy season	67.05 ± 0.00	<0.0001
Dry season	58.89 ± 0.00	
Over all season effect on CRFS		
Rainy season	66.78 ± 0.00	<0.0001
Dry season	61.67 ± 0.00	
Over all of both season	64.95 ± 0.00	<0.0001

4.4.7. Number of service per conception (NSPC)

The overall mean number of services per conception for retrospective study in the study area was 1.55± 0.05 and 1.75 ± 0.04, from peri-urban and urban production systems respectively as presented in (Table 24). The value obtained in both studies was consistent. The mean NSPC in the retrospective study was in line with the values 1.56, 1.6, 1.62 and 1.67 reported by Belay *et al.,* (2012), Belayneh (2012), Shiferaw *et al.,* (2003), and Yifat *et al.,* (2009) on cross breed in Jimma Town, North Shewa Zone, central Highlands, and in and around Zeway, Ethiopia, respectively. But it was lower than 1.74, 1.88 and 2.2 values reported by Aregawi (2013), Haileyesus (2006), and Emebet and Zeleke (2007) for cross breed in Eastern zone of Tigray, North Gonder Zone and in Eastern Lowlands of Ethiopia, respectively. NSPC was influenced ($p< 0.05$) by production system and it was higher for peri-urban compared to urban system. This could be due to the reason that urban beneficiaries had better awareness and skills on proper heat detection, better access for AI, better nutritional management. On the other hand, year had shown significant (P<.0001) effect on NSPC in the study area. Highest value of NSPC was recorded in the year 2020 as compared to 2021 and 2022 service years. The reason for the high NSPC was consistent with the explanation given for CRFS and ISI above.

Table 24 Means (±SE) number of service per conception in the study area

Variables	NSPC from retrospective study;(n=2296 inseminations)	P
Overall mean	1.61 ± 0.45	
Effect of production system		
Peri urban	1.75 ± 0.04	<0.0001
Urban	1.4 ± 0.05	
Effect of year		
2020	1.69 ± 0.06	
2021	1.54 ±0.06	0.0413
2022	1.49 ± .0.06	

4.4.8 Calving rate (CR)

Calving rate was defined as the number of calves born per 100 services (Peters and Ball, 1995). Furthermore, calving rate also defined as the number of calf born per cow per year. From a biological point of view, calving rate was the most appropriate measure of fertility (Peters and Ball, 1995).The overall annual mean calving rate in the current study was 55.64 ± 1.08 as presented in (Table 25). The finding of the current study was lower than 63.4% reported for crossbred dairy cows in Dire Dawa (Emebet and Zeleke, 2007) and 76.92% reported for Holstein Frisian Dairy cows at Alage Agricultural Technical vocational and educational college (Haile, 2014). The main reasons for low annual CR registered in the current study was that, in selected area there was high tendency of selling pregnant dairy animals owing to the encouraging price for pregnant animals, less follow up and profiling of AI technicians for calved cows and also abortion and still births due to different reproductive diseases had also contributing for the problem in the area. The present study also showed that year had significantly (p<0.0001) effect on annual calving rate. Significantly different value of CR was found in the year 2022. The results suggested that the annual calving rate of the herd improved from the earlier year to the recent year. This could be the result of change in management over the years. However, production system did not influence CR. Even though there was still problem with follow up of AI technicians on parturition, accurate pregnancy diagnosis, monitoring of pregnant cows/heifers and farmers problems with the overall dairy management, there is an improvement of annual calving rate in the study area from the year 2020 up to 2022.

Table 25 Mean (±SE) annual calving rate of dairy cows in the study area

Variables	Calving rate (n=769 birth)	P
Overall mean	55.64 ± 1.08	
Effect of production system		
Peri urban	55.49 ±0.1	0.968
Urban	55.5 ± 0.12	
Effect of year		
2020	50.8 ± 0.14	<0.0001
2021	55.09 ±0.14	
2022	60.58 ± .0.13	

4.5 Response of Heat Sign Detection under Dairy Smallholders

The awareness of the smallholder about estrus sign detection in the present study indicated that were detected cows/ heifers by observation of physical signs. In the present finding, the dairy farmers were able to detect their cow in heat based on physical estrus signs namely, swollen and red vulva (16.28%), mounting (15.1%), mucus discharge (20.8%), restlessness (15.84%), bellowing (15.84%) and loss of appetite (16.13%) from both production systems as shown in Table 26. This result was higher than previous studies such as Milkessa G, (2012), who reported mucus discharge (10%), bellowing (4.6%) and restlessness (3.1%) in and around Ambo town whereas contradicted with Riyad J, *et al.*, (2017), who was reported mount other cows (41.4), bellowing (20.6), vulva discharge (12.6), in appetence (9.5) and restlessness (15.9) in and around Tullo districts West Hararghe. There was also disagreed with another previous study Binayew T, *et al.*, (2017), who reported mounting of the cow on another animal (23%), vulva discharge (12.5%), mounting and vulva discharge (35.8%), bellowing (1.7%), restlessness (2.5%), swollen red vulva and frequent urination (0.8%) and all above-mentioned estrus sign (7.5%) in and around Ejere and by Belete Y, *et al.*, (2018), who reported vulvar mucus discharge (26.6%), standing in heat (24.3%), mounting on other cows (21%), bellowing (16.7%) and restlessness and in-appetence (11.4%) in and around Bishoftu. The above-mentioned variation might be due to the health of cows, dairy awareness, and regular follow-up of heat detections practices. The common heat detection practices under smaller dairy farmers in the study were clear mucus discharge, swollen/redness of the vulva, and in appetence. There was a significant difference in all estrus signs. This could be due to production systems, awareness of dairy owners, cow's health, types of shade and regular follow up of heat detection practices, the season of the years/ hot or cold environment.

Table 26 Dairy cattle owners' knowledge about specific estrus signs

Signs of Estrus	Production systems				Overall (N=198)		P
	Peri urban (N=119)		Urban(N=79)				
	Frequency	%	Frequency	%	Frequency	%	
Swollen red vulva	50	15.67	61	16.8	111	16.28	0.000
Mounting other cows	50	15.67	53	14.6	103	15.1	0.001
Mucus discharge	69	21.65	73	20.11	142	20.81	0.000
Restlessness	50	15.67	58	15.98	108	15.84	0.000
Bellowing	50	15.67	58	15.98	108	15.84	0.000
In-appetence	50	15.67	60	16.53	110	16.13	0.000
Total	319	100	363	100	682	100	-

In the focus group discussion (FGD), the most obvious heat sign that has practical importance used by AITs was mucus discharge from the vulva, swollen/ redness of vulva, mounting, bellowing, and restlessness/ in-appetence. Almost all of the AITs revealed that cow/heifer that comes to heat early in the morning should be inseminated on the same day afternoon and when the cow/heifer comes to heat in the afternoon majority of the members should be inseminated on the next day morning.

4.6 Determinants of Artificial Insemination Efficiency in the Study area

The major determinants of AI services in the study area forward by dairy farmers were infertility (1st), management practices (2nd), time of insemination (2nd), a long distance from the center (2nd), heat detection practices (5th), shortage of AITs (5th), , lack of AIT skill (5th), farmer awareness (8th), shortage of AI inputs /semen and nitrogen (8th) and diseases and parasites (10th) in peri-urban whereas heat detection practices (1st), shortage of AITs (2nd), management practices (4th), time of insemination (4th), lack of AIT skill (5th), farmer awareness (6th), shortage of AI inputs /semen and nitrogen (7th), a long distance from the center (8th), diseases and parasites (9th),and infertility (10th) from urban production systems. The overall determinants in the districts were time of insemination (1st), shortage of AITs (2nd), heat detection practices (3rd), management practices (4th), lack of AIT skill (5th), farmer awareness (6th), a long distance from the center (7th), infertility (8th), shortage of AI inputs /semen and nitrogen (9th) and diseases and parasites (10th), as shown in Table 27.

This finding was contradicted with Tewelde Medhn M, and Leul B, (2020), who reported lack of dairy awareness 1st, management problem 2nd, unskilled AITs 3rd, Inadequacy of AITs 4th, heat detection problem 6th, delayed time of insemination 8th, disease problem 9th, and 1ong distance 11th, in Humera agriculture research and with Misganu A, (2018), who reported that heat detection problems (1st), semen quality (2nd), the distance of AI center (3 rd), shortage of AITs (5th), diseases problems (5th) and AIT inefficiency (6th) in Jimma Zone, South-Western Ethiopia. This variation might be due to extension service and awareness, infrastructures, and AITs skills.

Table 27 Major determinants of AI efficiency in the study area

Major determinants	Production systems				Overall	
	Peri-urban (N=119)		Urban (N=79)			
	Index	Rank	Index	Rank	Index	Rank
Time of insemination	0.11	2	0.106	4	0.112	1
Heat detection	0.1	5	0.112	1	0.11	3
Shortage of AITs	0.1	5	0.11	2	0.111	2
Diseases and parasites	0.08	10	0.086	9	0.085	10
Unskilled of AITs	0.1	5	0.1	5	0.105	5
Lack of dairy awareness	0.09	8	0.099	6	0.097	6
Long distance	0.11	2	0.09	8	0.092	7
Shortage of AI inputs	0.09	8	0.091	7	0.089	9
Repeated breeding	0.12	1	0.084	10	0.091	8
Total	1		1		1	

CHAPTER 5, CONCLUSSION AND RECOMMENDATION

5.1 CONCLUSION

The breed preference of dairy farmers under this study had shown that the farmers under peri urban and urban setting had preference for crossbreed. The reason of selection for crossbreed by all production system farmers preferred selling milk than processing it to butter.

It is, therefore, concluded that the reproductive performance and efficiency of reproduction of crossbred dairy (HF X Zebu) cows were better in urban as compared to peri-urban area. The variation between the production systems shows there is an opportunity for further improvement in the study area through dairy farmers awareness, training, by delivering extension services, by developing infrastructures, by providing AITs and AI equipment's. In both production systems heat detection was carried out mainly based on observing physical signs namely, swollen /red vulva, bellowing, and mounting on other animals, clear mucus discharge, restlessness, and in-appetence in the study area. But heat detection observed from peri-urban and urban dairy production was significantly different due to production systems, infrastructures, and number of AITs, extension services, and dairy awareness. According to this study, the most important constraint decreasing the efficiency of AI were all over management practices, time of insemination, heat detection, small numbers of AITs, diseases, and parasites, unskilled AI technicians, lack of dairy farmers awareness, long distance of AI centers from farmers place, shortage of AI inputs especially nitrogen and semen. Therefore, proper animal selection, heat detection efficiency, farmers' awareness to detect heat, and on time bringing of cattle for insemination should be satisfactorily considered for effective AI efficiency.

5.2 RECOMMENDATION

The following recommendations were drawn in this study;

- To improve the reproductive performance of crossbred dairy cows (HF Zebu) efforts should be geared to improve the level of management.
- To increase the efficiency and effectiveness of AI services; capacity building of AITs, AI centers at districts level supply of AI facilities, awareness creation, and increase the number of AITs at districts level should be done in the study area.
- Well organized and comprehensive recording system at regional, woreda, kebele and farmer level need to be properly established, monitored and updated regularly.
- Provide improved breeding bull to avoid down breeding using locally available low genetic potential bulls in times when AIT fails to come on time.
- Efforts should be geared towards forage development through the participation of value chain actors and service provider.
- Further study on BSP, parity, age, site of semen deposition, and semen quantity, quality, and preservation, Impact assessment of estrus synchronization and mass insemination program and its challenges faced.

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APPENDIX

APPENDIX TABLES

Table 1Means (±SE) CRFS of crossbred cows in the study area

Parameters	Breed	Production systems								Over all
		Peri-urban				Urban				
		Year (2020)	Year (2021)	Year (2022)	Overall	Year (2020)	Year (2021)	Year (2022)	Over all	
Inseminated cows	Cross HF	155	156	156	467	348	348	349	1045	1512
	Cross Jersey	100	101	101	302	160	161	161	482	784
	Total	255	257	257	769	508	509	510	1527	2296
conceived cows	Cross HF	105	95	104	304	233	215	242	690	994
	Cross Jersey	63	61	67	191	105	99	111	315	506
	Total	168	156	171	495	338	314	353	1005	1500

Table 2ANOVA for age at first service (AFS)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	325.7086057	65.1417211	83.92	<.0001
Error	192	149.0439195	0.7762704		
Corrected Total	197	474.7525253			

Table 3 ANOVA for age at first calving (AFC)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	540.2919049	108.05838	135.78	<.0001
Error	192	152.7990042	0.7958281		
Corrected Total	197	693.0909091			

Table4 ANOVA for calving interval (CI)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	212.2683097	42.4536619	373.6	<.0001
Error	192	21.8175489	0.1136331		
Corrected Total	197	234.0858586			

Table 5 ANOVA for day open (DO)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	7829.39325	1565.87865	1622.91	<.0001
Error	192	185.253215	0.96486		
Corrected Total	197	8014.646465			

Table 6 ANOVA for inter service interval (ISI)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F

Model	5	190.246559	38.049312	15.32	<.0001
Error	192	476.9302086	2.4840115		
Corrected Total	197	667.1767677			

Table 7 **ANOVA for conception rate to first service**

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1615.973135	323.195	356.46	<.0001
Error	192	174.080251	0.90667		
Corrected Total	197	1790.053386			

Table 8 **ANOVA for number of service per conception**

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	8.33206419	1.6664128	8.22	<.0001
Error	192	38.94066308	0.202816		
Corrected Total	197	47.27272727			

Table 9 **ANOVA for calving rate**

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	3140.681293	628.136	538.23	<.0001
Error	192	224.073505	1.16705		
Corrected Total	197	3364.754798			

Table 10 **Major feeding systems in the study area**

Parameters		Peri-urban (N=119)			Urban (N= 79)		
		R1	R2	R3	R1	R2	R3
Feeding system	Communal grazing	16	63	40	21	44	14
	Private grazing	71	32	16	22	24	33
	Stall feeding	32	24	63	36	11	32

index=the sum of (3 times first order + 2 times second-order +1 times third order) for individual variables divided by the sum of (3 times first order + 2 times second-order +1 times third order) for individual variables divided by the sum of (3 times first order + 2 times second-order +1 times third order) for all variables.

Table 11 **Overall feed resource in the study area**

Parameters		Peri-urban (N=119)				Urban (N= 79)			
		R1	R2	R3	R4	R1	R2	R3	R4
Feed sources	Crop residues	24	55	16	24	9	32	12	26
	Grass/hay	71	24	8	16	36	22	11	10
	AIBP	0	8	48	63	25	8	40	6
	Improved forage	24	32	47	16	9	17	16	37

Index=the sum of (4 times first order + 3 times second-order +2 times third order, 1 times fourth order) for individual variables divided by the sum of (4 times first order + 3 times second-order +2 times third order +1 times fourth order) for all variables.

Table 12 **Overall animal health problems in the study area**

Parameters		Peri-urban (N=119)				Urban (N= 79)			
		R1	R2	R3	R4	R1	R2	R3	R4
Dairy cow health problem	Retained Fetal membrane	32	63	8	16	28	32	6	13
	Repeated Breeding	71	24	16	8	8	19	43	9
	Abortion	8	16	24	71	9	6	19	45
	Milk fever	8	16	71	24	34	22	11	12

Index=the sum of (4 times first order + 3 times second-order +2 times third order, 1 times fourth order) for individual variables divided by the sum of (4 times first order + 3 times second-order +2 times third order +1 times fourth order) for all variables.

Table 13 overall reason for dairy cows culling

Parameters		Peri-urban (N=119)						
		R1	R2	R3	R4	R5	R6	R7
	Less production	7	16	48	7	7	16	18
	Feed shortage	16	16	7	16	41	16	7
	Disease and parasites	16	7	7	16	16	32	25
	Space problem	16	16	7	16	16	16	32
	Financial requirement	16	32	7	16	16	16	16
	Infertility	32	16	27	16	7	16	5
	Old age	16	16	16	32	16	7	16

Overall reason for dairy cows culling (continued)

Parameters		Urban (N= 79)						
		R1	R2	R3	R4	R5	R6	R7
Culling reasons	Less production	7	6	10	7	10	26	13
	Feed shortage	29	10	9	12	8	5	6
	Disease and parasites	14	6	13	4	7	11	24
	Space problem	8	31	7	10	6	9	8
	Financial requirement	7	10	6	8	33	7	8
	Infertility	6	7	28	8	7	12	11
	Old age	8	9	6	30	8	9	9

Index=the sum of (7 times first order + 6 times second-order +5 times third order, 4 times fourth order + 3 times fifth order + 2 times sixth order + 1 times seventh order) for individual variables divided by the sum of (7 times first order + 6 times second-order +5 times third order + 4 times fourth order + 3 times fifth order + 2 times sixth order + 1 times seventh order) for all variables.

Table 14 Major determinants of AI services in the study area

Parameters		Peri-urban (n= 119)									
		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Major determinants	Management problem	16	23	8	8	8	16	16	8	8	8
	Time of insemination	8	8	8	8	8	16	31	16	8	8
	Heat detection	8	16	8	8	31	8	8	8	16	8
	Shortage of AITs	8	8	31	8	8	8	8	16	8	16

Diseases and parasites	16	0	8	16	8	8	16	8	8	31
Unskilled of AITs	8	8	16	16	8	31	8	8	8	8
Lack of dairy awareness	8	8	8	8	16	8	8	31	16	8
Long distance	8	16	8	31	16	8	8	8	8	8
Shortage of AI inputs	8	16	8	8	8	8	8	8	31	16
Repeated breeding	31	16	16	8	8	8	8	8	8	8

Major determinants of AI services in the study area (continued)

Parameters		Urban (N= 79)									
		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Major determinants	Management problem	6	9	5	4	28	6	8	3	3	7
	Time of insemination	26	3	4	6	4	8	7	4	9	8
	Heat detection	6	9	7	22	9	4	5	9	4	4
	Shortage of AITs	3	25	5	7	7	6	6	8	7	5
	Diseases and parasites	4	7	10	5	7	8	9	6	4	19
	Unskilled of AITs	6	4	23	5	6	8	6	7	7	7
	Lack of dairy awareness	5	6	7	12	8	10	5	18	5	3
	Long distance	10	5	7	4	6	7	5	7	21	7
	Shortage of AI inputs	8	7	5	9	3	3	18	9	8	9
	Repeated breeding	5	4	6	5	1	19	10	8	11	10

Index=the sum of (10 times first order + 9 times second-order +8 times third order + 7 times fourth order + 6 times fifth order + 5 times sixth order + 4 times seventh order +3 times eight order + 2 times nine order + 1 times tenth order) for individual variables divided by the sum of (10 times first order + 9 times second-order +8 times third order + 7 times fourth order + 6 times fifth order + 5 times sixth order + 4 times seventh order +3 times eight order + 2 times nine order + 1 times tenth order) for all variables.

Table 15 Means (±SE) CRFS of crossbred cows in the study area

Parameters	Breed	Production systems								Overall
		Peri-urban				Urban				
		Year (2020)	Year (2021)	Year (2022)	Overall	Year (2020)	Year (2021)	Year (2022)	Overall	
Inseminated cows in number	Cross HF	155	156	156	467	348	348	349	1045	1512
	Cross Jersey	100	101	101	302	160	161	161	482	784
	Total	255	257	257	769	508	509	510	1527	2296
conceived cows	Cross HF	105	95	104	304	233	215	242	690	994
	Cross Jersey	63	61	67	191	105	99	111	315	506
	Total	168	156	171	495	338	314	353	1005	1500

Means (± se) conception rate to first service of crossbred cows in the study area (continued)

Production systems	Types of season					
	Rainy season	Dry season	Overall	Rainy season	Dry season	Overall
	Inseminated cow			conceived cows		
Peri-urban	516	253	769	346	149	495
Urban	1015	512	1527	675	330	1005
Overall	1531	765	2296	1021	479	1500

APPENDIX FIGURES

Figure 1 Interview of AITs face to face at office level

Figure 2 Handling of AI equipments in the office level

Figure 3 Recorded data of Inseminted and conceived dairy cows in the office level

Figure 4 Handling and top up of bull semens during AI services

Figure 5 Retrospective of recorded data sample taken from AI office

Figure 6 Taking of retrospective recorded data dairy cows from AITs office

Appendices Questionnaire for the Survey

Part 1. General Information on Study Area

- ✓ Questioner code number---------------------Date of interview …………………….
- ✓ Name of numerator ---------------------------Phone no. ……………………….
- ✓ Name of interviewee -----------------District name…… Kebele name ------Village name ---

Part 2. Household Composition and Characteristics

1. Gender of the HH head 1. Male 2. Female: Age....years and Family size male…..female …Total …
2. Marital status: 1. Married 2. Single 3. Divorced 4. Widowed 5. Others (Specify) …
3. Educational status: 1. Illiterate 2. Can read &write 3. Primary 4. Secondary 5. college and above

Part 3. Livestock Population and Composition

1. Type and number of cattle kept by the household 1. Local….. 2. Crossbreed…..
2. Type of crossbreed Cattle kept

Cows				Heifers	Bull calves			Breeding bull
Milking	Pregnant	Dry	Open			Weaned	unearned	

Part 4. Livestock Production and Management

1. Type of dairy management 1. Extensive 2. Semi-intensive 3. Intensive
2. Members of household who manage dairy cow? 1. Husband 2. Wife 3. Both together 4. Sons and Daughters 5. The whole family
3. What is the reason for culling your animal? 1. Production 2. Feed shortage 3. Disease 4. Space problem 5. to get financial requirement
4. Do you keep mating records (heat period, times of service, the bull and others) of your cow? 1. Yes 2.No
5. What are the main constraints for dairy cattle production?

Constraints	Tick	Rank
Feed shortage		
Water shortage		
Disease		
Low genetic potential		
Market		
Others (specify)		

Part 5. Livestock Feed Source and Feeding Practice

1. What is major grazing system 1? Un herded 2. Herded 3.Paddock 4. Zero-grazing
2. What are the major livestock feeding systems you use?

Feeding System	Rank	Remark
Communal grazing		
Private grazing		
Stall feeding		

3. Major feed resource (rank)

Feed resources	Season	Rank
Crop residues		
Hay		
Concentrate		
Improved		

4. Do you have faced feed shortages for your livestock? 1. Yes 2. No
5. If yes, which is season encountering feed shortage? 1. Dry 2. Rainy 3. Both dry and rainy
6. If there is shortage of feed, what are the alternatives mostly used? -------
7. Supplementation regime in dry season 1. Green feed 2.Minerals (salts) 3. Vitamins 4. Atela 5.cuctus
8. Supplementation regime in rainy season 1. Green feed 2.Minerals (salts) 3. Vitamins 4. Atela 5.cuctus
9. Dairy animals which are supplemented 1. Lactating cows 2. Dry cows 3. Pregnant 4. Heifers 5. breeding bull

10. What are the most commonly used nonconventional feeds? -------------

Part 6. Watering the Animals

1. What is the water source of cattle?

Water sources	Season			Distance of water source from the homestead in km for a trip	Availability of Water (month)
	Dray	Rainy	Year round		
1. Tap water					
2. Rain					
3. Wells					
4. Pond					
5. River					
6.Others(specify)					

2. Source of water 1. River 2. Pond 3. River 4. Tape water 5. Well
3. Distance to nearest watering point for adult animals 1. Watered at home 2. <1km 3. 1–5 km 4. 6–10 km 5. >10 km
4. Frequency of watering for dairy cows in dry season 1. Adlibitum 2. Once a day 3. Twice a day 4. Once in 2 days 5. Others ……………..
5. Frequency of watering for dairy cows in wet season 1. Adlibitum 2. Once a day 3. Twice a day 4. Once in 2 days 5. Others ……………..
6. Do you have a shortage of water? 1. Yes, 2. No
7. If yes, which season? 1. Dry season 2. Wet season 3. Both dry and wet

Part 7. Housing Systems

1. What type of housing do you use? 1. House open barn separate enclose 2. Backyard enclosed (fenced) 3. Housed together with humans 4. Others
2. What type of housing do you use? 1. Stone made 2. Plastic made 3. Made of metal sheet
3. Type of roof? 1.Rain proof 2.Not rain proof
4. Frequency of cleaning the barn 1. Three times a day 2. Two times a day 3. Once a day 4. Others (specify)
5. Type of floor? 1. Hardened soil 2. Concrete 3. Stone paved
6. Types of ventilation? 1. Very good 2. Good 3. Poor
7. Do you have maternity (calving) pen? 1. Present 2. Absent
8. The facility will be used in house 1. No facility 2. Feed through 3. Water through 4. Both feed and water through
9. Types of feeding and watering trough 1. Concrete 2. Car tyre 3. Both Type

Part 8. Health Aspect

1. What are the major dairy cattle diseases in your locality? List their local name and signs and symptoms of the disease?

Type of disease	Symptoms	Susceptible age group blood level	Source of occurrence	Rank	Treatment	
					Traditional	Modern

2. Kind of veterinary service

Kinds of VS	Tick one or more	Distance from home (in k/m)
Government		
Private		
Shop market		
others specify		

3. Do you think that there is a risk of diseases in using AI service? 1. Yes 2. No
4. If you think that there is a risk, do you know any disease(s)? 1.Yes 2.No

Part 9. Reproductive Performance

1. What type of breeding method do you practice? 1. Controlled 2. Extensive (Uncontrolled)
2. What are the criteria employed to select a breeding cow? 1. Milk yield 2. Body size 3. Availability 4. Breed 5. Fat content 6. Other
3. What is the source of replacement stock in your farm? 1. Own herd 2. P purchased
4. Does number of cows bred at the farm vary seasonally? 1. Yes 2. No
5. Which season do you prefer to breed your cows? 1. Rainy season 2. Dry season
6. If your answer is yes, what is the reason? 1. Feed and water availability 2.disease occurrence 3. Other (specify)
7. Do you follow your cow's reproductive performance?

Measure of reproduction	Value	Breed type
		HFXZebu crossbreed
Number of services per conception		
Age at first service (months)		
Age at first calving (months)		
Inter service interval (month)		
Conception rate at first service (%)		

Part 10. For AI Service Users

1. Do you have AI service in your area? 1. Yes 2. No
2. If yes, how long the service rendered in the area? 1. 5yrs 2. 15yrs 3. 15-20yrs 4. >20yrs
3. Do you have experience of using AI service? 1.Yes 2. No
4. If no, what prevents you from using AI service (Put priority numbers in descending order of their severity)?

No	Reasons	Priority
1	Efficiency	
2	Price	
3	Availability	
4	Awareness	
5	Availability of feed	
6	Distance from AI center	
7	Others	

5. Do you get AI service regularly without interruptions? 1. Yes, 2. No
6. If your answer is to the above question is no, what is the reason for this? 1. Service is not available on weekends & holidays 2. Shortage of AITs 3. Shortage of inputs 4. Long-distance
7. How do you communicate with AI technicians? 1. AITs visit us daily 2. We call AITs when we need those 3. We take our cows to the AI station 4. Call and take the cow

Part11. Heat Detection Practices

1. Do you have experience/system of detecting heat? 1. Yes 2. No
2. If yes, how do you detect heat period? 1. Herdsman information 2.feeding and milking 3. Regular follow up 4. during morning &night
3. Do you have particular time for estrus detection: 1, Yes 2.No if yes, after how many hours ………

4. Signs of estrus you use to report your cows for AI service (frequency)

Types of sign	Yes	No	Remark
Swollen red vulva			
Mounting			
Standing			
Mucus discharge			
Restlessness			
Bellowing			
In-appetence			
Decrease milk			

5. When should your cow, which came in heat in the morning, be inseminated? 1. As heat sign is seen on it 2. On the same day afternoon 3. On the next day morning 4. As AITs order 5. When I am not busy
6. When should your cow, which came in heat in the afternoon, be inseminated? 1. As heat sign is seen on it 2. On the same day afternoon 3. On the next day morning 4. As AITs order 5. When I am not busy

Part12. AI Delivering System

1. How much, do you pay for insemination? ----------------
2. What is the basis for the insemination fee? 1. cost/conception 2. cost/ service
3. Do you think the existing insemination fee is fair? 1. Yes 2. No
4. How do you get AI service? 1. AI technicians visit my cow 2. I take the cow to AI center 3. Telephone call 4. Others (specify) ----------------
5. Is there any difference in conception rate among AI technicians? 1. Yes 2. No
6. Are there enough AI technicians for proper AI service delivery in the area? 1. Yes 2. No
7. How long does the AI technician need to provide you the service right after the request? 1. < 6 hours 2. 6-12 hrs. 3. 12-18 hrs. 4. 18-24, hrs. 5. >24 hrs.
8. Have you postponed insemination time of your cow, which is in heat? 1. Yes 2. No
9. If yes what was the reason? 1. Heat detection problem 2. Maturity of the animal 3. Disease problem 4. Absence of AI technician 5. Other
10. What alternative do you have when AI service interrupted? 1. Privet exotic bull 2. Extending to next 21 day 3. Use any available bull 3. Use exotic communal bull
11. Are you satisfied with the overall AI service? 1. Yes 2. No

Part13. Major Determinants for the Failure of AI (Frequency)

1. What do think the reason for the failure?

No	Determinants	Rank	Remark
1	Time of insemination		
2	Heat detection problem		
3	Lack of AITs		
4	Disease and parasites problem		
5	AI technician efficiency		
6	Lack of dairy awareness		
7	Distance of AI center		
8	Input shortages (semen and nitrogen)		
9	Service Charge		

Part14. General Discussions with Beneficiaries

1. What are feed resources and feeding systems in your area? Discuss ----------------
2. Please mention all problems associated with AI service in your area------------------
3. Give your view as to what interventions must be made for better implementation of AI technologies
4. Discuss with regards to any negative impacts and constraints of AI-------------------
5. Please indicate any positive or negative economic implication of AI technology ---------
6. Are you satisfied with the use of overall AI service? Discuss. --------------------------

Part15. Questionaries' for Retrospectives Data

1. Retrospective data of AI service through natural heating (2020-2022)

Peasant Association Name …………………………………………………………						
Year	Number of cows/heifers					
	AI inseminated			Conceived		
	HF	Jersey	Remark	HF	Jersey	Remark
2020						
2021						
2022						
Total						

2. Retrospective data on Estrous Synchronization and Mass Artificial Insemination (OSMAI)/2020-2022)

Peasant Association Name …………………………………………………………												
Year	Number of cows/heifers											
	Hormone treated			Heat observed			AI inseminated			Conceived		
	HF	Jersey	Remark	HF	Jersey	Remark	HF	Jersey	Remark	HF	Jersey	Remark
2020												
2021												
2022												
Total												

BIBLIOGRAPHICAL SKETCH

The author was born in December 03/1985 G.C. in North Wollo Meket Woreda, Maserut kebele. He started attending his elementary school since1994 G.C to 2004 G.c and pursued his secondary school in Filakit secondary school from 2005 to 2010 G.c. Then he joined Mersa ATVET College and got a Bachelor's degree in rural development from St. Mary University College. Then, he joined Meket Woreda in North Wollo since 2019 G.C as an Environment and forest protection expert. Then March 2021 G.C, he joined again Woldia University, College of Agricultural, and Department of Animal Science to pursue his postgraduate study on Animal Production.