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ASSESSMENT OF THE STATUS OF ARTIFICIAL INSEMINATION AND ITS CONSTRAINTS IN EAST ARSI ZONE, OROMIA REGION, ETHIOPIA

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ABSTRACT

Ethiopia's genetic enhancement efforts have included directly importing exotic cattle from other countries or introducing genes from an external source via artificial insemination (AI) to enhance the breed composition of local cattle. The study aimed to evaluate the status of artificial insemination and identify its constraints in the selected districts of East Arsi Zone, Oromia regional state. The data were collected from 301 farmers and 9 AI technicians (AIT) using semi-structured questionnaires. Five-year secondary data were used from the annual summary of the casebook to evaluate AI status. Data on AI status, satisfaction, breeding method, controlled mating and AI delivery were analyzed using Statistical Analysis Systems (SAS) chi-square procedures. Secondary data were analyzed using General Linear Model SAS methods. The ranking coefficient was analyzed using the R software Plackett–Luce model procedure. The study found that 43.52% of participants were dissatisfied with AI services, while 56.48% were satisfied. Furthermore, 72.43% of respondents indicated an increase in AI services, whereas 13.62% reported a decrease and 13.95% no change. The respondents' satisfaction with AI and AI status differed (P<0.05) among districts, but no difference (P>0.05) between the production systems. The secondary data revealed a gradual increase in AI delivery from 2018 to 2022. The average AI delivery was 2281.5±275.6 per year. While AI services did not differ (P > 0.05) across districts, there was a significant (P< 0.05) variation over time. About 55.48% of the districts' dairy producers used AI for breeding. Most respondents (61.79%) received AI from government administrations, while 36.21% received from government and private and only 1.99% obtained it from private suppliers. Breeding methods varied significantly across production systems (P<0.0001), but controlled mating and AI provision were non-significant. The farmers preferred neighbor bulls with estimated coefficients of 2.24 followed by their bulls (1.05) for breeding purposes. The respondents indicated that conception failure (0.72) and poor conception rates (0.56) were the biggest challenges for AI in the study areas. Transportation (2.89) was the main constraint in delivering AI services identified by AITs. Despite these challenges, there has been an increase in the use of AI in study areas over the past five years. Because AI is the only accessible technology for increasing dairy cow performance in the country, it is vital to address these challenges to increase AI utilization in the study regions. Focusing on semen quality is necessary to achieve a high conception rate per service. Supporting commercial AI businesses could improve farmers' access to services.

Key words: artificial insemination, breeding method, controlled mating, satisfaction, status

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INTRODUCTION

Major initiatives for genetic improvement in Ethiopia included the direct importation of exotic cattle from other possible countries or the introduction of genes from an external source (AI service) to improve the breed composition of local cattle [1]. The supply of crossbreed heifers, providing AI service, and setting up of bull service stations were major components of livestock genetic improvement. However, among the others, AI is a simple, quick, and low-price technology [2, 3]. On the other hand, livestock breeding is generally uncontrolled in Ethiopia; so right bull selection criteria have not been applied and controlled, making genetic enhancement difficult [1, 4]. Hence, AI was recognized as the primary tool for genetic improvement in cattle breeding. Similar studies in many African countries, where agro-climatic conditions are the same as in Ethiopia and where there is good market access and adequate feed, genetic improvement can be achieved through crossbreeding using AI and hormone synchronization [2, 4, 5].

According to the study of Temba [6] in Zebu cows, AI technology increases the milk potential of a cow to double their potential per year. Furthermore, Temba [6] proved that the pure Zebu breed produces 900 liters per year, whereas the crossbreed produces 1500 liters under the same conditions. This indicates that AI plays an important role in increasing the yielding capacity of cows and is the appropriate and cheapest way of genetic improvement when it is incorporated with good animal husbandry, such as effective heat detection, feeding, and health management [2, 7, 8, and 9]. In the same way, Sarakul *et al.* [10] enlightened that genetic improvement of cattle is essential for economic purposes, particularly milk production, so AI technology is an important component of an overall strategy to improve the profitability and sustainability of dairy cattle operations as well as to improve the livelihood of the farmers. Mugisha *et al*. [11] also pointed out that access to AI technology is an appropriate strategy for the dairy industry to improve milk production and productivity through genetic improvement of the local cattle. In addition to this, a study conducted by Riyad *et al.* [12] and Kassa and Wuletaw [13] found that AI is the most commonly used and valuable biotechnology that has been used in Ethiopia for over 4 decades (40 years). Extension agencies have pushed AI technology to farmers, but its uptake and intensity are yet to be determined. To address the increasing demand for milk and milk products, productivity and reproductive potential improvement of dairy cattle via appropriate breeding programs needs great attention. Intensification of the dairy farm and market development and infrastructures play vital roles [14].

In Ethiopia, AI was introduced in 1938 in Asmara, then part of Ethiopia, which was interrupted due to the Second World War and restarted again in 1952 [15]. Again, it was halted due to the costs of importing semen, liquid nitrogen, and other related input requirements. In 1967 an independent service was started in the Arsi Region, Chilalo Awraja under the Swedish International Development Agency (SIDA). It has been described that the technology of AI for cattle was introduced at the farm level in the country over 50 years ago as a tool for genetic improvement [16]. Despite the longer age of AI introduction in the country, the number of improved animals is negligible since 96.76% of the total cattle in the country are local breeds, whereas 2.71% and 0.41% are hybrid and exotic breeds, respectively [17]. This means that the number of exotic and hybrid female cattle generated in the country through crossbreeding is low, demonstrating that AI based crossbreeding was ineffective [18].

To boost dairy cattle productivity, excellent dairy breeds are commonly used for crossbreeding to combine the production specialist exotic and adaptability of local breeds [19]. Local dairy cattle breed of the country, have special adaptive traits for disease resistance, heat tolerance, ability to utilize poor quality feed and soundly fit with local farmers' farming conditions, which they have acquired through natural selection via countless generations. Thus, AI has become one of the most important techniques ever developed for the genetic improvement of farm animals. It has been most widely used for breeding dairy cattle and has made bulls of genetic merit available to all [20, 21]. This implies that the application of AI and its success rate in Ethiopia is still low owing to several technical, financial, infrastructural, managerial, and heat detection problems [22]. So, the objective of this study was to examine the current status of artificial insemination and the key obstacles connected with the service in the study areas.

MATERIALS AND METHODS

Study Areas and Site Selection

The study was carried out in the East Arsi Zone of the Oromia Regional State, which is located at 7°08'58" to 8°48'00"N latitude and 34°41'55" to 40°43'56"E longitude. Assela serves as the zone and Tiyo district administrative center. Assela is about 175 kilometers southeast of Addis Ababa and has an elevation of 2430 meters above sea level. Mount Chilalo is the highest point in the Arsi Zone. The zone covers an area of 19,825.22 km2 and is divided into 25 districts. The mean annual rainfall ranges from 633.7 mm to 1020 mm, while the average yearly temperature ranges from 10°C to 25°C. Three districts (Lemunabilbilo, Tiyo and Digelunatijo) were purposely chosen from 25 districts.

The Lemunabilbilo district is located at 7°43'18" latitude and 39°17'51" longitude about 223 kilometers southeast of Addis Ababa. Bokeji serves as the district administrator. The district has 81,400 hectares (ha) of land total, of which 70,154 are used for crop cultivation, 6,746 for grazing, 3,839 for forest, 262 for bush and shrub

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cover, 99 for barren land and 300 ha for other uses. The district climatic conditions are varied, featuring agroecologies such as highlands (80%), midlands (17%), and lowlands (3%), with elevations ranging from 2500 to 3560 meters above sea level. The district has an annual rainfall of 1000-1200 mm and a temperature of 13°C. The district has two main rainy seasons: a long one from June to August and a short one from mid-March to April.

The Tiyo district is located at 7°50'N latitude and 39°10'E longitude at 167 kilometers southeast of Addis Ababa. Of the 65,000 ha of land in Tiyo, 25,060 are used for crop cultivation, 9,697 for grazing, 3,959 for forest, 9,479 for bush and shrub, 10,828 barren land, and 5,977 ha for other uses. The district climate conditions are varied, featuring agroecologies of midlands (52%), highlands (37%), and lowlands (11%) with elevations ranging from 2300 to 3200 meters above sea level. Tiyo experiences 1300 mm to 1350 mm of annual rainfall, with an average temperature of 18 to 25 °C during the dry season and 5 to 10°C during the wet season. The district has two main rainy seasons: a long one from June to August and a short one from February to April. Its climate and soil provide extremely fruitful environmental conditions.

The Digelunatijo district is located at 7°46' latitude and 39°15'E longitude at 192 kilometers southeast of Addis Ababa. Segure serves as the district administrative. The district comprises 92,700 ha of land, of which 43,873 are cultivated for crops, 15,054 for grazing, 11,122 for forests, and 22,651 ha are used for other uses. The district agroecologies are midlands (22%) and highlands (78%), with elevations ranging from 2500 to 3560 meters above sea level. The district has an annual rainfall of 1200 mm and a temperature of 10-15°C. The region has two distinct rainy seasons: a long one from June to September and a short one from mid-March to April.

Study Design and Study Population

A multi-stage purposeful sampling strategy was used. Livestock and fishery office experts of the district were briefed on the study's objectives. First, potential districts were purposively selected. Second, based on the information obtained from the districts' livestock and agriculture development agencies, peri-urban and rural *Kebeles* in each district were purposefully selected based on dairy animal availability, beneficiaries of artificial insemination and road accessibility. Finally, the farmers were selected using a purposeful random selection procedure and informed about the study's objective. The study population was smallholder dairy owners who own dairy cows and beneficiaries of artificial insemination services in the study area.

Sampling Procedures and Sample Size Determination

A purposeful sampling technique was employed. The sample size was determined based on the formula given by Arsham [23] for survey studies:

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$N = 0.25/SE^2 = 0.25/0.05^2$ = Where: SE = Standard error, N = required sample size. At 5% standard error, 301 households were chosen (Lemunabilbilo = 100, Tiyo = 101 and Digelunatijo = 100).

Data Collection Methods and Data Analysis
The data were collected using semi-structured questionnaires. Farmers were interviewed in person about their level of satisfaction with AI, AI status, breeding methods, AI delivery sources, controlled mating, breeding bull sources, and AI constraints. Secondary data were gathered to assess the AI status in the districts during the past five years using the yearly AI delivery summary from the casebook. Additionally, nine AI technicians were provided with questionnaires to determine the constraints of AI. The data were entered and organized in the Excel spreadsheet and then subjected to statistical analysis using SAS version 9.0 software and R version 4.3.2. To analyze and compare the data, the chi-square procedures of SAS were used to analyze data on satisfaction levels of AI, AI status, breeding methods, AI delivery sources, controlled mating and breeding bull sources. Furthermore, the secondary data were analyzed using SAS's GLM procedures. In addition, the PLM procedure was utilized to analyze the ranking coefficient on AI constraints data. The means, standard errors, coefficients, and percentages were used as descriptive statistics. Means separation was done by using Duncan's multiple comparisons for secondary data. So, the following models were used for data analysis.

Model:

$$Yijk = \mu + Bi + Cj + eijk$$

Where:
Yijk is the k^{th} response parameter from the j^{th} district in i^{th} year
μ is the overall mean
Bi is i^{th} year of deliver (1-5)
Cj is j^{th} district (1, 2, and 3)
Eijk is the error term

The PLM was designed to model the probability of a specific rank ordering for a set of I items and is based on Luce's axiom [24], which states that for a set of items, S, the probability of selecting item i from the set is given by:

$$P(S) = \frac{ai}{\sum_{i \in S} \quad ai}$$

Where
αi =Worth of item i

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RESULTS AND DISCUSSION

Satisfaction and Status of Artificial Insemination

Table 1 summarizes the status and satisfaction with artificial insemination (AI) and breeding methods. The study revealed that 83.10% of the respondents in the Lemunabilbilo district were dissatisfied with AI services. There could be several reasons behind their dissatisfaction such as poor quality of semen, difficulty in accessing the services, and technical inefficiency. In contrast, 91.00% of the respondents in the Digelunatijo district reported satisfaction with AI services. Similarly, 61.39% of the respondents in the Tiyo district reported satisfaction with AI services. According to the survey, respondents were satisfied with AI services in peri-urban and rural production systems at 52.38% and 59.43%, respectively. About 56.48% of the respondents were satisfied with the AI service delivery. This finding is consistent with the study conducted in the Central Highlands of Ethiopia, in which 61.27% of respondents reported being satisfied with the overall AI service, despite its known shortcomings [25]. However, other studies found that, respectively, 55.80%, 69.17% and 52.5% of the respondents were dissatisfied with the AI services in Tullo district, West Hararghe, West Gojjam Zone and in and around Adama town, which is not aligned with the current findings [12, 26, 27]. Furthermore, a study conducted in Essera Woreda, Dawuro zone, Southern Ethiopia and Kacha Bira District, Southern Ethiopia indicated that 90.6% and 78.5% of the respondents were dissatisfied with the delivery of AI services, respectively [13, 28]. This has been linked to low conception rates, lack of knowledge about the advantages of AI, poor conception rates, a lack of services in the immediate area, and lower calving rates by AI than those of natural mating.

The study revealed that AI services are increasing in the study areas (Table 1). The respondents' perspective indicated that, with an overall percentage of 72.43%, the status of AI is increasing in Lemunabilbilo, Tiyo and Digelunatijo, at 66.00%, 75.25% and 76.00%, respectively. Further, both peri-urban (67.46%) and rural (76%) respondents reported that AI services were increasing. The respondents pointed out that the retrospective analysis supported the rise of AI services in the study areas. This result is consistent with the study conducted in and Around Ejere District, Western Shoa Zone, in Ada'a District Oromia Regional State Ethiopia and in the Central High Land of Ethiopia which discovered an increase in the number of animals inseminated, respectively [29, 30, 31]. This may be attributed to farmers' knowledge of AI advantages and their struggles with raising bulls due to the higher costs of management and feed than AI.

Breeding Method, Controlled Mating and Artificial Insemination provider

In the Tiyo and Digelunatijo districts, about 75.25% and 83.00% of the respondents used AI for breeding, respectively. On the other hand, in Lemunabilbilo, natural

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mating and AI were mainly used (Table 2). Similarly, the results from peri-urban (58.73%) and rural (53.14%) production systems indicated that most dairy producers used AI. This result is congruent with a study conducted in Ada'a District, Oromia Regional State, Ethiopia, which found that 69.77% of respondents utilize AI for crossbreed dairy cows [30]. Furthermore, this finding is congruent with the study conducted in the central zone of Tigray, northern Ethiopia and Northwestern Ethiopia, which indicated that 42.77% and 45.1% of the respondents used AI, respectively [32, 33]. Moreover, 71% of respondents used AI in Ethiopia [34]. The willingness of the farmers to use AI might be attributed to the additional cost of management, feed costs, and the chance to use genetically superior bulls via AI services. In contrast, a study conducted in West Oromia, Ethiopia found that 63.8% of dairy producers practiced natural mating [35]. Furthermore, in the Central High Land of Ethiopia and Jimma town, 71% and 100% of the respondents practiced natural mating [31, 36]. This might be due to the shortage of AI services in the study areas compared to the current study areas and other constraints of AI like a low conception rate, conception failure, and service interruptions on weekends and holidays.

About 89.00%, 74.26% and 84.00% of the respondents practiced the controlled mating method in Lemunabilbilo, Tiyo and Digelunatijo, respectively, with an overall percentage of 82.39% (Table 2). Further, most dairy producers in the peri-urban (79.37%) and rural (84.57%) production systems practiced controlled mating methods. In contrast to the current results, the study conducted in Jimma town reported that 81.5% of the respondents did not practice controlled mating [36]. This could be linked to the reliance on mating during communal grazing. In dairy cattle, precise and effective oestrus identification is generally necessary for the success of AI. To do this, artificial insemination with efficient heat detectors must be used in controlled mating to obtain high conception and calving rates. The study revealed that most of the respondents in the Tiyo (84.16%) and Digelunatijo (64%) districts got AI services from the government, whereas, in the Lemunabilbilo district, about 63.00% of the producers got AI services from both the government and private. Similarly, in peri-urban and rural production systems, 67.46% and 57.71% of dairy farmers received AI services from the government, respectively. These findings are congruent with a study conducted in the Ada'a district of Oromia Regional State Ethiopia, which reported that the government provided most of the AI services [30]. This could be explained by the fact that commercial providers demand a higher fee per dissemination than governmental services.

The mean details of AI delivered for the last five years in the study areas are presented in Table 3. The study revealed that more artificial inseminations were delivered in 2022 with a mean value of 2715.0±205.6 services per year, whereas

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there were no statistical differences in AI delivery from 2018 through 2021. There was a significant (P<0.05) difference in AI services over the years. Animals that were inseminated from 2018 through 2022 were slightly increasing, which aligned with the research done in and around Adama Town which stated inconsistencies in the number of animals inseminated and the number of calves born [27]. On the other hand, this study was unlike the findings of Sisay *et al.* [29], Alem *et al.* [30] and Temesgen *et al.* [31], who reported an increase in the number of animals inseminated and calves born in the Western Shoa Zone, Ethiopia, Ada'a District Oromia Regional State, Ethiopia and Central High Land of Ethiopia, respectively. These variations might be due to differences in farmers' awareness of the advantages of AI over natural services, a lack of AI technicians and heat detection problems. Despite the well-known merits of artificial insemination, a large number of dairy farmers all over the world still use natural service bulls to breed their cows [37]. The main arguments allegedly justifying their choice are higher AI costs than keeping herd bulls and additional costs resulting from extended calving intervals because of low conception rates when AI is used [37]. Labor, equipment, liquid nitrogen, semen and three "services per conception" ratios all contribute to the expense of artificial insemination [37]. The availability of economically priced liquid nitrogen for the cryopreservation of semen is also a constraint in utilizing AI as a whole [37]. The delivery of AI was non-significant (P>0.05) among the study districts (Table 4).

The respective results revealed that 47.00% of the total population inseminated over the previous five years conceived, 42.47% gave birth, with 46.69% of the calves being female and 53.31% being male. The ratio of females to males obtained in this study was not aligned with the study done in Central High Land of Ethiopia, which discovered that out of the total calves born were 50.4%, and 49.6% female and male, respectively [31]. Furthermore, the study shows that conception and calving rates were lower than 69.8.8% and 73.1%, respectively of the total inseminated population conceived and gave birth in the Central Highlands of Ethiopia [31]. Additionally, the conception rate found here was lower than the conception rate (56%) but higher than the calving rate (36.94%) in Tigray Regional State [38]. Furthermore, conception rates in this study were lower than 54.28% and 59.76% in indigenous and crossbreed cows, respectively, in the South Wollo Zone [39]. This could be explained by differences in management regarding heat detection and timely insemination, the effectiveness of the inseminator, and the animal's body condition at the time of insemination, which results in different calves relative to the total inseminated animals. The results of this study demonstrated that the rates of conception and calving varied according to the total number of animals inseminated within a specific time frame. This could be a sign of conception failure because of inappropriate insemination timing, low-quality semen, and other relevant factors.

Sources of Bull for Breeding

The estimated overall results for bull sources are presented in Table 5. The coefficients of bull used for own, rent, neighbor, and communal grazing land were statistically significant (P<0.0001). The use of neighbor bulls had the highest positive (2.24) and significant estimated coefficient, indicating that, above all, farmers preferred to use their neighbor bulls. In addition, the use of their bull was the second most preferred bull source and had a significant positive estimated coefficient (1.05), implying that the farmers did not incur expenses to serve their cows. On the other hand, the farmers were not willing to use the rent bull and bull from communal grazing land. The negative (-2.78) preference towards the rent bull could be related to the cost incurred for renting. Further, the farmers were not interested in using bulls from the communal grazing land. The negative (-0.51) preference towards bulls on communal grazing land would be associated with identification and inbreeding problems.

The study found that dairy farmers in the study areas favored neighbor bulls for breeding their cows. This finding is congruent with the study conducted in the mid-rift valley of Oromia, Ethiopia, which discovered that 59.1% of dairy producers got breeding bulls from the communal grazing land for local cows [40]. In contrast, the use of own bulls ranked first with an index of 0.43 for local cows in North Amhara [41]. This could be connected with producers' knowledge of inbreeding issues and the availability of the bulls. In addition, the use of their bull was the second most preferred bull source and had a significant positive estimated coefficient (1.05), implying that the farmers did not incur expenses to serve their cows. About 25.9% and 21.7% of the use of own bulls for breeding was also reported in Jimma town and Gedeo Agroforestry, Ethiopia, respectively [36, 42]. Producers should be aware that using their own-bred bulls in the herd for an extended period may raise the risk of inbreeding. Farmers should be instructed to avoid keeping their bulls for too long.

Constraints of Artificial Insemination under Farmer's Condition

Table 6 summarizes the main artificial insemination (AI) constraints that dairy producers have reported. Except for untimely insemination, the AI constraints considered were statistically significant (P<0.0001). The results revealed that conception failure was ranked first, followed by a low conception rate with an estimated coefficient of 0.72 and 0.56, respectively. On the other hand, a high charge per service was ranked last with an estimated coefficient of -1.14. Conception failure was reported by Yohanis and Tilahun [27], Mesfin *et al.* [28] and Temesgen *et al.* [31] as one of the main limitations taken into account in their study in and around Adama town, in Kacha Bira district, Southern Ethiopia and in the central highlands of Ethiopia, respectively, which was consistent with the present findings. Further, a low conception rate was the second most prevalent barrier affecting the application of AI. The low conception rate was associated with management, nutrition, timely inseminating, reproductive diseases, and semen quality in Selected Areas of Ethiopia [43]. Furthermore, high conception failure and low conception rate may be attributed to improper placement of semen in the reproductive tract of the animal and poor body condition.

The sex ratio of female to male was among the major constraints of AI service, which was also reported by Alem *et al*. [30] in Ada'a district, Oromia Regional State, Ethiopia. The study found that interruptions on holidays, shortage of semen supply, distance from the service center, timely insemination, heat detection and AIT inefficiency were among the most challenging aspects of AI use in the study areas. Lack of regular delivery of AI service, lack of input (liquid nitrogen and semen), distance to the AI center, lack of an AI technician, and heat detection problems were reported by Afras [44] as major constraints of AI service in Southwestern Ethiopia, which was in line with the current study. According to Narendra and Manesh [45], there is a shortage of liquid nitrogen and AI manpower shortage in South Sikkim, India, which is consistent with the current findings.

Consistent with the current finding, heat detection problems were also reported by Wolelie [25], Yohanis and Tilahun [27], Mohammed *et al. [*46] and Teweldemedhn and Leul [47] in the Central highlands of Ethiopia, in and around Adama Town, in and around Alamata district, Tigray Ethiopia and the Western zone of Tigray Region, respectively. Heat detection has been performed and reported to AI technicians by dairy cattle producers observing signs of heat like mounting on other animals, vulva discharge, bellowing, swelling, redness and mucus discharge of the vulva, restlessness, and nervousness [48]. Heat detection is one of the key elements influencing AI practice in smallholder dairy producers [49]. Similarly, Roelofs *et al.* [50] noted that several factors, including heredity and the number of days postpartum, might affect the manifestation of heat; lactation quantity, milk supply, and health are known to influence the expression of estrus.

Smallholder farmers engage in different farm operations, making it difficult to determine the best period of heat [51]. So, this leads to the heat period of the cows and heifers passing away before the AI service has been delivered or an inappropriate time of insemination, which fails conception or causes low conception rates. Additionally, the success of AI is determined by several factors, including the efficiency, capacity and commitment of AI centers to create, process, handle and distribute semen in a procedurally and ethically acceptable manner [52]. Furthermore, the success of AI depends on the efficiency of AITs, the presence of appropriate breeding strategies, proper regulation of indiscriminate crossbreeding and proper heat detection by farmers [52].

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Constraints of Artificial Insemination Identified by Technician

The main constraints of AI highlighted by AI technicians (AITs) are presented in Table 7. According to AIT's response, the primary obstacle to AI services was transportation, followed by service delivery distance with an estimated coefficient of 2.89 and 1.35, respectively. The most difficult barriers to providing AI services in the study areas included timely insemination (0.99), service interruptions during holidays (0.83) and low conception rates (0.41). This study aligns with the AI constraints reported by AITs in and around Adama Town, such as heat detection and conception failure findings [27]. Furthermore, AITs noted several restrictions, including heat detection problems, untimely insemination, and technician inefficiency in and Around Alamata District, Tigray, Ethiopia [46], which aligned with the current findings. Lack of training to improve the technician's ability and knowledge (-0.49) was another constraint highlighted by AITs, which aligned with the study conducted in West Gojjam Zone, Ethiopia [26]. Artificial insemination technician's inefficiency was not significant (P>0.05) among the constraints it detected, which is consistent with the finding in Selected Districts of Wolaita Zone [53]. Further, shortages of transportation infrastructure, improper timing of insemination, and lack of AI inputs were among the limitations noted by AITs [53], which aligned with the current findings.

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

The survey results showed that artificial insemination services are becoming more popular and widely used in the study areas. In the districts of Tiyo and Digelunatijo, the study found that most farmers preferred artificial insemination for breeding, nevertheless, in the Lemunabilbilo district, both artificial insemination and natural mating are commonly utilized. According to the secondary data analysis, AI deliveries increased in the study areas between 2018 and 2022. The study found that most of the farmers in Tiyo and Digelunatijo districts received artificial insemination from the government, nevertheless, in the Lemunabilbilo district, most of the farmers received it from both government and private providers. Controlled mating was the most popular breeding method practiced in the study areas. Additionally, the study found that artificial insemination was the most commonly used breeding technique in both peri-urban and rural production systems. Based on the survey results, there has been a slight increase in the use of artificial insemination in the study areas. Despite an increase in AI delivery, the overall status of artificial insemination is still relatively low compared to its age. While many respondents were satisfied with the AI services, some challenges were highlighted. The most common limits mentioned by respondents were conception failure and low conception rates. Additionally, AITs identified that transportation was a main hindrance followed by distance to the service provider. Both farmers and AITs were placed pricing per service at the bottom. This suggests that charging for services was not an issue in the studied locations. To address these obstacles, it is crucial to use controlled mating and precise heat detection to ensure efficient and effective artificial insemination. Furthermore, it is essential to resolve the problems and limits mentioned by artificial insemination technicians in the study areas to widen the use of artificial insemination. Additionally, focusing on improving the quality of semen is essential to increase the conception rate per service, which is a common issue that farmers face. To make the services more accessible to farmers, it would be beneficial to encourage private AI companies. By doing so, farmers can efficiently and effectively breed their livestock and improve their livelihoods.

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CONFLICT OF INTEREST

No potential conflict of interest was reported by the author (s).

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Table 1: Satisfaction and status of artificial insemination

Variables		Districts			Overall	P-value
		Lemunabilbilo (n=100)	**Tiyo (n=101)**	**Digelunatijo (n=100)**		
Satisfaction	Dissatisfaction	83.00%	38.61%	9.09%	43.52%	<0.0001
	Satisfied	17.00%	61.39%	91.00%	56.48%	<0.0001
Status	Increasing	66.00%	75.25%	76.00%	72.43%	0.0182
	Decreasing	11.11%	12.87%	17.00%	13.62%	0.0182
	No change	23.00%	11.88%	7.00%	13.95%	0.0182
		Production systems				
		Peri-urban (n=126)	Rural (n=175)			
Satisfaction	Dissatisfaction	47.62%	40.57%		43.52%	0.2237
	Satisfied	52.38%	59.43%		56.48%	0.2237
Status	Increasing	67.46%	76.00%		72.43%	0.0921
	Decreasing	13.49%	13.71%		13.62%	0.0921
	No change	19.05%	10.29%		13.95%	0.0921

Table 2: Breeding method, controlled mating and artificial insemination provider

Variables		Districts			Overall	P-value
		Lemunabilbilo (n=100)	**Tiyo (n=101)**	**Digelunatijo (n=100)**		
Breeding methods	NM	20.00%	12.87%	14.00%	15.62%	<0.0001
	AI	8.00%	75.25%	83.00%	55.48%	<0.0001
	Both	72.00%	11.88%	3.00%	28.90%	<0.0001
Controlled mating	Yes	89.00%	74.26%	84.00%	82.39%	0.0203
	No	11.00%	25.740%	16.00%	17.61%	0.0203
AI provider	Government	37.00%	84.16%	64.00%	61.79%	<0.0001
	Private	-	4.95%	1.00%	1.99%	<0.0001
	Both	63.00%	10.89%	35.00%	36.22%	<0.0001
		Production systems				
		Peri-urban (n=126)	Rural (n=175)			
Breeding methods	NM	20.63%	12.00%		15.62%	0.0109
	AI	58.73%	53.14%		55.48%	0.0109
	Both	20.63%	34.86%		28.90%	0.0109
Controlled mating	Yes	79.37%	84.57%		82.39%	0.2420
	No	20.63%	15.43%		17.61%	0.2420
AI provider	Government	67.46%	57.71%		61.79%	0.1434
	Private	0.79%	2.86%		1.99%	0.1434
	Both	31.75%	39.43%		36.22%	0.1434

AI = Artificial insemination, NM = Natural mating

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Table 3: Mean (±SD) of artificial insemination provision by years

Variables	Years					Overall mean	Sig. level
	2018	2019	2020	2021	2022		
AI	2069.3±21.6^{b}	2115.7±45.2^{b}	2197.0±111.8^{b}	2310.7±267.7^{b}	2715.0±205.6^{a}	2281.5±275.6	0.0098
Conceived	888.7±62.7^{b}	864.7±265.6^{b}	1163.0±29.60^{ab}	1110.3±236.6^{ab}	1335.0. ±21.80^{a}	1072.3± 228.4	0.0436
Calves born	817.0±55.6^{b}	753.7±228.0^{b}	1006.0±85.0^{ab}	1016.3±193.^{4ab}	1252.3±113.3^{a}	969.1±221.2	0.0250
Male	468.0±75.3	428.7±141.9	544.0±23.8	527.0±115.9	615.3±84.3	516.6±105.5	0.1416
Female	349.0±33.6^{b}	325.0±104.9^{b}	462.0±90.1^{b}	489.3±101.3^{ab}	637.0±46.4^{a}	452.5±134.4	0.0154

Within columns means not carrying the same superscripts are significantly different. AI = artificial insemination

Table 4: Mean (±SD) of artificial insemination provision by districts

Variables	Districts			Overall mean	Sig. level
	Lemunabilbilo	Tiyo	Digelunatijo		
AI	2219.6±232.7	2323.4±251.3	2301.6±375.5	2281.5±275.6	0.6103
Conceived	1048.4±312.2	1138.8±174.1	1029.8±215.2	1072.3± 228.4	0.5757
Calves born	976.4±301.1	1030.6±206.8	900.2±164.7	969.1±221.2	0.4292
Male	543.4±144.5	562.8±55.1	443.6±69.5	516.6±105.5	0.1012
Female	433.0±161.5	467.8±164.0	456.6±96.9	452.5±134.4	0.8204

AI = artificial insemination

Table 5: Estimate coefficient of overall bull sources

Variables	Coefficient	Standard error	Z-score	P-value	Probabilities	Rank
Own	1.05	0.09	11.28	$< 2^{-16}$	22.18	2
Rent	-2.78	0.15	-18.20	$< 2^{-16}$	0.48	4
Neighbor	2.24	0.11	20.31	$< 2^{-16}$	72.69	1
Communal grazing	-0.51	0.09	-5.57	2.51^{-08}	4.65	3

Table 6: Constraints of artificial insemination service identified by dairy producers

Variables	Coefficient	Standard error	Z-score	P-value	probabilities	Rank
High charge per service	-1.14	0.08	-14.64	$< 2^{-16}$	2.72	10
Conception failure	0.72	0.06	11.32	$< 2^{-16}$	17.34	1
Low conception rate	0.56	0.06	8.98	$< 2^{-16}$	14.75	2
Shortage of semen supply	0.32	0.06	5.00	5.74^{-7}	11.64	5
Service interruption	0.45	0.06	7.08	1.41^{-12}	13.31	4
AI service center distance	0.20	0.06	3.17	0.00151	10.32	6
Inefficiency AI technician	-1.11	0.07	-15.79	$< 2^{-16}$	2.78	9
Sex ratio Problem	0.46	0.07	6.94	4.01^{-12}	13.44	3
Heat detection problem	-0.42	0.06	-6.69	2.24^{-11}	5.56	8
Untimely insemination	-0.04	0.06	-0.63	0.5258	8.13	7

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Table 7: Constraints of artificial insemination service identified by artificial insemination technician

Variables	Coefficient	Standard error	Z-score	P-value
Lack of interest by user	-0.79	0.35	-2.24	0.025004
Lack of training	-0.49	0.37	-1.35	0.176693
High price per service	-2.05	0.46	-4.41	1.06^{-05}
Conception failure	-0.06	0.35	-0.18	0.856486
Low conception rate	0.41	0.35	1.16	0.246317
Shortage of semen supply	0.16	0.37	0.43	0.665332
Service interruption on a holiday	0.83	0.43	1.95	0.051739
Distance to give service	1.35	0.38	3.53	0.000419
Inefficiency of technician	-1.11	0.40	-2.74	0.006235
Problem with a sex ratio	-0.78	0.43	-1.83	067730
Heat detection problem	-1.36	0.41	-3.32	0.000894
Untimely insemination	0.99	0.38	2.59	0.009645
Transportation problem	2.89	0.50	5.73	1.01^{-08}

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