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FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE

An investigation of factors contributing to success rate of bovine artificial insemination carried out in Hurungwe district.



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Submission date: 30 May 2026

APPROVAL FORM

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DECLARATION

I Vhiringani Kingsley do hereby declare that this dissertation herein is my original work and has not been copied from any source without acknowledgement of the source. It has not been submitted before for any degree or examination at any other University

DEDICATION

This research project is dedicated to my mother.

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I firstly appreciate the help of the Almighty God for leading me through this beautiful study. I also acknowledge the assistance from my supervisor Mr Pagute and his department who tirelessly helped me to complete this thesis. Great appreciation to my family who provided resources to carry out this research study.

ABSTRACT

Artificial insemination (AI) is the main used reproductive biotechnology in the world when it comes to livestock production. It offers important advantages in genetic improvement and disease control. In Zimbabwe, it is not adopted as it should, although it has all these benefits. This study sought to investigate the factors contributing to bovine AI success rates in Hurungwe District. The main objective was to examine factors contributing to the success rates of bovine AI services within the district. Specific objectives included determining the role of government and private sector extension in supporting bovine AI; identifying the sources of semen used by farmers practicing AI and assessing the level of knowledge and experience of individuals conducting AI in the district. 100 cattle farmers were used after stratified random sampling from a population of 400 which consist of communal, smallholder, commercial beef and dairy farmers. Extension officers, AI technicians and veterinary officers were also engaged through purposive sampling. Interm of data collection structured questionnaires and interviews were used and the data was analyzed using SSPS. The study showed that the majority of participating farmers (45%) were aged 40– 50 years, with 80% having attained secondary education. Regarding semen supply, private companies contributed 60% of semen used in the district, followed by university processing units at 25% and NGOs at 15%. Organizational roles were divided with Agritex providing farmer education, the Veterinary Department overseeing animal health, the Research Department conducting semen evaluation and NGOs offering financial aid. Interm of knowledge and experience 60% of individuals conducting AI were non-skilled or untrained and a further 20% were only semi-skilled, this shows that 80% of practitioners lacked formal technical competency. Only 20% were classified as trained or fully skilled. AI success in Hurungwe District is mainly affected by a shortage of skilled personnel, a weak semen supply chain, partitioned institutional coordination and limited infrastructure. The study recommends the establishment of at least one community-based semen and liquid nitrogen storage depot in the district. It also advocates on a restructuring of Agritex extension programmes to include AI-specific modules covering estrous detection, semen handling, nutritional management of breeding females. The department of Veterinary services must train post-AI pregnancy monitoring skills since it's part of gap identified.

Keywords: Artificial Insemination, small scale farmers, success rates, livestock

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ABBREVIATIONS

AI	Artificial Insemination
NGO	Non-governmental organization
USAID	United States Aid
RCZ	Research Council of Zimbabwe
LN2	Liquid Nitrogen
BSC	Body Condition Scoring
THI	Temperature Humidity Index
FMD	Foot and Mouth Disease
IBR	Infectious bovine rhinotracheitis

CHAPTER 1

INTRODUCTION

1.1 Background

By 2050, total world numbers will hit roughly 9.3 billion people, putting huge stress on farming groups to make at least 60 percent extra food now needed for rising needs. Getting enough and lasting yield from limited nature resources is thus a key focus area. This calls for basic changes in food and farm setups ones that keep food safe and nutrition secure, create money and social chances and protect eco systems (M. Andrea *et al.*, 2020).

According to the Food and Agriculture Organization of the United Nations (FAO), food making relies on meat output and should rise greatly, especially where big grass lands and agricultural fields exist like Zimbabwe. Per DVS Cattle Situation Report 2024 written by Dr Biko Gadaga, Zimbabwes main beef group went up 1.3 percent, going from 5,642,400 cows in 2022 to 5,718,523 in 2023, hitting 5,741,397 by 2024. Keeping and speeding this growth path means taking better breeding technologies with artificial insemination being top easy and strong fix available.

Inside Zimbabwe, artificial insemination work comes from mixed private firms, non government organizations and development projects. Within private sectors, Excel Breeding Consultancy gives AI help for goats, pigs, cows and dogs; Devor Livestock Solutions pushes digital AI and D Zhou supplies AI aid for cows using normal and sexed sperm for milk and beef types. Within the NGO and development project sector, Mimosa Mining runs a livestock revitalization programme using AI to improve cattle genetics among communal farmers in the Zvishavane and Mberengwa districts (Takudzwa Mahove, 2025).

The Value Project backs the creation of pig AI stations to provide cheap semen to small and medium-sized producers. Farm Zimbabwe, supported by USAID and Feed the Future, has pushed AI methods across chosen districts. The Research Council of Zimbabwe (RCZ) finances AI-linked research projects together with Lupane State University, Chinhoyi University of Technology and Bindura University of Science Education.

Government also started the National Artificial Insemination Rollout Programme in 2018, aiming for nationwide reach via partnerships with mining firms to bring AI services to rural farming communities (Government of Zimbabwe, 2020). Artificial insemination for livestock in Zimbabwe is mainly managed by the Department of Livestock Production and Development and the Department of Livestock Research. The Department of Livestock Production and Development, working inside the Ministry of Lands, Agriculture, Fisheries, Water and Rural Development, holds a key part in pushing AI uptake by running animal production schemes and helping move new breeding technology to farmers, thus raising national livestock productivity.

Proof of AI success in Zimbabwe appears in a study done among smallholder dairy farmers in the Nharira and Lancashire farming areas, showing the workability and relative effectiveness of AI when farmers get enough training and take active parts in handling the process (Mutukumira et al., 2002). A 2016 study recorded an overall conception rate of 59%. Since 2018, government-led AI programmes in provinces such as Matabeleland South targeting the reduction of inbreeding and the introduction of superior genetics from breeds including Boran and Tuli.

The primary legislative framework governing AI services in Zimbabwe is the Animal (Artificial Insemination) Act of 1955. This Act establishes a permit-based regulatory system centred on inspection, training and genetic improvement. Any entity seeking to collect, sell, import or export animal semen or to carry out the AI procedure must obtain a permit issued by the Minister of Agriculture. The Act further empowers veterinary officers to inspect premises, equipment, animals and records associated with AI activities. It also enables accredited agricultural institutions including Bindura University of Science Education (BUSE) and Chinhoyi University of Technology (CUT), to conduct training programmes for farmers and AI technicians.

This study now fits into the Agricultural Industry by equipping farmers, extension officers, AI technicians and the government on factors which is leading to low success rates of bovine artificial insemination in Hurungwe district.

1.2 Problem Statement

I observed there is poor growth performance of calves currently produced in the district as a result of inbreeding depression after natural mating. There is low success rates of artificial insemination of cattle farmers already practicing in the district. There is generally a challenge in

timing, technical application of artificial insemination and semen handling procedures. The investigation of factors contributing to success rates of bovine artificial insemination seeks to give answers to these problems.

1.3 Justification

Following the analysis of factors affecting bovine artificial insemination outcomes in Hurungwe district, this aids the district regarding government and NGO funding for AI services. Since our nation initiated a National AI Rollout Programme in 2018, Hurungwe ranks among selected districts. Knowing what functions well or poorly directs future resource distribution and policy choices. In Hurungwe exists a substantial cattle population yet low productivity because of inferior genetics. AI enhances genetics thus determining causes of failure assists farmers resolving problems, therefore adopting AI improves breeds possessing higher productivity within the district. Research findings assist informing Extension services too. It executes training courses regarding conducting AI properly and technical assistance tailored to farmer requirements in the district. Outcomes from the research aid contributions toward sustainable breeding initiatives such as group breeding schemes/nucleus breeding.

The study backs long-term breeding plans targeting climate-adaptive, disease-resistant and more productive herds matching Zimbabwe's Livestock Growth Plan. A reason AI fails could stem from lack of localized research in the district. If research indicates scarce data regarding AI results within the district, this work bridges the void by concentrating solely on Hurungwe, offering information to guide local extension activities and national strategy. The investigation assists farmers in tackling elements influencing the effectiveness levels of AI programs. This enables them to choose between adopting AI following cost-benefit evaluation or selecting natural breeding instead

1.4 OBJECTIVES

1.4.1 Main objective

To examine factors that contribute to the success rates of AI services in Hurungwe district.

1.4.2 Specific Objectives

1. To determine the role of government and private sector extension on bovine artificial insemination of farmers.

2. To determine the source of semen used by farmers who are practicing artificial insemination in Hurungwe.

3. To determine the level of knowledge and experience of individuals carrying out artificial insemination of cattle in Hurungwe district.

1.5 Hypotheses

H_0 There is little government and private sector extension staff involvement, those available have little or no knowledge of AI, as well as having poor source of semen.

H_1 There is more government and private sector extension staff involvement, full of knowledge of AI and they have a good source of semen.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

High reproductive performance is one of the primary goals for both dairy and beef farm cows, and artificial insemination (AI) is the first and most widely used biotechnology in reproduction worldwide (Varisanga, 2024). AI is frequently used in animal breeding to enhance livestock genetic traits because it makes it possible to carefully breed animals with desired traits, which raises livestock quality and productivity (Marques *et al.*, 2020). Less than 2% of breed able females are inseminated in Africa, despite artificial insemination's proven success worldwide. This low level of efficiency is primarily caused by a number of factors, including inadequate infrastructure, management problems, financial limitations, inadequate heat detection and inappropriate timing of insemination as well as additional social issues (Alvarez *et al.*, 2025).

The success rates of bovine AI will be examined in this review of the literature, with an emphasis on their applicability and possible influence in the Hurungwe District of Zimbabwe. Comprehending these contributing factors is essential for creating focused interventions and guaranteeing the effective execution of AI initiatives in comparable socioeconomic and geographic contexts.

2.2 Biological and Physiological Factors Affecting AI Success

2.2.1 Estrous Detection Inefficiency

The accurate identification of cows or heifers in estrus is the most restrictive aspect of artificial insemination programs. Every 18 to 24 days, sexually mature, non-pregnant female cattle go through a period known as estrus, or "heat," during which they are open to mounting activity by bulls or other cows (Perry, 2021). For AI to be successful, estrus must be accurately identified. In order to boost pregnancy rates, estrus detection rates and reproductive efficiency, all of which have a direct impact on the success of AI programs—efficient and accurate estrus detection is crucial (Marques *et al.*, 2020).

Many farmers adhere to what is referred to as the a.m.– p.m. rule, according to which a cow observed in estrus in the morning should be inseminated around the same time that afternoon and a cow in estrus in the afternoon should be bred the following morning (Bayemi, 2012). While this heuristic offers a practical guideline, it lacks the precision afforded by modern detection technologies such as activity monitors, progesterone assays and electronic heat detection patches. In Hurungwe where access to such technologies is limited, farmers are disproportionately exposed to the risks associated with missed or incorrectly timed inseminations

2.2.2 Semen Quality and Handling

Conception rates can be considerably decreased by storage (Abeygunawardena *et al.*, 2021). Strict adherence to cold-chain procedures and hygienic practices is necessary for effective semen handling in order to avoid contamination or sperm viability loss (Al-Rawashdeh *et al.*, 2023). Due to subpar semen handling procedures, areas like Hurungwe, where access to trustworthy semen storage and qualified staff may be scarce, are more vulnerable to AI failure (Mutambara *et al.*, 2025).

Long-term semen preservation depends equally on the upkeep of liquid nitrogen (LN2) supply chains. Many communal and smallholder farming districts in Zimbabwe, including Hurungwe, lack a consistent supply of liquid nitrogen, so semen is either stored in hazardous conditions or purchased at significant expense from far-off suppliers (Mutambara *et al.*, 2025). A disruption in the LN2 supply may result in the total loss of important genetic material, which would be a financial loss as well as a lost chance to procreate. Therefore, addressing the LN2 logistics chain is crucial for Hurungwe District's AI programs to be sustainable (Al-Rawashdeh *et al.*, 2023).

2.2.3 Insemination Technique and Technician Skill

The success of AI is largely dependent on the expertise and proficiency of the AI technician (Rathore *et al.*, 2022). Low conception rates or reproductive harm can result from improper insemination methods, such as depositing semen in the cervix rather than the uterine body or handling semen improperly during the thawing process (Fikremariam *et al.*, 2024). According to Arthur *et al.* (2008), accurate insemination methods and accurate anatomical knowledge are crucial.

A key factor in the success of AI is the availability of skilled and knowledgeable AI technicians, which could be a barrier in rural areas. The technique of insemination is developed through practice with live animals. With repeated practice and mentored supervision, the ability to correctly and skillfully place semen in the right place within the reproductive tract using hygienic and appropriate techniques improves (Perry, 2021). Without proper supervision and ongoing professional development, technicians may become accustomed to using improper techniques over time, resulting in consistently produce results that cannot be attributed to technique (Ndlovu *et al.*, 2023).

AI technicians may receive training in brief workshops that offer theoretical knowledge but little practical experience in many developing nations. According to a 2024 study by Fikremariam *et al.*, conception rates were positively correlated with technician experience as indicated by the quantity of inseminations carried out.

2.2.4 Nutritional Status of the Breeding Female

The success of AI in cattle is significantly influenced by nutritional status. Seasonal feed shortages and low-quality pastures frequently cause energy and protein deficiencies in Southern Africa, which hinder ovarian activity and postpone the onset of estrus (Cooke *et al.*, 2024). These deficiencies result in poor estrus expression and decreased conception rates after AI by reducing follicular development and ovulation rates (Fushai and Oke, 2025). Estrous cyclicity and conception efficiency are disrupted by inadequate mineral intake, particularly phosphorus, selenium and copper, which have been connected to hormonal imbalances (Ndhlovu *et al.*, 2023).

According to Magwede *et al.* (2025), cows with a BCS of less than 2.5 on a scale of 1 to 5 exhibit considerably less cyclicity and lower conception rates than those with a score of 2.5 to 3.5. AI success may be impacted in Hurungwe, where smallholder farming is common, because it can be challenging to supplement high-quality pasture, particularly during dry seasons. The district's farmers mainly rely on communal grazing, which deteriorates significantly between May and October during the dry season, which also happens to be the typical AI window for

planned calving. It has been demonstrated that protein supplementation enhances BCS recovery, ovulation rates, and estrus expression during the transitional phase prior to AI.

An economical way to enhance AI results in Hurungwe is to incorporate strategic supplemental feeding into AI programs, such as the use of urea-molasses blocks, crop residue treatment and the introduction of legumes (Fushai and Oke, 2025). Therefore, nutrition should be covered by extension services as a necessary part of any AI advisory program.

2.3 Management and Environmental Factors

2.3.1 Herd Management Practices

The efficacy of AI services is diminished by inadequate organizational support and poor record-keeping resulting in ineffective service delivery and low conception rates (Tola, 2025). Tola emphasizes that the implementation of AI in many African livestock systems is hampered by issues like inadequate infrastructure, poor heat detection and technician coordination. Making educated reproductive decisions requires accurate herd records that include calving dates, prior AI attempts, pregnancy outcomes and each animal's medical history.

Many communal farmers in Hurungwe rely on memory and casual observation rather than keeping official herd records. It is nearly impossible to assess the effectiveness of AI programs, find repeat breeders, or identify systemic issues with program implementation due to this lack of documentation. Therefore, structured record-keeping systems should be an essential part of the service delivery frameworks of AI programs funded by the government and non-governmental organizations (Government of Zimbabwe, 2020).

By enabling batch insemination on predetermined dates, hormonal protocols like Synch (GnRH–PGF2 α –GnRH) have been widely used to synchronize estrus and increase the effectiveness of AI delivery. However, these procedures call for careful timing, trained personnel to administer injections and cold-chain preservation of hormones (Cooke et al., 2024). Conception rates may be no higher than those obtained through natural estrus detection in situations where implementation is inconsistent (Magwede *et al.*, 2025). It is therefore essential to implement

suitable context-specific synchronization protocols that correspond with the resource availability of Hurungwe's various farming systems.

2.3.2 Housing and Environmental Stress

It has been demonstrated that environmental stress, especially heat stress, dramatically lowers AI success. According to research, heat stress during insemination reduces the likelihood of a successful conception; higher temperature-humidity index (THI) values are associated with lower rates of conception (Baccouri *et al.*, 2025). According to Baccouri *et al.* (2025), severe heat stress has the greatest detrimental impact and even mild heat stress during insemination significantly reduces the likelihood of pregnancy.

By upsetting hormonal balance and lowering oocyte quality, heat stress also has an impact on cows' physiological reproductive processes, which further lowers fertility outcomes (Khan, 2023). Peak temperatures in Hurungwe District can reach 35°C in October, during the AI breeding season for many farmers who aim for a July– August calving window. Dairy cows and crossbreeds start to exhibit detectable reproductive depression at THI values greater than 72. Heat stress management must be included in AI program design because a large portion of Hurungwe is located in agro-ecological Regions 3 and 4, where temperatures are constantly high and shade and water resources are scarce. Thermal stress-related conception failures can be reduced by providing shade structures, strategically timing AI during cooler morning hours and choosing more heat-tolerant breed combinations.

2.3.3 Disease Control and Biosecurity

In sub-Saharan Africa, reproductive disorders are a significant factor in AI failure. According to a 2025 study conducted in South Africa's Limpopo Province, inadequate farmer knowledge and delayed disease detection, particularly for brucellosis and foot-and-mouth disease (FMD), result in ongoing pathogen circulation in herds, endangering both AI outcomes and reproductive health (Kiayima *et al.*, 2025). According to a community-based surveillance project in Uganda, livestock abortion cases that underlie outbreaks of Rift Valley fever or brucellosis go mostly unreported and interfere with AI by keeping breeding females out of service (Walekhwa *et al.*,

2023). Inadequate biosecurity can lower AI conception efficiency and raise the risk of reproductive tract infections in breeding cows (Ngom *et al.*, 2024).

The communal grazing system in Hurungwe permits close contact between cattle of various ownership and health status, which fosters the spread of sexually and contact-transmitted reproductive pathogens like infectious bovine rhinotracheitis (IBR), vibriosis (bovine campylobacteriosis), and bovine trichomoniasis. Herd-level conception rates can be increased by identifying and eliminating high-risk animals through pre-AI reproductive health screening, which includes vaginal discharge assessment and a history of prior reproductive failures. District livestock health calendars should incorporate brucellosis and IBR vaccination programs as a requirement for taking part in government-funded AI initiatives.

2.4 Socio-Economic and Infrastructure Factors

According to a recent study conducted in Botswana, the use of AI services by beef farmers was significantly correlated with socioeconomic characteristics such as age, occupation, educational level, farming purpose and land type. This suggests that production and demographic factors affect the adoption of AI among smallholder and commercial farmers in the region (Thutwa *et al.*, 2024).

2.4.1 Farmer Knowledge and Awareness

Farmers may be reluctant to adopt AI technology, adopt it incorrectly and ultimately fail due to a lack of knowledge about its advantages, timing, and the significance of good management practices. Because valuable AI equipment and semen can be seriously harmed without proper training, adequate supervised guidance is crucial. To guarantee high fertility, frozen semen needs to be handled and stored using extremely specific methods (American Breeders Service, 1988). In their study on AI adoption in Zimbabwe, Makina *et al.* (2019) identified farmer knowledge as a critical success factor. This disparity may be significant in Hurungwe, where extension services may be scarce.

According to a study by Tavirimirwa *et al.* (2025) on smallholder farmers' opinions of AI technology in Beitbridge, Zimbabwe, many farmers held false beliefs about AI, such as the idea

that AI-conceived calves were intrinsically weaker and that AI was more expensive than natural mating without a commensurate benefit. These largely false beliefs hampered program sustainability and contributed to low AI adoption rates. Improving Hurungwe's adoption of AI requires addressing these misconceptions through focused farmer education campaigns that use evidence-based messaging. Although women oversee daily livestock care in many smallholder farming systems and are best suited to identify estrus, AI training and extension services are frequently targeted disproportionately at male household heads (Chimonyo, 2021). Program outcomes and overall detection efficiency can be enhanced by making women the main focus of AI training initiatives.

2.4.2 Access to Services and Infrastructure

The effectiveness and uptake of AI services in developing country contexts have been found to be significantly impacted by issues like a lack of extension services, inadequate inseminator skills, and inadequate infrastructure (Mekonnen *et al.*, 2024). In Hurungwe's more isolated wards, where roads become impassable during the rainy season, road infrastructure is a specific limitation. Any logistical delays brought on by inadequate road infrastructure can directly result in missed conception opportunities because AI success is extremely time-sensitive, requiring insemination to take place within a certain window relative to ovulation. Liquid nitrogen availability and infrastructure quality are closely related. It is necessary to transport liquid nitrogen safely and to replenish it periodically. The closest LN2 refill station in Hurungwe might be in Karoi or farther away, which presents significant logistical difficulties for communal farmers in outlying wards. A workable solution for increasing semen access and lowering the risk of cold-chain failure could be the creation of community-based semen storage depots, possibly located inside agricultural extension offices (FAO, 2021).

2.4.3 Economic Constraints and Affordability

Smallholder farmers' adoption of AI technology is constrained by the expense of acquiring and maintaining it due to infrastructure and economic factors (The Diversity Institute, 2025). Semen straws, a liquid nitrogen tank, the AI gun and sheaths, hormones for synchronization, veterinary consultation, and technician fees—which range from \$20 to \$40 USD per insemination attempt—are among the direct costs of AI in Hurungwe. The total cost per calf born may be

higher than anticipated because conception on the first try is not guaranteed. Recurring AI costs may be too much for smallholder farmers with subsistence or near-subsistence margins, especially after unsuccessful attempts. Even when the long-term genetic benefits of AI are known, this economic vulnerability may cause farmers to return to natural mating following early AI failures. Potential strategies for lowering financial barriers to AI adoption in Hurungwe include government-subsidized AI programs, group-purchasing cooperatives for semen and LN2, and results-based financing models where payment is dependent on confirmed pregnancy.

2.4.4 Institutional Support and Extension Services

Institutional preparedness for AI adoption is dependent on coordinated training frameworks and governance structures within extension networks in addition to tool access, according to FAO (2021) and Hansen (2020). The importance of robust extension systems in advancing livestock technologies was highlighted by Kachali *et al.* (2015). Inadequate or nonexistent extension services may deprive farmers of the direction and assistance they need to make effective use of AI. Support for AI extension is required of Zimbabwe's Department of Livestock Production and Development (DLPD), which is part of the Ministry of Lands, Agriculture, Fisheries, Water, and Rural Development. However, many districts have fewer functional extension officers due to resource limitations. The 2020 Livestock Recovery and Growth Plan recognized the necessity of decentralizing AI services and increasing the density of extension workers with AI training (Government of Zimbabwe, 2020).

Many AI-practicing farmers in Hurungwe operate without regular access to technical support due to the insufficient ratio of extension officers to farming households. This gap has been partially filled by private sector players and non-governmental organizations (NGOs). AI training and semen supply support have been implemented in certain districts of Zimbabwe by organizations like Farm Zimbabwe (supported by USAID/Feed the Future) and Mimosa Mining's livestock revitalization program (Takudzwa Mahove, 2025). Their experiences provide valuable insights into partnership models that Hurungwe might be able to duplicate or expand.

2.5 Review of Related Studies on Artificial Insemination

Magwede *et al.* (2025) assessed the effects of semen quality characteristics and synchronization protocols on fertility outcomes and reproductive efficiency in Zimbabwean dairy cattle production. They also assessed the impact of body condition score on reproductive performance. Due to the omission of other potential causes of AI failure, this leaves a gap in the literature. Even if a cow has a good BCS of 2.5– 3, which is ideal for reproduction, and the best-quality semen is used, the results will be subpar if the procedure is carried out by a technician with inadequate training. Nutrition is another important consideration; the particular nutrients given to the breeding stock must be evaluated in addition to the BCS. By analyzing every element influencing AI success rates, determining the primary determinants and suggesting remedies, the current study closes this gap.

A study by Mpofu (2002) examined the significance of breeding infrastructure and support services in connection to the success or failure of AI as a means of distributing genetic material to Southern African smallholder dairy farmers. The main focus of that study was infrastructure, so it is unable to fully explain why AI is failing in Hurungwe District in particular. Hurungwe, many farmers who use AI operate without regular access to technical support because the ratio of extension officers to farming households is still insufficient. This gap has been partially filled by private sector players and non-governmental organizations (NGOs). AI training and semen supply support have been implemented in certain districts of Zimbabwe by organizations like Farm Zimbabwe (supported by USAID/Feed the Future) and Mimosa Mining's livestock revitalization program (Takudzwa Mahove, 2025). Their experiences provide valuable insights into partnership models that Hurungwe might be able to duplicate or expand.

Tavirimirwa *et al.* (2025) investigated the perceptions of communal farmers in Beitbridge, Zimbabwe, regarding the adoption of AI technology. Because farmers may not fully understand reproductive technology and may share biased or incomplete information because of social desirability concerns, perceptions alone cannot provide trustworthy answers. Because data will be collected from a variety of stakeholder groups, including farmers, extension agents and inseminators, the current investigative study on the factors influencing AI success rates will be more trustworthy due to the triangulation of perspectives to reach more solid conclusions.

Mutukumira *et al.* (2002) studied smallholder milk production, handling, and utilisation in the Nharira and Lancashire farming areas of Zimbabwe, reporting an overall conception rate of 59% following AI in smallholder dairy settings. This historical benchmark illustrates both the potential and the limitations of AI under smallholder conditions. Given the 23 years that have elapsed since this study, updated evidence reflecting current farming conditions, breed compositions and extension service realities in Hurungwe is essential for informed policy-making.

CHAPTER 3

METHODOLOGY AND EXPERIMENTAL DESIGN

3.1 Study Area

Hurungwe district is located 205km away from Harare, the capital city of Zimbabwe. It has different agro ecological natural regions, that is some parts are in natural region 2, some region 3 and others region 4. The main town is Karoi located in the highly productive natural region 2,

practicing intensive farming. Other parts of the district are classified under region 3 a semi-intensive farming region with moderate and less reliable rainfall which ranges from 500 - 700mm per year. The lower-lying northern and southern areas of the district, particularly towards the Zambezi Valley for example the Hurungwe Safari Area are in natural region 4, which is a semi-extensive farming region with low rainfall (400 - 650mm) per year. The land use of the district is primarily based on livestock production, forestry and wildlife. Hurungwe District, located in Mashonaland West Province of Zimbabwe and is generally situated between 16°S - 17°S latitude and 29°E - 30°E longitude

In Hurungwe district, livestock production is an important activity within a mixed crop-livestock farming system, with the primary types including cattle, goats and poultry. The dominant form of livestock in the district and a key asset for most rural livelihoods is cattle production. Cattle are raised for multiple purposes such as draught power, milk production for semi-intensive milk production and household consumption, meat (beef) production and a source of income through sales. Both local Mashona-type cattle and improved dairy cattle/crossbreeds like Brahman pure and crosses are reared. The physical topography of the Hurungwe district is varied, characterized by a mix of elevated central plateau areas and lower-lying regions. The district's elevation ranges significantly, from a minimum of approximately 325m to a maximum of 1459m above sea level. Throughout the year, Hurungwe district experiences a temperature range generally from a low of around 7°C in July to a high of around 35°C in October.

3.2 Cattle production systems

In Hurungwe district farmers practices two types of cattle productions which are intensive and extensive production system. These systems are practiced both in beef and dairy productions. Beef is practiced at large and small scale while dairy is done at small scale in farms like Brockley farm.

Artificial insemination is a process through which cows are bred by a technician using pre-collected semen, as opposed to natural breeding (Hammonds Tara, 2025). Foote, described it as a reproductive biotechnology technique in which semen is collected from male animal, processed and then deliberately introduced into the reproductive tract of a female using specialized equipment, without natural mating.

3.3 Reasons for Artificial Insemination

AI helps in genetic improvement. It allows the use of superior sires with desirable traits for example high milk yield across many females, accelerating genetic progress (Hansen, 2020). AI helps in disease control by reducing the transmission of sexually transmitted diseases since there is no direct physical contact between male and females (Diskin and Kenny, 2018). AI helps in the efficient use of semen. A single ejaculate can be diluted and used to inseminate multiple females, increasing the reproductive potential of valuable males (Perry, 2021). AI facilitates breeding management by enabling better control of breeding schedules, including synchronization of estrus and planned calving or lambing seasons (Hansen, 2020).

The procedures of Artificial Insemination are as follows: 1. Semen Collection- Semen is collected from a healthy male using methods such as an artificial vagina or electro-ejaculation (Noakes *et al.*, 2019). 2. Semen Evaluation and Processing- The semen is evaluated for quality (motility, concentration, morphology) and diluted with extenders to preserve sperm cells (Perry, 2021). 3. Semen Storage- Semen may be used fresh or frozen and stored in liquid nitrogen at -196°C for long-term preservation (Foote, 2019). 4. Heat Detection in Females- Females must be identified in estrus (heat) since this is the optimal time for insemination (Diskin and Kenny, 2018). Finally, the insemination technique is carried out through a procedure of semen thawed, a sterile AI gun is loaded with semen, and the gun is inserted into the reproductive tract in the uterus in cattle. Semen is deposited at the correct site for fertilization (Noakes *et al.*, 2019). Post-Insemination Management- Animals are tested monitored for pregnancy success rate and proper care is given to those conceived, (Hansen, 2020).

3.4 Study population and sampling

The study was carried out in Hurungwe district of Mashonaland West Province of Zimbabwe while targeting communal, smallholder, commercial beef cattle farmers and a small portion of dairy farmers. The research also involved AI technicians, government extension officers, veterinary officers and NGO livestock programme personnel.

In order to determine the role of government and private sector extension on bovine artificial insemination of farmers, the source of semen used by farmers who participated in artificial insemination as well as determining the level of knowledge and experience of individuals carrying out artificial insemination of cattle in Hurungwe district, the study administered some

questionnaires to selected participants. Target population were cattle farmers and a few selected individuals from partners in the ministry within the district such government officials.

The study used purposive sampling for key informants (extension officers, AI technicians). It also used stratified random sampling for selecting participating cattle farmers. A total of 100 farmers were used in the study survey out of 400 cattle farmers in the district. The final selected strata were as follows: 30 from communal, 30 from smallholder and 30 from commercial beef cattle farmers, 10 of dairy cattle production.

3.5 Experimental Designs

The study area constituted of 400 cattle producing farmers in the whole district. Each cattle producing farmer out of the 400 was having 3 cows to be inseminated and pregnant diagnosis was carried out to find out the cows which were already pregnant and some were found to be pregnant. A total of 100 cattle farmers with 1 cow each were found suitable for insemination and their cattle were inseminated while using semen which was purchased.

3.6 Data Collection

The researcher examined selected cattle producing farmers using questionnaires and interviewing livestock specialist on extension services provided by the government and private companies in order to have a deeper insight into the study. The researcher also assessed the monitoring and evaluation programs in relation to AI practiced by veterinary department, the department of livestock production and development and the department of livestock research in-order to establish their roles within the program of AI. The researcher also examined any government inclusion and private sector in the district in order to further examine their involvement in semen availability and AI program as a whole.

The researcher also examined the source of semen used by farmers who participated in the AI program. The researcher also assessed the availability of any semen processing unit in the district as well as the ones that were used in the program. The researcher also investigated the proximity and estimated time frame required for the farmers to reach the semen processing units. The researcher also investigated on the availability and accessibility of liquid nitrogen in the area and if farmers were able to buy and use liquid nitrogen for the preservation of semen either fresh or frozen semen.

The researcher also used key informants interviews and questionnaires to determine the level of knowledge and experience of individuals carrying out AI of cattle in Hurungwe district. From the questionnaire there was a section which was asking the cattle producing farmer or the technician to state times he performed the procedure, successes, failures and the training center where one got information on AI procedures.

3.7 Data analysis

The collected data was entered in to the Microsoft Excel sheet and then descriptive statistics like percentages and tables to summarize the data were produced. The data was further analyzed using the Social Statistical Package of Scientific Study (SSPS).

CHAPTER 4

RESULTS

4.1. Demographics of participants

4.1.1 Age groups

Below in table 4.1 are the age groups of the 100 cattle farmers who participated in the cattle artificial insemination programme. The results revealed that majority of farmers out of the selected were in the age range of 40 to 50 years. A significant number of farmers 25 % were in the age range of 30 to 40 years. Farmers above 50 years of age were contributing 20 % while the least 10 % were of 20 to 30 years.

Table 4.1: Age groups of participating farmers

Age range (years)	Number of farmers	Percentage
20 – 30	10	10%
30 – 40	25	25%
40 – 50	45	45%
50+	20	20%
Total	100	100%

Below is a chart that indicate the age ranges of the farmers who participated in AI programme in Hurungwe district.

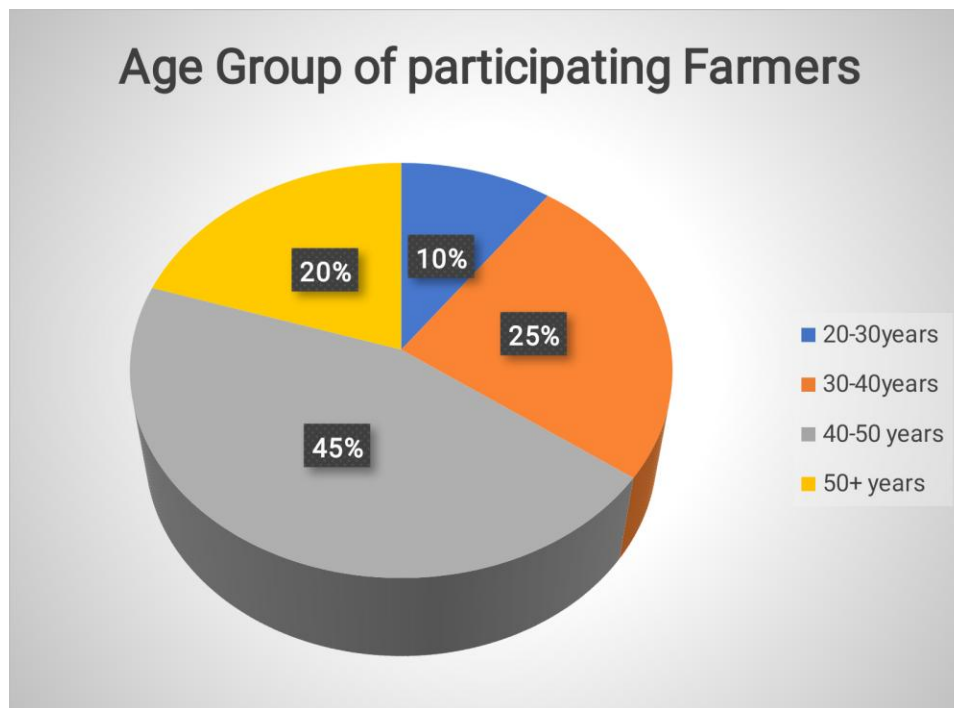


Figure 1: Chart of participating age ranges

4.2 Level of Education

Table 4.2 below indicates that most farmers (80 %) who participated in the artificial insemination programme had at least secondary level of education, followed by those farmers

(15 %) who had tertiary level of education. A significantly smaller amount (5 %) of the farmers had primary level.

Table 4.2: Level of education of participating farmers

Level	Percentage (%)
Primary	5
Secondary	80
Tertiary	15

Below is a chart that indicate the level of the education farmers who were selected and participated in AI programme.in Hurungwe district.

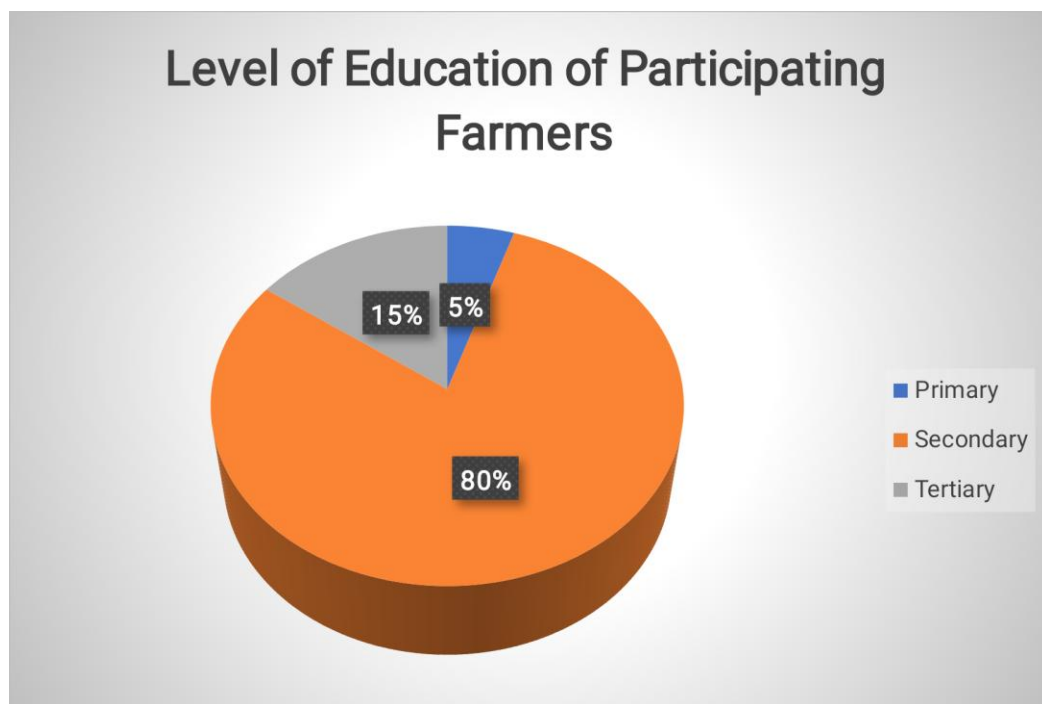


Figure 2: Level of Education of participating farmers

4.3 Roles of organization in AI

The results revealed as indicated in table 4.3 below, shows that each organization have its own role in the process of artificial insemination process which was carried out. The results indicated that Agritex have an educating role in relation to the AI carried out in the area. The department of veterinary field services have been identified to have a major role in ensuring the health of cattle to be inseminated to be in good condition. Research department was observed to be involved in the testing and evaluation of semen used in the AI programme. Non-governmental Organizations were identified to be financing the farmers who participated in the AI programme.

Table 4.3: Roles of Organization on AI

Organization	Percentage (%)
Agritex	Education
Veterinary	Animal Health
Research	Semen Evaluation
NGO	Financial Aid

4.4: Source of semen used for AI

Table 4.4 illustrate source of semen used in Hurungwe district and the percentage of their provision during the program of bovine AI. Private companies are playing the leading role in supplying semen to the study area having 60%, followed by universities processing unit supplying 25% of the semen used. A significant smaller percent is on NGOs supplying 15%.

Table 4.4: Source of semen used by farmers

Organization	Percentage (%)
Universities	25
Private Companies	60
NGO	15

Below is a chart that indicate the source of semen used farmers who were selected and participated in AI programme.in Hurungwe district.

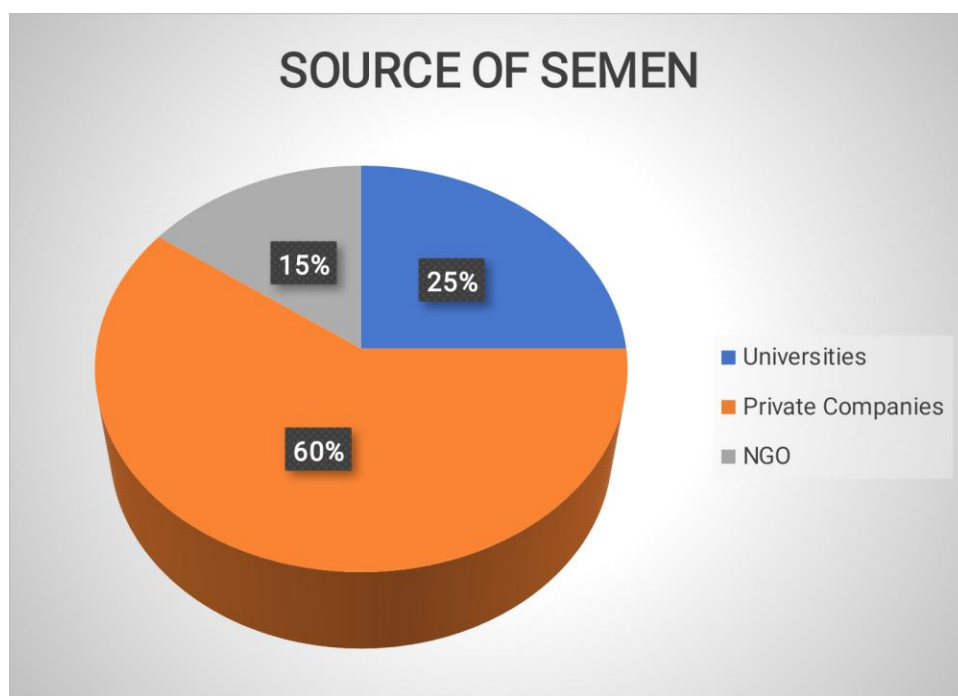


Figure 3: Chart of semen source

4.5: Knowledge and experience of individuals conducting AI

Table 4.5 below, shows the level of knowledge and experience of individuals who took part during the programs of cattle artificial insemination. The results shows that most of the people who took part in the program were non-skilled having 60 %, 20 % were semi-skilled. The other two categories which are trained and skilled constitute 20 % of the total individuals who participated in the program of bovine artificial insemination, 10 % are trained and the other 10 % skilled .

Table 4.5: Knowledge and experience of individuals conducting AI

Categories	Number	Percentage
Trained	10	10%
Semi-Skilled	20	20%
Skilled	10	10%
Non-skilled/non trained	60	60%

Below is a chart that indicate the source of semen used farmers who were selected and participated in AI programme.in Hurungwe district.

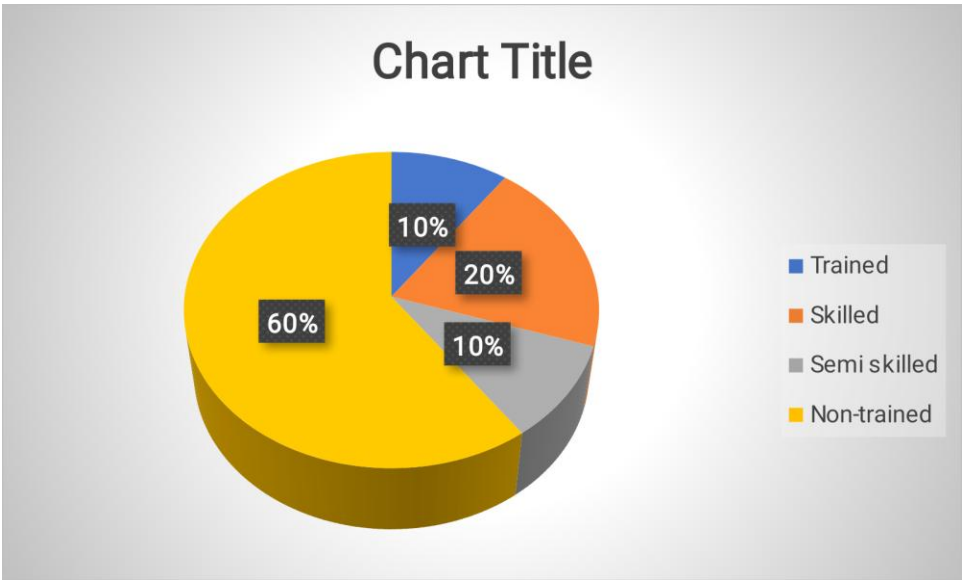


Figure 4: Level of knowledge and experience of participants

CHAPTER 5

DISCUSSION

5.1 Demographic Profile and Its Implications for AI Adoption

The results revealed that 45% of participating farmers ranges from 40-50 years of age. These are middle aged farmers who can accept the introduction of new technologies when compared to older farmers. However, the low representation of young farmers (20-30 years) which constitute 10% of the participants is of great concern. It shows a potential succession gap in AI services that could remove the long-term sustainability of the reproductive technology in the district. This finding aligns with Thutwa *et al.* (2024), who established that age significantly influences farmers’ utilization of AI services among smallholder producers in the region.

The study shows that 80% of participants had attained secondary education and this is good since the technology requires secondary education to interpret AI protocols, extension guidance and

maintain basic herd records. Yet, secondary education alone is insufficient for understanding complex reproductive biology and the technical demands of AI. The 5% with only primary education represents a particularly vulnerable group, likely to struggle with adoption without intensive, hands-on support from extension services. This strengthens the justification for this study which says without understanding who is practicing AI and at what educational level, targeted training interventions cannot be designed effectively.

5.2 Roles of Organizations

The results in Table 4.3 shows that the roles of organizations which participate in AI programmes are divided across Agritex (education), the Veterinary Department (animal health), the Research Department (semen evaluation) and NGOs (financial aid). While this multi-stakeholder structure is appropriate in principle, the distinct sharing of roles raises serious coordination concerns.

From the research one can realize that no single organization was identified as taking control of the entire AI program in the district. This gap can be defined as systemic weakness. As Tola (2025) observed, poor organizational coordination directly reduces AI efficiency in African livestock systems. This systemic weakness confirms the problem stated in the justification of this study that, without a clear understanding of which institution is responsible for what, accountability for AI failure is diffused and remedial action becomes difficult to initiate. This study is therefore necessary to map these roles precisely and recommend a coordinated, district-specific delivery framework.

5.3 Semen Source

Table 4.4 showed that 60% of semen supplied in the district comes from private companies, 25% from universities and 15% from NGOs. The heavy dependence on private suppliers who operate on commercial incentives introduces affordability risks for smallholder farmers. As discussed in the literature review, the cost of a single AI attempt in Zimbabwe can reach USD 20–40. Communal farmers cannot afford private-sector priced semen without financial support mechanisms.

The contribution from university processing units (25%) such as BUSE and CUT is of great significance because it shows the relevance of theory to practical livestock improvement.

However, university supply chains are subject to institutional constraints such as limited production capacity and logistical reach. The 15% NGO contribution, while valuable, depends on the project and therefore unsustainable in the long term.

This finding answers one of the core specific objectives of the study to determine the source of semen used by farmers practicing AI and highlights the urgent need for the establishment of community-based semen storage depots as proposed by FAO (2021). The study fills the gap by documenting and addressing the unstable supply of semen in Hurungwe district.

5.4 Knowledge and Experience of AI Practitioners.

The study showed that 60% of individuals conducting AI in Hurungwe District were non-skilled or non-trained (Table 4.5). A further 20% were only semi-skilled, meaning that a combined 80% of AI practitioners lacked formal competency. Only 10% were trained and 10% fully skilled, a combined 20% with demonstrable technical proficiency.

This finding is critical and is the main reason why this study was needed. As established in the literature review, insemination technique is one of the primary determinants of AI conception rates. Fikremariam *et al.* (2024) demonstrated a direct positive correlation between the number of inseminations performed and conception rates, with inexperienced technicians achieving significantly poorer outcomes. The deposition of semen at an incorrect anatomical site, improper thawing technique or inadequate sanitation can each independently cause AI failure, and an untrained practitioner is exposed to all of these risks simultaneously.

This finding confirms the problem statement stated in Chapter 1, that there is a general challenge in the technical application of AI and semen handling in the district. It also validates null Hypothesis that individuals available have little or no knowledge of AI.

This finding also exposes a critical gap that previous studies failed to illuminate for Hurungwe specifically. Magwede *et al.* (2025) focused on semen quality and body condition score; Mpofu (2002) examined infrastructure; Tavirimirwa *et al.* (2025) investigated farmer perceptions. None of these studies evaluated the actual competency profile of AI practitioners operating in this specific district. This study fills that gap with original, locally grounded data.

5.5 Synthesis

Taken together, the results reveal a district where AI is technically possible, institutionally supported in divided ways and yet undermined by a deficit of skilled human capital. There is also an aging farmer base, a poor semen supply chain dominated by one sector, organizational roles and a majority of untrained AI practitioners which creates conditions in which AI failure is obvious.

This is the main reason why this study was needed. Without systematic data collection across farmers, extension officers, technicians and institutional actors in Hurungwe, these factors would have remained invisible to policy-makers and extension planners.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This study set out to investigate the factors contributing to the success rates of bovine artificial insemination (AI) carried out in Hurungwe District. After collecting and analysing data from 100 cattle farmers and some key informants, including extension officers, AI technicians, and institutional actors. The research has generated an evidence specific to the district that fills a critical gap in the existing literature on AI adoption and performance in smallholder communal farming systems. The findings of this study confirm that AI success in Hurungwe District is affected by lack of trained practitioners after revealing that 80% of practitioners are not formally educated on AI. The study also revealed that the semen supply structure in the district is not reliable and affordable to smallholders since it is mainly supplied by commercial suppliers. The roles of organizations that helps in AI services were divided as follows, Agritex offers farmer education, the Veterinary Department assessing animal health, the Research Department conducting semen evaluation while NGOs offering financial aid. This multi-stakeholder structure

has created accountability gaps and coordination failures that directly undermine programme effectiveness.

6.2 Recommendations

The government, in partnership with NGOs and research institutions, should establish at least one community-based semen and liquid nitrogen (LN2) storage depot in Hurungwe District. Agritex extension programmes in Hurungwe should be specifically redesigned to include AI-focused modules covering estrous detection, optimal insemination timing using the a.m.– p.m. rule, basic semen handling precautions, nutritional management of breeding females, and post-AI pregnancy monitoring.

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APPENDICES



**BINDURA UNIVERSITY OF SCIENCE EDUCATION
FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE
DEPARTMENT OF ANIMAL SCIENCE**

RESEARCH QUESTIONNAIRE

*An Investigation of Factors Contributing to Success Rates of Bovine Artificial Insemination in
Hurungwe District*

Dear Respondent

Your responses will be treated with strict confidentiality and used solely for academic purposes.
There are no right or wrong answers.

Please tick (✓) or fill in the appropriate answer.

SECTION A: DEMOGRAPHICS

A1. What is your gender?

☐ Male

☐ Female

☐ Prefer not to say

A2. What is your age group?

☐ Below 25 years

☐ 25 – 34 years

☐ 35 – 44 years

☐ 45 – 54 years

☐ 55 – 64 years

☐ 65 years and above

A3. What is your highest level of education?

☐ No formal education

☐ Primary school

☐ Secondary school (O-Level)

☐ Secondary school (A-Level)

☐ Certificate / Diploma

☐ Bachelor's Degree or higher

A4. What is your role / occupation in relation to bovine AI? (Tick all that apply)

☐ Smallholder farmer

☐ Commercial farmer

☐ AI Technician / Inseminator

☐ Veterinary officer

☐ Agricultural extension officer

☐ NGO / Development project worker

☐ Researcher / Academic

☐ Other (specify below)

Other:

A5. How many years have you been involved in cattle production or AI services?

☐ Less than 1 year

☐ 1 – 3 years

☐ 4 – 6 years

☐ 7 – 10 years

☐ More than 10 years

A6. What is the approximate size of your cattle herd? (For farmers only)

☐ 1 – 5 cattle

☐ 6 – 15 cattle

☐ 16 – 30 cattle

☐ 31 – 50 cattle

☐ More than 50 cattle

☐ Not applicable

A7. Which ward / area of Hurungwe District are you located in?

Ward / Area:

SECTION B: ARTIFICIAL INSEMINATION AND PRACTICE

B1. Are you currently practicing or involved in bovine artificial insemination?

☐ Yes

☐ No

B2. If yes, approximately how many AI procedures have you performed or been involved in (per year)?

☐ 1 – 10

☐ 11 – 30

☐ 31 – 60

☐ 61 – 100

☐ More than 100

☐ Not applicable

B3. What is the approximate conception rate (success rate) you have observed from AI in your herd or practice?

☐ Less than 20%

☐ 20 – 39%

☐ 40 – 59%

☐ 60 – 79%

☐ 80% and above

☐ Not sure / No records kept

B4. Have you received formal training in artificial insemination?

☐ Yes – from the government (e.g., DLPD)

☐ Yes – from an NGO or project

☐ Yes – from a private company

☐ Yes – from a university / college

☐ No formal training received

SECTION C: SEMEN QUALITY AND HANDLING

C1. Where do you source your semen straws?

☐ Government (DLPD / DVS)

☐ Private company (e.g., Devor, Excel Breeding)

☐ NGO / Development project

☐ Importation from outside Zimbabwe

☐ Other farmers / inseminators

☐ I do not handle semen directly

C2. How do you store the semen used for AI?

☐ Liquid nitrogen (LN₂) dewar flask

☐ Dry shipper (short-term transport)

☐ Refrigerator (not recommended)

☐ I do not store semen – sourced on the day

☐ Not applicable

C3. How often do you experience disruptions in your liquid nitrogen (LN₂) supply?

☐ Never

☐ Rarely (once a year)

☐ Sometimes (2–3 times a year)

☐ Frequently (monthly)

☐ I do not use liquid nitrogen

C4. What is the distance to your nearest liquid nitrogen refill station?

☐ Less than 10 km

☐ 10 – 30 km

☐ 31 – 60 km

☐ More than 60 km

☐ I do not know / Not applicable

C5. How do you thaw semen straws before insemination?

☐ Water bath at 35–37°C for 30–45 seconds

☐ Warm water (approximate temperature)

☐ At room or ambient temperature

☐ I do not thaw – used directly

☐ Not applicable / I don't thaw semen myself

C6. Have you ever experienced semen quality problems that you believe contributed to AI failure?

☐ Yes, frequently

☐ Yes, occasionally

☐ No, not that I am aware of

☐ Not sure

SECTION D: EXTENSION AND INSTITUTIONAL SERVICES

D1. How often do you receive a visit from an agricultural extension officer regarding AI?

- | | |
|---|--|
| ☐ Monthly or more | ☐ Every 2–3 months |
| ☐ Once or twice a year | ☐ Rarely / almost never |
| ☐ Never | |

D2. Which organizations provide AI-related support in your area? (Tick all that apply)

- | | |
|---|---|
| ☐ Government (DLPD / DVS) | ☐ NGOs (e.g., Farm Zimbabwe) |
| ☐ Private companies | ☐ Mining company programmes (e.g., Mimosa) |
| ☐ Farmer cooperatives / groups | ☐ None / no organizational support |

D3: How do you rate the quality of AI extension services available to you in Hurungwe?

- | | |
|--|-------------------------------|
| ☐ Excellent | ☐ Good |
| ☐ Fair | ☐ Poor |
| ☐ No services available | |

D4. Do you feel the AI costs (semen, LN₂, equipment, technician fees) are affordable?

- | | |
|---|---|
| ☐ Very affordable | ☐ Somewhat affordable |
| ☐ Unaffordable | ☐ Only affordable with subsidies |
| ☐ I have not used paid AI services | |

D5. Is government financial support / subsidy available for AI in your area?

- | | |
|--|--|
| ☐ Yes, and I have accessed it | ☐ Yes, but I have not accessed it |
| ☐ No subsidy available | ☐ I am not aware of any subsidy |

D6. What barriers have prevented you from adopting or continuing AI? (Tick all that apply)

- | | |
|--|---|
| ☐ High cost | ☐ No trained technician nearby |
| ☐ Poor LN ₂ / semen access | ☐ Poor road infrastructure |
| ☐ Lack of information / awareness | ☐ Previous AI failures / low success |
| ☐ No interest / prefer natural mating | ☐ Other (specify below) |

Other: _____

SECTION E: ATTITUDES AND PERCEPTIONS SCALE

Please indicate your level of agreement with each statement by ticking (✓) the appropriate box.

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Estrus detection is the most difficult part of successfully applying AI.	☐	☐	☐	☐	☐
2. The quality and handling of semen straws in my area is generally good.	☐	☐	☐	☐	☐
3. AI technicians in Hurungwe District are adequately trained and skilled.	☐	☐	☐	☐	☐
4. Poor nutrition of cattle is a major reason AI fails in this district.	☐	☐	☐	☐	☐
5. Heat stress in October significantly reduces conception rates after AI.	☐	☐	☐	☐	☐
6. Extension officers provide sufficient guidance and follow-up after AI.	☐	☐	☐	☐	☐
7. The cost of AI services is the biggest barrier to adoption in my area.	☐	☐	☐	☐	☐
8. Reproductive diseases in communal	☐	☐	☐	☐	☐

herds are a serious threat to AI success.					
9. Farmers in my community have adequate knowledge about AI procedures.	☐	☐	☐	☐	☐
10. Government and NGO support for AI in Hurungwe is effective and consistent.	☐	☐	☐	☐	☐
11. Keeping proper reproductive records improves AI outcomes significantly.	☐	☐	☐	☐	☐
12. AI is overall more beneficial than natural mating for genetic improvement.	☐	☐	☐	☐	☐

Thank you for your time and participation