



**Perceptions and willingness to adopt Artificial Insemination: a case of cattle
farmers in Bojanala Platinum District**

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Master of Science in Agricultural Extension at the North-West University

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DECLARATION A - PLAGIARISM

I, Lerato Motshabi Maria Tsholo, declare that:

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DECLARATION B – PUBLICATIONS

The following publications (published and under review) form part of the research presented in this dissertation.

Publication 1: Tsholo L.M.M, Letsoalo S.S, Christian M, Luvhengo U

Perceptions and willingness of cattle farmers on Artificial Insemination in Bojanala Platinum District, North West Province.

Publication 2: Tsholo L.M.M, Letsoalo S.S, Christian M, Luvhengo U

Cattle farmers' Perceptions towards Artificial Insemination Technology: The case of Bojanala Platinum District, North West Province

***Manuscript/abstract submitted to the South African Society for Agricultural Extension Conference review**

Date: 09 March 2023

DEDICATION

This work is dedicated to my beloved late grandfather, Mr Keboutlwile Petrus Tsholo Tsholo, my late grandmother, Ms Kelatlhegile “Moeder” Mamokongwa Tsholo, my beloved mother, “Minora” - Ikgomotseng welheminah Mokaila, my family and children at large, Kutlwano, Oarabile, Ogomoditse and Katlego Teme, for their continuous support and encouragement throughout my studies. Their patience with me while I was unavailable during the times of need humbled me. Hats off!!

Lastly, to my late Chief Director and Supervisor, Mr Thebe Mothusi ‘Bossie’ for his encouragement, support and motivation in my studies for both personal and professional development when I started the journey of lifelong learning.

With a bleeding heart, I deem it fit to dedicate this dissertation, to the memory of my well conversant and well anchored Co – Supervisor, Mr Usaph Luvhengo (Post humous) who have journeyed with me through my Research Proposal, and the last submission of my dissertation to External Examiners.

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would not have made it possible to carry out this study looking at the financial commitments involved.

ABSTRACT

The study aimed to investigate cattle farmers' perceptions and willingness to adopt Artificial Insemination (AI) technology as an alternative to the traditional bull-to-cow breeding method. A structured questionnaire and a focus group discussion were used for data collection, and a sample size of 167 farmers was selected using a multi-stage sampling technique. The study used both qualitative and quantitative methods to analyse data. The results of descriptive statistics revealed that the majority (76%) of the respondents were male with a secondary level of education (54%) and an age range of 46 - 65 years. Also, the average household size of the interviewed farmers was found to be between five (05) and eight (08) members per household. Moreover, the results showed that only 42% of the farmers owned land. For support services, the farmers (91.13%) also indicated that they had access to extension services, and 59% indicated that they were not satisfied with the monthly visits, while 98.29% posited that they did not receive any information about AI technology. The study found a significant positive perception and willingness among farmers towards adopting AI, influenced by factors such as gender, farm size, and income. In conclusion, cattle farmers in the study area have a positive perception and willingness towards AI Technology as it increases productivity. However, they are concerned about the use and cost of AI technology. The study recommends targeted training and government interventions to reduce AI costs and enhance farmer education on its benefits

Keywords: Artificial insemination, perceptions, adoption, livestock farmers, Tobit Regression Model

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LIST OF ABBREVIATIONS AND ACRONYMS

AI	Artificial Insemination
BPDM	Bojanala Platinum District Municipality
NDP	National Development Plan
ARC	Agricultural Research Council
CAQDAS	Computer Aided Qualitative Data Analysis
CASP	Comprehensive Agricultural Support Programme
DAFF	Department of Agriculture, Forestry and Fisheries
DALRRD	Department of Agriculture Land Reform and Rural Development
FSP	Farmer Support Programmes
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GHS	General Household Survey
IDP	Integrated Development Plan
LED	Local Economic Development
NGO	Non-Governmental Organisations
NDA	National Department Of Agriculture
NWU	North West University
SASAE	South African Society for Agricultural Extension
STATS SA	Statistics South Africa

CHAPTER 1: INTRODUCTION

1.1 Background of the study

The livestock sector plays a significant role in the sustainability of the world's economy and in attaining food security. According to Steinfeld *et al.* (2006), livestock production systems occupy 30% of the planet's ice-free terrestrial surface area. The sector employs over one billion people worldwide, of which 60% are from rural households (Braun, 2010). Livestock production accounts for more than one third of the Global Agricultural GDP in developing countries. The use of technology in the livestock sector/livestock production enhances productivity, reduces threats of diseases and ensures environmental sustainability in productive areas (Kimunya, 2014)

The North West Province is mainly dominated by rural areas. A large part of the population in rural communities farm with livestock, especially cattle, goats, sheep, pigs and poultry. The province contributes immensely to the country's economy through agricultural produce, and farmers play a pivotal role in this regard. It has been said on many platforms that Agriculture is the backbone of our economy. Therefore, as a farmer, when the yield improves, not only do farmers create better livelihoods for themselves or their families, but such produce goes beyond what they see in improving the economy.

Dreyer *et al.* 1999, Randela, 2003 and Delali *et al.* (2006), as quoted by Mugwabana *et al.* (2018), indicated that cattle farming is popular in rural areas because of the multiple benefits that cattle provide to households, which include the provision of meat, milk, skin, draught power, fertilizer, payment of lobola and cash regeneration through sales. Generally, there is heavy reliance on agriculture by villagers in South Africa, especially livestock for survival. During those times, as there were no tractors, animals were used to plough, and the best animals were used or carefully selected to carry out this task. Even if it was like that, they did not keep quality breeds, as they did not have good bulls to improve the genetic material of their animals. Mostly in rural areas, they relied on community members who had low-quality bulls to service their livestock. This happened when animals roamed in the veld or streets searching for food. Poor quality breeds were produced, and they did not generate much profit as expected during auctions because of this element. This was compounded by the perception that Artificial Insemination was expensive and could not be carried out by ordinary rural community farmers.

Mugwabana *et al.* (2018) indicated that unreliable rainfall, water shortages and periodic droughts influence the majority of rural households to depend on livestock farming for survival. Improved livestock productivity in rural areas can reduce unemployment, poverty and household food security (Integrated Sustainable Rural Development Strategy, 2004; Coetzee *et al.*, 2005; Nqeno, 2008). The above argument supports the South African Government 2030 objectives of the National Development Plan objectives (NDP, 2012).

Currently, cattle production efficiency in the communal and emerging farming areas of South Africa is low due to low reproductive efficiency, among other factors (Mapekula *et al.*, 2009). Animal production is increasingly adapted or followed on a large scale, especially in rural areas by cattle farmers. The method of animal improvement has been a thing of the past for some but only practised by the privileged in using advanced technology and commercial farmers. The main problem is and was still the buying of expensive bulls in communal areas and, in some instances, having fewer cattle herds besides the affordability of a quality bull to improve the herd. There was dependency on the bulls of other farmers, which would be roaming around the area for grazing or in search of food. The perception was that Artificial Insemination could not thrive in rural areas due to infrastructural development and that farming was done on communal land where there was no fencing. Individual farmers do not see Artificial Insemination as something that can be used by rural black farmers and is only deemed a modern technique meant for a particular sector of society.

Livestock production constitutes a significant part or component often the agricultural economy of developing countries. This contribution goes beyond direct food production to include multipurpose uses such as skins, fibre, fertilizer, fuel and capital accumulation. Furthermore, livestock is closely linked to the social and cultural lives of several million resource-poor farmers for whom animal ownership ensures varying degrees of sustainable farming and economic stability (Sansoucy R: FAO feed Resource Group).

According to Stats SA (2013), North West is the biggest or largest producer of cattle after Free State and Gauteng Provinces. North West is the third (3rd) biggest income-generating province in terms of commercial agriculture and as such, agriculture contributes 3% to the provincial economic activity, while Bojanala Platinum District ranks third as one of the districts that drive agricultural production (Stats SA – Census of Commercial Agriculture). In terms of employment, Bojanala is the biggest agricultural employer (18 216) followed by Ngaka Modiri Molema district with 15

626. Statistics South Africa (2020) released findings from the Census of Commercial Agriculture report, which showed that the total number of farms/farming units involved in the commercial agriculture industry in 2017 was 40 122. The largest portion of farms was in livestock farming, 913 639 or 33,9% of the total, followed by mixed farming (12 458 or 31,1%) and field crops (8 559 or 21,3%).

The National Development Plan (NDP) Vision 2030 (2012) is founded on six pillars that represent the broad objectives of the plan to eliminate poverty and reduce inequality. It is a plan of economic and social development, including any amendment of or addition to such plan, prepared by the Government and approved by the National Assembly by resolutions.

The National Development Plan (NDP) aims to eliminate poverty and reduce inequality by 2030. South Africa can realise these goals by drawing on the energies of its people, growing an inclusive economy, building capabilities, enhancing the capacity of the state and promoting leadership and partnerships throughout society (NDP, 2012).

NDP aims to achieve the following objectives by 2030: uniting South Africans of all races and classes around a common programme to eliminate poverty and reduce inequality, encouraging citizens to be active in their development, strengthening democracy and holding their government accountable (NDP, 2012).

Definition and history of Artificial Insemination

According to Webb (2003) and Temesgen *et al.* (2017), Artificial Insemination (AI) or the introduction of semen in the female genital tract using instruments is the first generation of reproductive biotechnologies which was feasible in cattle. It is a process by which sperms are collected from the male, processed, stored and artificially introduced into the female reproductive tract for conception. The first commercial AI cooperative was established in 1936 by a Dane, Sorenson (Foote, 2002). Before the Second World War, most cows in Europe and North America were fertilised through natural service. However, since several cows on different farms were mated by the same bull, the spread of genital diseases with decreased fertility outcomes was a constant threat. Moreover, keeping herd bulls was expensive and represented a potential danger for the herd manager (Vishwanath, 2003).

Thibier and Guerin (2000) argued that apart from these facts, the limited number of offspring produced per bull after natural mating made it impossible to set up effective progeny testing schemes, resulting in a very poor genetic gain. The introduction of AI in cattle was mainly forced by sanitary reasons, especially by fertility problems caused by *Campylobacter foetus* subspecies *venerealis* (vibriosis) and *Trichomonas foetus*. Besides, the control and prevention of non-sexually transmitted diseases such as tuberculosis, brucellosis and paratuberculosis at the farms benefitted from the introduction of AI.

The first successful insemination was performed by the Italian physiologist and priest, Abbe Lazzaro Spallanzani (1780), in a dog which whelped three (03) pups 62 days later (Foote, 2002). Over 100 years later, in 1890, it was used for horse breeding. According to Webb (2003), the history of AI is interesting in that old Arabian documents dated around 1322A.D. indicate that an Arab chieftain wanted to mate his prize mare to an outstanding stallion owned by an enemy. He introduced a wand of cotton into the mare's reproductive tract and then used it to sexually excite the stallion, causing him to ejaculate. The semen was introduced into the mare resulting in conception. In 1999, Ivanoff of Russia pioneered AI research in birds, horses, cattle and sheep and was the first to successfully inseminate cattle artificially. Mass breeding of cows via AI was first accomplished in Russia, where 19 800 cows were bred in 1931 (Webb, 2003; Temesgen *et al.*, 2017).

In Britain, AI in dairy cattle began to be available in 1942, and by 1950, 20% of dairy cattle were being inseminated. By 1960, more than 2 million cows were inseminated yearly, which was about 80% of the maximum level that AI would reach (Braaley, 2007). The established procedure for AI in cattle since the 1960s is the transcervical deposition of semen into the uterine body. This technique replaced the original vaginal or shallow cervical insemination performed in the 1940s, as the intrauterine method proved to be more efficient and resulted in higher fertility (Lopez-Gatius, 2000).

1.2 Problem statement

Despite government efforts through public extension and advisory services, the adoption rates of artificial insemination (AI) by farmers in rural communities of South Africa is very low level given the Fourth Industrial Revolution (FIR) era. For instance, a study conducted by Nengovhela (2021) in KwaZulu Natal, Limpopo and Mpumalanga showed that the adoption rates of assisted

reproductive technologies (ARTs) is still low. The ART method was not only introduced to improve productivity but also to address the problem of bull shortages in the rural areas.

Although there are some studies about artificial insemination in developing countries such as Kenya, there is little or no information about factors affecting adoption rates, willingness and awareness by smallholder farmers in South Africa. There is therefore a need to investigate the challenges that hamper the use of artificial insemination in rural communities of the North West Province.

1.3 Aim of the study

The study aimed at investigating the perceptions and willingness to adopt Artificial Insemination (AI) Technology by cattle farmers as an alternative to the traditional bull-to-cow breeding method in the North West Province, South Africa.

1.4. Research questions

The research following research questions are addressed in the study:

- I. What is the nature of cattle farmers in Bojanala District, North West Province?
- II. What are the perceptions of cattle farmers towards Artificial Insemination?
- III. Are cattle farmers in Bojanala District willing to adopt AI technology?
- IV. What are the awareness and understanding levels of farmers of Artificial Insemination?
- V. Which challenges prevent cattle farmers from adopting AI Technology?
- VI. Which socio-economic factors influence the farmers' willingness to adopt AI technology?

1.5 Objectives

The following are the specific objectives of the study:

- I. To investigate the nature of cattle farmers in Bojanala District, North West Province.
- II. To determine the perceptions of cattle farmers towards Artificial Insemination
- III. To explore if cattle farmers in Bojanala District willing to adopt AI technology
- IV. To determine the awareness and level of understanding of farmers of Artificial Insemination.

- V. To investigate the challenges that prevent cattle farmers from adopting the AI Technique.
- VI. To determine the socio-economic factors influencing the farmers' willingness to adopt the AI technology

1.6 Significance of the study

The present study is aimed at improving livestock numbers in a bid to alleviate poverty and welfare of people in rural communities. Artificial insemination is very crucial in improving milk and beef production. As a result, it was very crucial to understand the awareness, perceptions and willingness to adopt such important innovation. Technology is moving or changing at a very rapid speed, and rural communities need to be on par with their counterparts in other countries in terms of production and in order to ensure production efficiency through the use of artificial insemination. Most studies on artificial insemination have been conducted in other countries and have focused on the implementation part. This study brings together the three important concepts i.e awareness, adoption and perceptions on artificial insemination. The insights generated from this study will be useful for decision-makers, LED strategy and the Department of Agriculture and Rural Development since they are in line with their integrated development plan of improving livestock numbers and sustainable food production by embracing new technologies by 2030 (IDP, 2019). Policymakers and extension officers can also use the study for various interventions when addressing challenges of poor breed and economic spin-offs in rural areas. Moreover, the study is also aligned with the sustainable development goal number (SDG 2) of ending hunger by 2030.

1.7 Delineation

The study was conducted in Bojanala Platinum District, and the findings reflect on the perceptions towards AI by cattle farmers. The study focuses on cattle farmers and not other livestock that are found in the area. The research also focused on smallholder farmers only instead of covering all cattle farming households in the region.

1.8 Definition of key terms

- **Technology** - is defined by Loevinsohn *et al.* (2013) as the means and methods of producing goods and services, including methods of organization, as well as physical techniques.

- **Adoption** - is defined as an integration of new technology into existing practice and is usually preceded by a period of trying and some degree of adaptation.
- **Artificial Insemination** - is the process of collecting sperm cells from a bull and manually introducing them into the reproductive tract of a cow or heifer.
- **Synchronisation** - it is the process of manipulating the estrus cycle that results in standing estrus (heat) in the majority of animals in a short time. It is very effective to increase the number of animals bred at a particular breeding season.
- **Livestock animals** - it encompasses animals primarily such as cattle, sheep, pigs, goats, horses, donkeys and mules and other animals such as buffalos, oxen, llamas or camels that may predominate in the agriculture of other areas.
- **Livestock production**- is simply the management and breeding of domestic livestock or farm animals to obtain meat and products (milk, eggs and leather, to mention a few).
- **Rural communities** - it is communities or areas comprising open country and settlements with fewer than 2 500 residents (thus according to the current delineation released in 2012 and based on the 2010 decennial census.).

1.9 Dissertation outline

This dissertation is organized into five chapters. The statement of the problem, aim of the study, research questions, study objectives, significance of the study and delineation are covered under the introductory/initial chapter, which is **Chapter One (1)**. The next is **Chapter Two (2)** which reviewed relevant literature and research on the perception of cattle farmers towards adopting the Artificial Insemination technology. This chapter also covered the theoretical framework and a thorough review of relevant empirical studies and/or qualitative research. In **Chapter Three (3)**, the research design and methodology were incorporated, together with the population and sampling, qualitative research classification and procedures, as well as data analysis. The findings/results of the study and discussions were discussed in detail in **Chapter Four (4)**, which included the presentation of such results in figures and tables. Finally, **Chapter Five (5)**, entails the summary, major findings, conclusions, limitations, guidelines and recommendations.

1.10 Chapter summary

The chapter incorporates the background of the study, the problem area, research aims, research questions and objectives. It further expatiated on the significance of the study which indicates the rapid level of technology change. It captures the delineation of the study where it would be conducted. Lastly, it outlines the keywords used in the research study and their explanations.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter examines the literature on the perceptions and willingness of cattle farmers to adopt Artificial Insemination (AI) in Bojanala Platinum District, North West Province. It then describes who cattle farmers are and what characterises them. In addition to that, the chapter provides a provincial overview of the nature of cattle farmers in North West Province, and the determinants of adopting new agricultural technology by smallholder farmers. These determinants included technological awareness and literacy, economic conditions, institutions and household-specific factors. Lastly, the conceptual framework showing the relationship between the studied variables is outlined.

2.2 The nature of livestock farmers in the North West Province

According to the North West Beef Production and Beneficiation programme (NWBPB) (2019), beef production in the four districts is highly dualistic, with subsistence, smallholder and commercial farmers/producers all co-existing. The off-take from the commercial sector is at an acceptable level, while the off-take from the communal farmers (subsistence or small-scale farmers) is still low. Smallholder farmers/producers are currently producing at lower levels of efficiency when compared to their counterparts in the commercial sector. As such, there is room for improving smallholder production efficiencies. There is skewed ownership through the domination of various commodity value chains by a few large, vertically integrated firms. To a large extent, the high input costs for smallholders/producers, who are mainly not well organised also limit entry into value chains.

Ultimately, beef cattle production is a numbers system with a narrow unit profit margin. Many units should be traded to ensure an economically viable enterprise. The contribution of the small-scale and or emerging sector, which is said to own 40% of a national herd, has not been accurately quantified, and this is a priority to ensure support is based on knowledge instead of conjecture. Smallholder/producers have challenges of inadequate support services, such as extension, infrastructure, marketing access and customised finance; this results in sub-optimal reproduction which negatively affects off-take rates (NWBPB programme, 2019).

Beef production is practised throughout the North West Province. According to DAFF (2018), the province has 1 588 147 cattle, including both beef and dairy (13% of the national herd). North West, especially Dr Ruth Segomotsi Mompati (RSM) and Ngaka Modiri Molema (NMM) districts, has the most diverse cattle population with well-adapted exotic breeds that are preferred by feedlots. The predominant breeds in the province include Bonsmara, Brahman and Simentaller and their respective crossbreds. Indigenous breeds such as Nguni, Drakensberger and Afrikaner cattle are perceived to be poor feedlot performers and are therefore shunned. However, farming with indigenous breeds has some untapped advantages such as their adaptability to climate change, resistance to tick-borne diseases and less usage of antibiotics.

2.3 Perceptions of livestock farmers towards Artificial Insemination

Livestock production has the potential to alleviate household food insecurity and poverty in rural households of the world, including South Africa (Musemwa *et al.*, 2008). For sustained agricultural production, there is a need to use all emerging technologies, especially assisted reproductive technologies (ART), (Verma *et al.*, 2012). Of all the ART, oestrus synchronisation and Artificial Insemination (AI) are among the most used and applicable techniques to increase the reproductive efficiency and genetic improvement of cattle and most applicable to organised communal farmers (Belay *et al.*, 2016); Maqhashu *et al.*, 2016).

Previous studies reported that reproduction rates and growth rates are very low in communal cattle herds in South Africa (Nengovhela and Nedambale, 2012). A high level of mortality (30%), low reproduction rates (48%) (Scholtz and Bester, 2010), low weaning rates (45%) (Bembridge and Tapson, 1993) and a low turnover have been reported in the communal cattle sector. Moreover, this contributes to poor economic returns from the sector. The introduction of exotic breeds in the communal cattle sector (Botsime, 2006) has led to an increase in the number of non-descriptive breeds which cannot prevail in the harsh conditions in communal villages (Musemwa *et al.*, 2008). Hence, cattle kept in communal areas need to be improved through modern breeding programmes to become adaptive breeds and survive under these conditions (Tyasi *et al.*, 2015).

According to Omondi *et al.* (2017), Africa has a shortage of animal products but increasing demand because of population growth, urbanisation and changing consumer patterns. Attempts to boost livestock production through the use of breeding technologies such as Artificial Insemination

(AI) have been failing in many countries because costs have escalated, and success rates have been relatively low. Kenya was mentioned as one good example of a country with a relatively large number of cows and a dairy industry model relevant to neighbouring countries. In addition to that, there is an innovative dairy marketing approach (farmer-owned collective marketing systems called dairy hubs) that had been implemented to enhance access to dairy markets and dairy-related services, including breeding services such as AI. It has been indicated that the rate of participation in the dairy hubs had been slow and mixed.

For them to understand the phenomenon better and to inform dairy-related development activities by the Kenyan government, they investigated which characteristics of AI services offered through the dairy hubs farmers prefer. To do that, they applied a choice experiment (CE), a non-market valuation technique, which allowed them to identify farmers' preferences for desired characteristics should more dairy hubs be installed in the future. The results to that effect revealed that dairy farmers prefer to have AI services offered rather than having no service. Farmers preferred AI services to be available at dairy hubs rather than being provided by private agents not affiliated to the hubs, have follow-up services for pregnancy detections and use sexed semen rather than conventional semen (Omondi *et al.*, 2017).

According to the study conducted by Omondi et al (2017), the farmers indicated that they liked to have some flexibility in payment systems which include input credit and sharing the costs of any AI repeats that might need to occur. It should be noted that the results indicated a positive attitude towards AI services provided through the hubs, which could mean that AI uptake would improve if service characteristics are improved to match farmer preferences. Lastly, it is indicated that the dairy hubs concept is currently in the implementation phase with most hubs in the startup phase, hence understanding which AI service characteristics farmers prefer can inform the design of high-quality and cost-effective AI services. In future, the Kenyan government hopes that AI can significantly improve animal productivity and help meet the soaring demand for animal products in Africa. The study conducted revealed farmer preferences about AI services and costs in Kenya, if implemented, could reverse a decline in use. As Kenya is closely watched by neighbouring countries, so innovations successfully implemented in the Kenyan livestock sector, particularly breeding technologies, are said to be widely emulated in the region (Omondi *et al.*, 2017).

Hafiz *et al.*, (2021) also researched farmers' perceptions towards Artificial Insemination services in Punjab, Pakistan and found that a considerable number of livestock farmers were still practising natural mating for their animals instead of the Artificial Insemination technology. Their study further aimed to determine the various insemination procedures being used by farmers and the reasons for their rejection or acceptance in rural areas of Punjab. The findings of their study infer that the AI technique was preferred by 0,5% of farmers, particularly for cows, whereas 75% of farmers preferred the natural mating process. The quality of private and public technicians in providing AI was rated at an average level. For the natural mating process of their animals, farmers were heavily dependent on fellow farmers for sourcing a bull, that is almost 73,8% of them.

According to Mahomed (2018), cattle production in the country is a source of food and cash income. The cattle production system in Ethiopia, for instance, is said to be mainly small-holder substance farming, with animals having multi-purpose use and as such, no specialised and systematic breeding is used (Giday, 2001).

The livestock sector is one of the fastest-growing segments of the agricultural economy, particularly in the developing world (Delgado *et al.*, 2009). Although AI has been considered a promising tool to improve the genetic potential of dairy animals, many farmers in field conditions are unaware of the technology with huge regional variations in terms of knowledge level and adoption of this promising technology (Foote, 2002).

Artificial Insemination plays an important in increasing the yielding capacity of cows and is the most appropriate and cheapest way of genetic improvement, and the realisation of the breeding programmes has to be well organised and reliable. AI is fully functional when it is blended with good animal husbandry such as effective heat detection (Noakes, 2009).

AI has proven to be a very effective reproductive technology that selectively increases genetic gain through increased selection pressure on males. Farm animals, males as well as females, are usually chosen for breeding programmes based on breeding soundness examinations (BSEs). These BSEs determine the suitability and likelihood of females or males to participate successfully in breeding programmes. Estrus cycles of females can be manipulated to institute efficient insemination programmes. With the use of these estrus synchronisation programmes, large groups of females can be inseminated at the same time. This does not only have the advantage of concentrating work on specific days during breeding (Webb, 2003).

Another reason for AI is to ensure the effective use of semen. An increased number of offspring from a superior sire can be produced when AI is employed. Overuse of males is prevented, and commercial distribution is facilitated. Other important aspects are the prevention of venereal disease transmission, for example, Trichomonosis and Campylobacteriosis, both of which decrease reproductive efficiency through decreased pregnancy rates, high return rates to estrus and increased pregnancy losses, which plays a major role in the economic system of offspring production and increased safety for valuable breeding animals as mating related injuries are avoided. Furthermore, AI can be used for frozen semen from males that have died or are not physically available for mating due to distance or physical inability (Gamborg, 2005).

2.4 Factors determining the adoption of new agricultural technology by smallholder farmers

Agricultural technologies are seen as an important route out of poverty in most developing countries. However, the rate of adoption of these technologies has remained low in most of these countries (Mwangi and Kariuki, 2015). The outlined factors below are found to be the determinants of agricultural technology adoption.

2.4.1 Technological factors

The characteristic of technology is a precondition of adopting it. Trialability or a degree to which a potential adopter can try something out on a small scale first before adopting it completely is a major determinant of technology adoption (Doss, 2003; Mwangi M and Kariuki, 2015). In studying the determinants of adopting Imazapyr-resistant maize (IRM) technology in Western Kenya, Mignouna *et al.* (2011) stated that the characteristic of the technology plays a critical role in the adoption decision process. They argued that farmers who perceive the technology as being consistent with their needs and compatible with their environment are likely to adopt it since they find it a positive investment. Farmers' perceptions of the performance of the technologies significantly influence their decision to adopt them. A study by Adesina and Zinnah (1993) showed that farmers' perception of the characteristics of modern rice varieties significantly influenced their decision to adopt them. A similar result was reported by Wandu *et al.* (2012) when studying the perceptions of farmers towards the adoption of aquaculture technology in Cameroon. Their study indicated that the perception of farmers towards fish farming facilitated its uptake. Therefore, it is important that for any new technology to be introduced to farmers, they should be involved in its evaluation to find its suitability to their circumstances (Karugia *et al.*, 2004).

2.4.2 Economic factors

Farm size is said to play a very critical role in the adoption process of new technology. Many authors have analysed farm size as one of the important determinants of technology adoption. Farm size can affect and in turn, be affected by other factors influencing adoption (Lavison, 2013). Some technologies are termed scale-dependent because of the great importance of farm size in their adoption (Bonabana – Wabbi, 2002).

Many studies have reported a positive relationship between farm size and the adoption of agricultural technology (Kasenge, 1998; Gabre-Madhin and Haggblade, 2001; Ahmed, 2004; Uaiene *et al.*, 2009; Mignouna *et al.*, 2011; Mwangi and Kariuki, 2015). Farmers with large farm sizes are likely to adopt a new technology, as they can afford to devote part of their land to try new technology unlike those with less farm size (Uaiene *et al.*, 2009). In addition, it is argued that lumpy technologies such as mechanised equipment or animal traction require economies of size to ensure profitability (Feder, Just and Zilberman, 1985).

It is indicated that some studies have shown the negative influence of farm size on the adoption of new agricultural technology. Small farm size may provide an incentive to adopt a technology, especially in the case of an input-intensive innovation such as a labour-intensive or land-saving technology. Farmers with small land may adopt land-saving technologies such as greenhouse technology and zero grazing among others as an alternative to increased agricultural production (Yaron, Dinar and Voet, 1992; Harper *et al.*, 1990).

Other studies have reported insignificant or neutral relationships with adoption. For instance, a study by Grieshop *et al.* (1988), Ridgley and Brush (1992), Waller *et al.*, (1998), Mugisa-Mutetikka *et al.* (2000), Bonabona-wabbi (2002) and Samiee *et al.* (2009) concluded that size of the farm did not affect the Integrated Pest Management (IPM) adoption, implying that IPM dissemination may take place regardless of farmers' scale of operation. Kariyasa and Dewi (2011) also found that the extensive land holdings had no significant effect on the degree of Integrated Crop Management Farmer Field School (ICM- FFS) adoption probability.

Off-farm income has been shown to have a positive impact on technology adoption. This is because off-farm income acts as an important strategy for overcoming credit constraints faced by rural households in many developing countries (Reardon *et al.*, 2007). Off-farm income is reported to act as a substitute for borrowed capital in rural economies, where credit markets are either missing

or dysfunctional (Ellis and Freeman, 2004; Diiro, 2013). According to Diiro (2013), farm income is expected to provide farmers with liquid capital for purchasing productivity-enhancing inputs such as improved seeds and fertilizers. For instance, in her study when analysing the impact of off-farm earnings on the intensity of adoption of improved maize varieties and the productivity of maize farming in Uganda, Diiro (2013) reported a significantly higher adoption intensity and expenditure on purchased inputs among households with off-farm income compared to their counterparts without off-farm income. However, not all technologies have shown a positive relationship between off-farm income and their adoption. Some studies on technologies that are labour intensive have shown a negative relationship between off-farm income and adoption. According to Goodwin and Mishra (2004), the pursuit of off-farm income by farmers may undermine their adoption of modern technology by reducing the amount of household labour allocated to farming enterprises.

2.4.3 Institutional factors

Belonging to a social group enhances social capital, allowing trust, ideas and information exchange (Mignouma *et al.*, 2011; Mwangi and Kariuki, 2015). Farmers within a social group learn from each other the benefits and usage of new technology. Uaiene *et al.*, (2009) suggest that social network effects are more important for individual decisions, and that, in the context of agricultural innovations, farmers share information and learn from each other. Studying the effect of community based organisations in the adoption of corm-paired banana technology in Uganda, Katungi and Akankwasa (2010) found that farmers who participated more in community-based organisations were likely to engage in social learning about technology hence raising their likelihood to adopt the technologies.

Although many researchers have reported a positive influence of social groups on technology adoption, social groups may also harm technology adoption, especially where free-riding behaviour exists. When studying the adoption of Green Revolution technologies in India, Foster and Rosenzweig (1995) found that learning externalities within social networks increased the profitability of adoption but also farmers appeared to be free riding on their neighbours' costly experimentation with the new technology. Bandiera and Rasul (2002), as cited by Hogset (2005), suggested that learning externalities generate opposite effects, such as the more other people engage in the experimentation with new technology, the more beneficial it is to join in but also the

more beneficial it is to free-ride on the experimentation of others. As a result of these contradictory effects, Bandiera and Rasul (2002) proposed an inverted U-shaped individual adoption curve, implying that network effects are positive at low rates of adoption but negative at high rates of adoption.

Acquisition of information about new technology is another factor that determines the adoption of technology. It enables farmers to earn the existence as well as the effective use of technology, and this facilitates its adoption. Farmers will only adopt the technology they are aware of or have heard about it. Access to information reduces the uncertainty about a technology's performance and hence may change an individual's assessment from purely subjective to objective over time (Caswell *et al.*, 2001; Bonabona-Wabbi, 2002). However, access to information about technology does not necessarily mean it will be adopted by all farmers. This simply implies that farmers may perceive technology and subjectively evaluate it differently than scientists (Uaiene *et al.*, 2009). Access to information may also result in non-adoption of the technology. For instance, where experience within the general population about a specific technology is limited, more information induces negative attitudes towards its adoption, probably because more information exposes an even bigger information vacuum hence increasing the risk associated with it (Bonabona-Wabbi, 2002). Therefore, it is important to ensure the information is reliable, consistent and accurate. Farmers need to know the existence of technology, its benefits and its usage for them to adopt it.

Access to extension services has also been found to be a key aspect of technology adoption. Farmers are usually informed about the existence as well as the effective use and benefit of new technology through extension agents. Extension agents act as a link between the innovators (researchers) of the technology and users of that technology. This helps to reduce transaction costs incurred when passing the information on the new technology to a large heterogeneous population of farmers (Genius *et al.*, 2010). Extension agents usually target specific farmers who are recognised as peers (farmers with whom a particular farmer interacts) exerting a direct or indirect influence on the whole population of farmers in their respective areas (Genius *et al.*, 2010).

Many authors are said to have reported a positive relationship between extension services and technology adoption. A good example includes the adoption of Imazapyr-Resistant Maize Technologies (IRM) by Mignouna *et al.* (2011), the factors that determine technology adoption among Nepalese by Karki and Siegfried (2004) and Uaiene *et al.* (2009), adoption of improved

maize and land management in Uganda by Sserunkuuma (2005) and adoption of modern agricultural technologies in Ghana by Akudugu *et al.* (2012), just to mention a few. That was because exposing farmers to information based on innovation-diffusion theory is expected to stimulate adoption (Uaiene *et al.*, 2009). It is said that the influence of the extension agents can counterbalance the negative effect of the lack of years of formal education in the overall decision to adopt some technologies (Yaron, Dinar and Voet, 1992; Bonabana-Wabbi, 2002).

Access to credit has been reported to stimulate technology adoption (Mohamed and Temu, 2008). It is believed that access to credit promotes the adoption of risky technologies through the relaxation of the liquidity constraint, as well as through the boosting of a household's -risk-bearing ability (Simtowe and Zeller, 2006). This is because, with an option of borrowing, a household can do away with risk reducing but inefficient income diversification strategies and concentrate on more risky but efficient investments (Simtowe and Zeller, 2006). However, access to credit is gender biased in some countries where female-headed households are discriminated against by credit institutions and as such, they are unable to finance yield-raising technologies, leading to low adoption rates (Muzari *et al.*, 2013). There is, therefore, a need for policymakers to improve current smallholder credit systems to ensure that a wider spectrum of smallholders can have access to credit, more especially female-headed households (Mkandawire, 1993; Simtowe and Zeller, 2006). This may in certain cases necessitate designing credit packages that are tailored to meet the needs of specific target groups (Muzari *et al.*, 2013). For instance, in Kenya, the government has started a programme that offers free interest loans to youths and women (UWESO fund). This will help empower women and enable them to adopt agricultural technologies, hence enhancing economic growth.

2.2.4 Household-related factors

The human capital of the farmer is assumed to have a significant influence on farmers' decisions to adopt new technologies. Most adoption studies have attempted to measure human capital through the farmer's education, age, gender and household size (Fernandez-Cornejo and Daberkow, 1994; Fernandez-Cornejo *et al.*, 2007; Mignouna *et al.*, 2011; Keelan *et al.*, 2014). Education of the farmer is assumed to have a positive influence on farmers' decisions to adopt new technology. The education of a farmer is said to increase his ability to obtain, process and use information relevant to the adoption of a new technology (Mignouna *et al.*, 2011; Lavison 2013;

Namara *et al.*, 2013). For instance, a study by Okunlola *et al.* (2011) on the adoption of new technologies by fish farmers and another one by Ajawole (2010) on the adoption of organic fertilizers found that the level of education had a positive and significant influence on the adoption of the technology. This is because higher education influences respondents' attitudes and thoughts, making them open, rational and able to analyse the benefits of the new technology (Waller *et al.*, 1998).

This eases the introduction of an innovation, which ultimately affects the adoption process (Adebisi and Okunlola, 2010). Other studies that have reported a positive relationship between education and adoption, as reported by Uematsu and Mishra (2010), Goodwin and Schroeder (1994) on forward pricing methods and Huffman and Mercier (1991) and Putler and Zilberman (1998) on the adoption of microcomputers in agriculture. The other studies were by Mishra and Park (2005) and Mishra *et al.* (2009) on the use of the internet, Rahm and Huffman (1984) on reduced tillage, Roberts *et al.* (2004) on precision farming and Traore *et al.* (1998) on on-farm adoption of conservation tillage.

On the other hand, some authors have reported insignificant or negative effects of education on the rate of technology adoption (Grieshop *et al.*, 1998; Khanna, 2001; Banerjee *et al.*, 2008; Samiee *et al.*, 2009; Ishak and Afrizon, 2011). Studying the effect of education on technology adoption, Uematsu and Mishra (2010) reported a negative influence of formal education towards adopting genetically modified crops. Since the above empirical evidence has shown mixed results on the influence of education and the adoption of new technology, more studies need to be done to come up with more consistent results.

Age is also assumed to be a determinant of the adoption of new technology. Older farmers are assumed to have gained knowledge and experience over time and are better able to evaluate technology information than younger farmers (Mignouna *et al.*, 2011; Kariyasa and Dewi, 2011). On the contrary, age has been found to have a negative relationship with the adoption of technology. The relationship is explained by Mauceri *et al.* (2005) and Adesina and Zinnah (1993) that as farmers grow older, there is an increase in risk aversion and a decreased interest in long-term investment in the farm. On the other hand, younger farmers are typically less risk-averse and are more willing to try new technologies. For instance, Alexander and van Mellor (2005) found that the adoption of genetically modified maize increased with age for younger farmers, as they

gain experience and increase their stock of human capital but declines with age for the farmers closer to retirement.

Gender issues in agricultural technology adoption have been investigated for a long time and most studies have reported mixed evidence regarding the different roles men and women play in technology adoption (Bonabana-Wabbi, 2002). In analysing the impact of gender on technology adoption, Morris and Doss (1999) found no significant association between gender and the probability to adopt improved maize in Ghana. They concluded that technology adoption decisions depend primarily on access to resources rather than on gender, and if the adoption of improved maize depends on access to land, labour or other resources and if in a particular context, men tend to have better access to these resources than women, then, in that context, the technologies will not benefit men and women equally.

On the other hand, gender may have a significant influence on some technologies. Gender affects technology adoption since the head of the household is the primary decision maker, and men have more access to and control over vital production resources than women due to socio-cultural values and norms (Tesfaye *et al.*, 2001; Mesfin, 2005; Omonona *et al.*, 2006; Mignouna *et al.*, 2011). For instance, a study by Obisesan (2014) on the adoption of technology found that gender had a significant and positive influence adoption of improved cassava production in Nigeria. His result concurred with that of Lavison (2013) which indicated that male farmers were more likely to adopt organic fertilizer, unlike their female counterparts. Household size is simply used as a measure of labour availability. It determines the adoption process in that, a larger household can relax the labour constraints required during the introduction of new technology (Mignouna *et al.*, 2011; Bonaban- Wabbi, 2002).

The notion that Artificial Insemination cannot be practised or applied in rural communal farms or rural communities needs to be proven beyond a reasonable doubt. There are issues and intervention strategies that could be applied to overcome some of the challenges that might impede the successful application of Artificial Insemination in rural communities (unauthored).

All farmers regardless of race, gender and age need quality breeds on the farm, as they are all aiming for profitability and contributing to food security in the country. It is true that most of our rural areas are characterised by poverty and a lack of intense technology with a high level of illiteracy in some instances. The old farming and breeding system of using a bull still poses a very

serious challenge to rural communities, where they found themselves in a very huge predicament, as breeding quality bulls tends to be expensive in terms of prices and as such, affordability remains a problem (unauthored).

Since the dawn of democracy, the government came up with plans to uplift our black commercial farmers and rural communities through the use of special grants (CASP and Ilema/Letsema), but special attention was not given to how the breeding genetics of rural community farmers could be improved through the use of a technical specialised procedure called Artificial Insemination. It is a process which will also eliminate the high rate of transmissible diseases by bulls, as in communal areas, bulls roam around with communal herds and that also poses a risk for a large herd of cattle to be infected, as well as the bull itself, as its safety is not guaranteed (unauthored).

The advantage of semen used during the Artificial Insemination process is that it has been tested and is free of diseases, thus curbing the above-alluded statement regarding disease contraction in herds. In most instances, communal farmers depend entirely on indigenous systems or indigenous knowledge to become successful farmers, including the use of traditional herbs or medicine where it warrants such.

Keeping bulls in communal areas or uncontrolled environments (even quality breeding bulls) will not play a significant role, as poor management will also contribute to inbreeding or line breeding, which is unwarranted in good farming practices. The government should consider some of these facts so that the strategy of handing over bulls to farmers or emerging rural farmers be reviewed or improved. It is seen as a good gesture and a sign of service delivery, while some of these challenges are not taken into consideration.

According to Greyling (2022), Artificial Insemination is a good way to improve your herd, as you can purchase top-quality genetics without having to buy a bull. This argument substantiates the above-cited argument as far as Artificial Insemination is concerned. Greyling (2022) indicated that approximately 60% of the 13,84 million cattle in South Africa are owned by commercial farmers and 40% by emerging and communal farmers. The latter keep their cattle on communal grazing land and rely more than commercial farmers on indigenous knowledge to manage their herds

Greyling (2022) argues that productivity from this farming system is likely to be affected by drought, stocking density and livestock reproductive diseases such as Brucellosis and vibriosis and poor genetic improvement due to high rates of inbreeding and poor-quality bulls.

2.5 Factors resulting in low technology adoption

(i) Age

The young farmers were said to be more aware of the benefits of Artificial Insemination utilisation than the older farmers. The result conducted reflected that the mean age of AI of adopters was 43.32 years and the non-adopters at 54.66 years and it seemed young farmers were more aware of the benefits of AI utilisation, whereas older farmers were less motivated to adopt AI technology. Cathal *et al.* (10) said that young farmers may have better education and therefore more aware of the advantages of AI technology. Abra *et al.* (11) also reported that the mean age of adopters is younger than those of non-adopters. Howley *et al.* hypothesised that younger farmers were more aware of the economic benefit of AI.

(ii) Knowledge of Artificial Insemination

The findings are in line with Abraha *et al.* (2011) who shared that farmer expertise and awareness could be a key determinant to adopt and use continuously the new method of AI to improve farmer income generation. The farmer's understanding of the breeding method of AI had a significant and strong correlation with AI adoption. The adopter mostly obtained AI information from the District of Animal Office. According to Baban (21), a package of interventions for increasing the use of intensity of AI technology should be considered. On the other hand, according to Quddus (22), inadequate knowledge of breeding and perception is the limitation of AI implementation on crossbred dairying, while Sezgin *et al.* (23) mentioned that participating in agricultural extension training activities had a positive impact on the implementation of innovation.

(iii) Difficulty in oestrus detection repeated failure during insemination

The study conducted by Surty (2021) indicated that the majority of farmers did not fully adopt this technology due to difficulty in oestrus detection.

(iv) High charges for Artificial Insemination

High charges of Artificial Insemination also is one of the reasons farmers did not adopt the technology (Surty, 2021).

(v) Distance of the centre from the village

In contrast, Rathod *et al.* (15) reported that the reason for AI adoption was a lack of good quality bulls from the village, farmers can choose the high genetic quality of semen and a good conception rate (Surty, 2021).

Cattle are the major livestock activity in the country in both commercial and smallholder farms. Cattle production in South Africa is more concentrated in the Eastern Cape, KwaZulu Natal, Free State and North West provinces, and beef accounts for approximately 80% of the national herd, with dairy accounting for 20% (Stats SA, 2020).

Cattle farming is a farming route that can result in a profit of R300 a piece, which equates to R350 every month if R300 to R350 per animal for a further income of at least R30 000 (Stats SA, 2020).

2.6 Theoretical framework

It is difficult to get an exact definition for a theoretical framework (Abd-El-Khalick and Akerson, 2007). Caliendo and Kyle (1996:225) cite Kerlinger's definition of theory as "a set of interrelated constructs (concepts), definitions and propositions that present a systematic view of phenomena by specifying relations among variables, with the purpose of explaining and predicting the phenomena". That is, theories deal with concepts which are interwoven with others and the relationships between them. When used by researchers as a knowledge base for research, they are often referred to as theoretical frameworks or conceptual frameworks.

There are several reasons why theoretical frameworks are important in research. Firstly, according to Borgatti (1996), a theoretical framework provides guidance for researchers to choose a relevant

research design to formulate appropriate research questions, to choose appropriate strategies to use when collecting and analysing data, and finally, to make interpretations based on data analysis. Secondly, Herek (1995) points out that a theoretical framework enables researchers to strengthen their research by identifying gaps or assessing whether unnecessary emphasis is being placed on a particular type of variable. Herek (1995) also points out that it connects researchers to existing knowledge which forms a basis for their hypotheses and helps researchers to address questions of why and how.

Caliendo and Kyle (1996) point out that a theoretical framework distinguishes research from journalism. Theoretical frameworks provide theories on which researchers can base their research.

Researchers working in different paradigms use theoretical frameworks for different purposes. According to Glesne and Peshkin (1992), positivists use theoretical frameworks to make predictions and explain phenomena. Interpretivists, by contrast, use theoretical frameworks to interpret a situation or to make sense of the world.

To estimate the true population adoption rate and its determinants of the adoption of AI, this study adopted the average treatment effect (ATE) estimation framework developed by Diagne (2006) and Diagne and Demont (2007). In the context of adoption, “treatment” means exposure to technology, and the ATE parameter measures the potential demand for the technology by the target population under complete exposure. In this framework, a farmer in the population is either exposed to AI technology (treatment) ($w = 1$) or unexposed ($w = 0$). Let y_1 be the potential adoption outcome of a farmer when exposed to AI technology and y_0 the farmer’s potential adoption outcome when not exposed to the technology. The estimated adoption outcome y can be expressed as a function of the two potential adoption outcomes, y_1 and y_0 , and the treatment status variable w which is expressed as $y = w y_1 + (1 - w)y_0$. The expected population adoption impact of exposure to artificial insemination technology of cattle on population adoption outcomes is expressed as the ATE of exposure and is estimated by the mean value of $E(y_1 - y_0)$.

Since exposure to the technology is a necessary condition for the adoption of it, $y_0 = 0$ for any farmer whether exposed to the technology or not. Hence, the population average potential adoption outcome of exposure is given by $ATE = E(y_1)$. The average potential adoption rate among the exposed subpopulation is expressed by the conditional expected value $E(y_1|w = 1)$, which corresponds to the ATE of exposure on the treated, commonly denoted by ATE_1 . Whereas, the

average potential adoption rate among the non-exposed sub-population (denoted by ATE_0) is given by $E(y_1|w = 0)$. Also, with $y_0 = 0$, the expression of the observed adoption outcome variable as a function of the two potential adoption outcomes and the exposure variable will be expressed as $y = wy_1$, which shows that the observed adoption outcome variable is derived from both the exposure and adoption outcome variables. This justifies calling the population mean observed adoption outcome $E(y) = E(wy_1)$, the population mean joint exposure and the adoption parameter denoted as JEA to differentiate it from the population mean adoption parameter $E(y_1)$, that is, ATE, which indicates the potential demand of the technology by the population in terms of adoption.

The difference between the population mean observed adoption outcome (JEA) and population mean potential adoption outcome (ATE) is the population adoption gap (GAP) or population non-exposure bias (NEB), expressed as $NEB = GAP = E(y) - E(y_1)$. The population adoption gap exists due to the incomplete diffusion of technology. The population selection bias (PSB) is estimated by the difference between the mean potential adoption outcome in the exposed subpopulation and the mean potential adoption outcome in the whole population and given by: $PSB = ATE_1 - ATE = E(y_1|w = 1) - E(y_1)$. It should be noted that the adoption outcome variable is a binary variable taking the values 0 and 1 (that is, a measure of adoption status with 1 corresponding to adoption), as is the case in our empirical analysis, then the expected values corresponding to the various population mean adoption outcomes reduce to probability quantities that correspond to measures of population adoption rate (that is, proportions of adopting farmers in the population).

2.7 Conceptual framework

The conceptual framework consisted of factors affecting the adoption of AI in Bojanala District. For a technology to be adopted, potential adopters should also perceive the problem which the technology intends to solve as a major constraint to their development efforts. An intended technology should not be complex, and its potential benefits should be easily visible. In this study, a combined effect of farmers, institutional, economic and technological characteristics towards enhancing the rise in farmers' knowledge level and thereby influencing change in farmers' attitudes to adopt or not to adopt AI technology was examined.

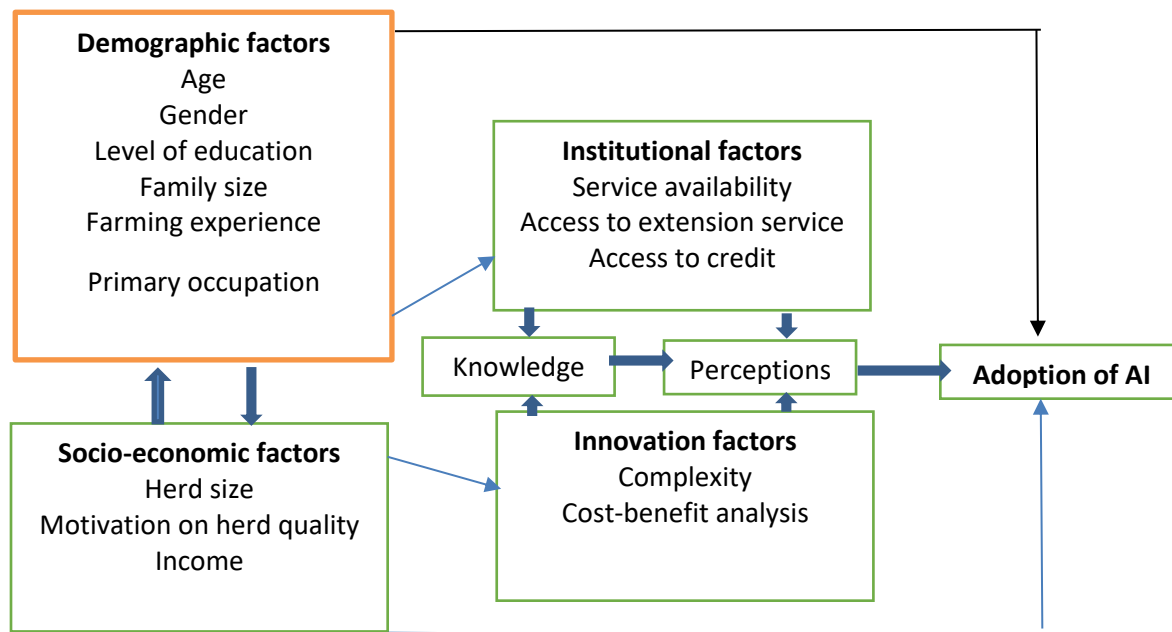


Figure 2.1: Conceptual framework for analysing the factors affecting the adoption of Artificial Insemination technology

Source: Author's compilation, 2022

2.9 Chapter summary

The chapter described the literature that backed up the research study in line with the research conducted. It covered perceptions of the livestock farmers towards Artificial Insemination and the factors determining the adoption of new agricultural technology by smallholder farmers, as well as the factors affecting the adoption of beef cattle Artificial Insemination in smallholder farmers. Lastly, it touched on the conceptual framework and theoretical framework.

CHAPTER 3: RESEARCH METHODOLOGY

3.1. Introduction

The chapter comprises a detailed discussion of the study area, research design and research methodology used, that is both the qualitative and the quantitative approaches. Sampling and pilot projects were discussed in depth, and a questionnaire was used as a method of data collection. Data analysis methods were also discussed. The questionnaire and focus group discussion were used as data collection tools.

3.2 Description of the study area

The selected area of study was Bojanala Platinum District in North West Province of South Africa. Bojanala District is 18 300 km² and comprises 17% of the total area of the province. The district includes five local municipalities namely; Rustenburg (Marikana, Mooiooi, Phatsima and Tlhabane), Madibeng (Brits and Hartebeespoort), Moses Kotane (Mogwase and Madikwe, to mention a few), Kgetlengrivier (Derby, Koster and Swartruggens, to mention a few) and Moretele (with villages such as Kgomo Kgomo, Ngobi, Tladistadt and Mathibestadt, to mention a few).

Cattle in Bojanala contribute only seven percent (07%) of North West Province cattle produce, especially on the western side of Bojanala as a lot of the area is encroached with bushes and making it difficult to farm with cattle. This is worse than in other districts

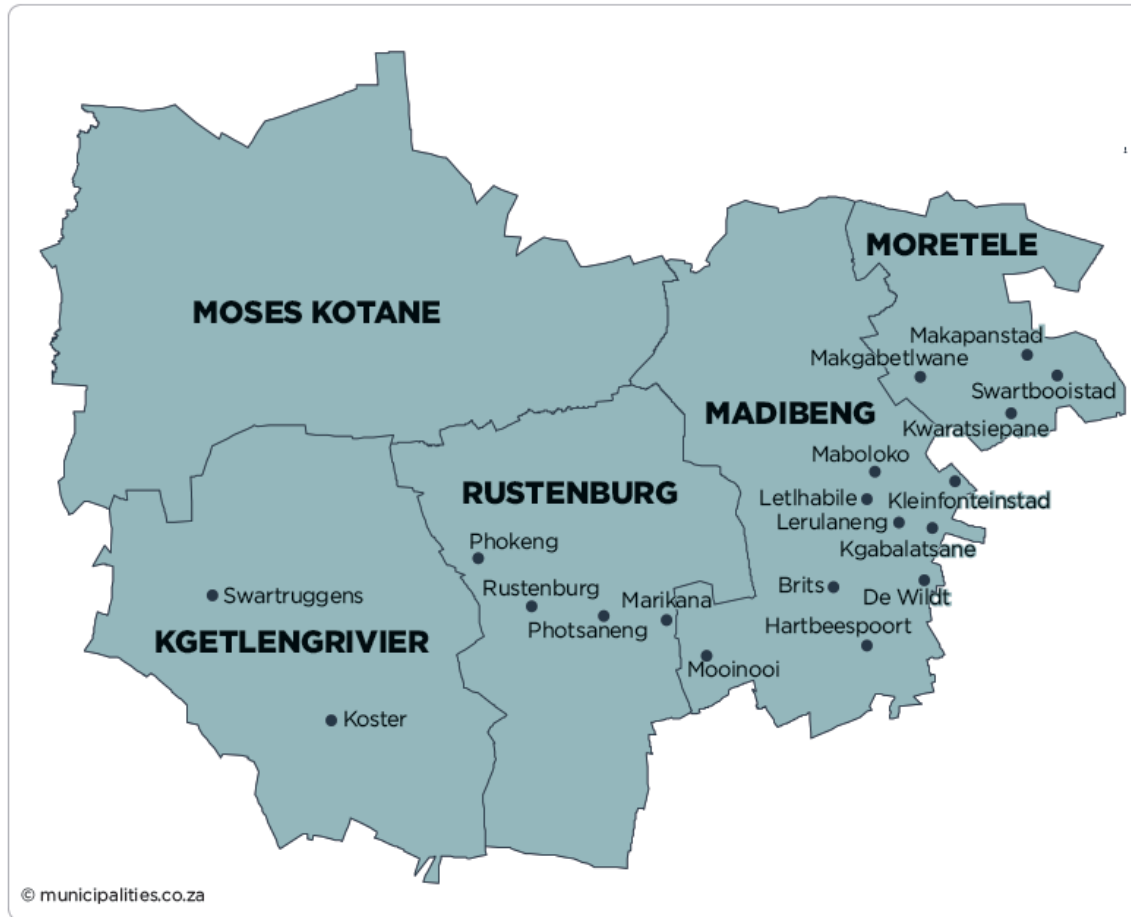


Figure 3.1. Map of the study area

Source: Google search (Bojanala Platinum District Municipality- map: 2011).

3.3 Research design

The study espoused a descriptive cross-sectional design to investigate the perceptions and willingness to adopt Artificial Insemination (AI) Technology by cattle farmers as an alternative to the traditional bull-to-cow breeding method. A cross-sectional research design is one of the most popular and convenient research designs among other research designs and is also known as a social survey design. The research design was espoused because it was not costly, and it was not even time consuming. It also allowed the researcher to collect data at one point in time.

3.4 Research approach

A mixed method approach (MMA) was used to answer the research questions. A mixed method approach was used too to collect and analyse both qualitative and quantitative data. According to Cant *et al.* (2005), the aim was to provide a better understanding of the research problem by combining the advantages of both qualitative and quantitative research methods.

Quantitative data were collected using the questionnaires, and qualitative data were collected through focus group discussions to draw upon the respondents' attitudes, feelings, beliefs, experiences and reactions in ways which would not be feasible using other methods. Leedy and Ormrod (2010) stated that these two approaches work hand in hand with the qualitative approach, providing an understanding of the problem and facilitating the formulation of the hypothesis for quantitative research.

A structured questionnaire comprising both open ended and close ended questions was used to collect data from the chosen respondents. Close ended questions provide a detailed great deal of information on the views of respondents/participants on the subject matter being studied (Schoeman and Johnson, 2017). Of paramount importance to note is that the questions were written in English, and translation was done in Setswana to ensure broad participation, as the level of literacy was taken into account in this study.

3.5 Population, sampling techniques and size

3.5.1 The total population

Gill *et al.* (2010) asserted that there are several approaches to determining the sample size. These include using a census for small populations imitating a sample size of similar studies, using published tables and applying formulas to calculate the sample size. Although tables can provide a valuable guide for determining the sample size, there is a need to calculate the necessary sample size for different combinations of levels of precision, confidence and variability (Breweton and Millward, 2001). In this case, Gill *et al.* (2010) further stated that the assumption should be that there is a large population, but the variability in the proportion that will adopt the practice is unknown, therefore, assume $p=0,5$ (maximum variability). Furthermore, suppose we desire a 95% confidence level and $\pm 5\%$ precision.

3.5.2 Sample size

Data used in this study were collected from a sample of 167 farm households in Bojanala Platinum District of North West Province in South Africa. The farmers were randomly selected from farmer groups that were given Artificial Insemination Training and starter kits by the Department of Agriculture and Rural Development, as well as ordinary farmers who were never exposed to Artificial Insemination technology. The sample consists of 90% of those who were farming in communal setups and 10% in their farms. In one camp, several farmers were sharing a sizeable land of hectares. A note to be made was that majority of these farmers are based in a rural setup, hence communal land sharing as far as farming is concerned.

3.5.3 Sampling technique

A multistage sampling procedure was used in this study. In the first stage, the Bojanala District Municipality of the North West Province was selected purposively because of the livestock numbers. In the second stage, Moretile, Madibeng and Rustenburg were selected as local municipalities with high livestock numbers. In the third stage, villages were randomly selected from Moretile, Madibeng and Rustenburg.

3.6 Data collection instruments

Data were collected through a structured questionnaire (*Appendix 2*). Before collecting data, a preliminary visit to Bojanala Platinum District Municipality was undertaken. That presented a viable opportunity for the researcher to present research objectives and questionnaires to local Agricultural Extension Officers, senior Agricultural Officers, Subject Matter Specialists, Veterinary Services Officials, Scientists and other roleplayers who work with farmers consistently to improve their production.

3.6.1 Questionnaire

A structured questionnaire was used as the research instrument to collect primary data from respondents. A structured questionnaire was used because of its ability to obtain information from a selection of people/households/farmers using self-report, that is, the people respond to a series of questions posed by the researcher (Creswell *et al.*, 2006).

The questionnaire consisted of different sections with pre-coded questions which were both open ended and close ended questions. Each section was supposed to accomplish the objectives of the study. The questionnaire was written in English, but in order to ensure reliability, two (02)

enumerators were trained for data collection and during the interviews, the enumerators, in some instances, translated the questions into Setswana as the majority of the respondents were incompetent in English as their second language.

The participants were interviewed inside and outside the households/farm, depending on whether they wanted privacy during the interviews or not. The focus group discussions were conducted with respondents after the survey has been completed. To ensure the validity of data collection tools, the questionnaire and focus group discussion guides were pre-tested within the study area. Fifty (50) livestock farmers were purposefully selected for this process (that is 10 from each local agricultural office). The respondents wrote down their answers. Open ended questions may require a respondent's viewpoint or opinion (Krosnick and Presser, 2010). In an open ended question, respondents can complete a sentence or a story as part of the questionnaire. Information from an open ended questionnaire is more complicated to analyse and is used more often in qualitative research.

In these questions, a variety of optional answers were provided by the researcher. According to Krosnick and Presser (2010), these are multiple choice questions, dichotomous questions or scaled questions. Farmers had to indicate their willingness to adopt Artificial Insemination and a deduction was made on their perceptions towards the adoption of Artificial Insemination, and they had to select their level of education from a given range. From the close ended questions, the researcher collected quantitative data. Close ended questions are easy for participants to answer, but they limit the information that the researcher can obtain due to the options given. These questions require a response based on the answer that is given to a prior question. Contingency questions prevent respondents from answering questions that are not meant for them (Krosnick and Presser, 2010; Sincero, 2012).

3.6.1.1 Advantages of the questionnaire survey

- A questionnaire is a cheap and flexible method to collect qualitative, descriptive and quantitative data.
- A questionnaire enables the researcher to collect data from a large group of participants.
- A questionnaire yields comparability (easy to compare and contrast to other research findings after quantifying the data).

- The results from a questionnaire are easy to analyse and visualise and allow the researcher to give conclusions and predictions. The researcher can give topics for further research.
- In a questionnaire, the participant's anonymity is granted, and this enables the respondents to answer truthfully (Leedy and Ormrod, 2010).

3.6.1.2 Disadvantages of a questionnaire survey

- Dishonest answers due to hidden agenda or fear of personalisation.
- Some questions can be skipped, but it remains a reliable instrument to collect information on surveys.
- Misinterpretation of questions is common, especially when presented in a language the participant is not fluent in (Sincero, 2012).

3.6.2 Focus group discussion

The Focus Group Discussion aims at bringing about a better understanding of perceptions towards Artificial insemination in livestock animals in rural communities. The Focus Group Discussion uses the participative ranking methodology (PRM). This methodology promotes an engaged and participatory process, drawing upon local knowledge and perceptions. It is community driven in that the participants identify, support or negate what is most important to them. It provides a forum for debate of relevant themes among peers, the contribution of ideas and strategies and the identification of barriers to interventions that either exist or might be implemented (Potts, 2010).

3.6.3 Data collection process

Extension officials, enumerators and the sampled farmers were briefed on the purpose and objectives of the study, and data needs were made clear. Knowing what was required, ideas were shared on how to approach the respondents. Before the interview, extension workers from each municipality introduced the researcher and enumerators to the respondents to put them at ease. The interviews continued once it was determined that the farmers were at ease and willing to answer questions. All these measures were taken to develop a positive relationship with respondents and encourage them to collaborate and provide honest responses.

The extension officials helped arrange community halls. After ensuring that farmers had settled and were ready for the interviews, they were asked to vacate the interview sites. This was important

to avoid biases or skewed answers from the farmers and dodge damaging their working relationship with extension officers. Farmers were given a questionnaire, and each group was assigned an enumerator with an interview guide to help the farmers understand the questions. Data were collected through face-to-face interviews and for focus groups, an interview guide was used. In unique circumstances, , door-to-door was embarked on for data collection. situations..

3.7 Reliability and validity of the tools

To ensure the validity of the data collection tool, the questionnaire was pre-tested on 10 cattle farmers in Bojanala areas. The results were excluded from the overall study data. The questionnaire was pre-tested, and how farmers answered revealed consistency in responses. Bernard *et al.* (2014) investigated the impact of drought on livestock farmers and made similar findings regarding the reliability and validity of the research instrument. There were no changes required on the questionnaire after it was piloted. The physical and psychological environment for data collection was made comfortable by ensuring privacy, confidentiality and physical comfort.

3.8 Ethical considerations

The informed consent was prepared and written in English. However, they were also explained using the local language (SeTswana). This allowed farmers to decide whether they wanted to be part of the study; those who agreed signed the consent form and accepted their participation in the study. As the data for this study were also collected using a questionnaire, privacy and confidentiality of the answers provided by farmers were protected, and questionnaires were put under the researcher's custody. In addition to this, no pictures were taken for the participants. An application for an ethical clearance certificate was made to the ethical committee at the North-West University before data collection, and it was received as such.

3.9 Method of data analysis

According to Mandikiana (2011), data analysis is a very important process in research, as it is used to transform, remodel and revise collected data with the vision of concluding a given situation or problem. Data analysis helps in structuring the findings from different sources of data collection, and it also serves as a filter when it comes to acquiring meaningful insight into a dataset (Cooper and Schindler, 2003). Furthermore, data analysis involves cleaning, editing, coding and processing data. Moreover, it improves the quality of the data that are collected through the correction of errors (Cooper and Schindler, 2003). This involves a tedious process of organising all the

questionnaires in one place through the inspection of complete questionnaires and the accuracy of the responses and dealing with incomplete questionnaires (Cooper and Schindler, 2003). The ultimate goal of screening and cleaning data is to make sure that the data is consistent, even, accurate and complete for the ease of data coding and data capturing.

Cooper and Schindler (2003) further states that data coding is a process that involves assigning numerical values to responses and grouping them into categories. Coding is dependent on how one has ensured the variables and also on how one wishes to communicate the findings about the variables. Besides, this is about how one wishes to communicate the findings about the variables and research questions to the readers. The advantage of coding is that it makes data understandable and easy to analyse without consuming a lot of time (Mandikiana, 2011). Similarly, the study used a pre-coded questionnaire which eliminates the difficulty of having to carry and refer to a coding sheet when conducting the interviews. This was done to make data capturing easy and less time consuming.

Primary data were collected by the researcher from first-hand sources using a questionnaire, and it was in line with the research project directly from the farmers (Yin, 2017), and this required farm visits. Questions included qualitative and quantitative questions and open and non-open questions. Data collected were analysed using descriptive statistics and Stata 14 computer software and Statistical Package for Social Scientist (SPSS) version 24.

A sub-district (LAO) to sub-district (LAO) visit was done by securing appointments with the farmers in their area of jurisdiction. The researcher made a schedule for a week to which each sub-district a day was dedicated to it. In some instances, various areas in one sub-district were visited per appointment made with cattle farmers. A thorough explanation of the research was made, and participants were allowed to ask questions of clarity and allowed deciding whether they participated in the study without any due influence or being coerced. In other instances, participants were requested to be recorded and taken some pictures as a form of Portfolio of Evidence (POE).

3.9.1 Method of analysing objective 1

The first objective identified the nature of cattle farmers in Bojanala District and descriptive statistics were used. Descriptive statistics are broken down into measures of central tendency (i.e. mean, median and mode) and measures of variability (i.e. standard deviation, variance).

Descriptive statistics helps to describe and understand the features of a specific dataset by giving short-term summaries about the sample and measures of the data.

$$\text{Mean: } \tilde{x} = \frac{\sum x}{n} \quad \text{standard deviation: } S = \sqrt{\frac{\sum (x - \tilde{x})^2}{n}}$$

Where : $\tilde{x}$ = mean of the data where: x = each of the values

$\sum x$ = sum of score, values of the data $\tilde{x}$ = mean of all

n = sample size of the score n = sample size of the score

3.9.2 Method of analysing objective 2

This objective sought to analyse the perception of farmers towards Artificial Insemination and the factors influencing their perceptions. Farmer preferences were analysed using the ordered probit model. The rank 1-5 given to attribute combinations was taken as the dependent variables and the levels present in the combinations as the independent variables. Since rankings and ratings all yield bounded discrete indices, the empirical utility function can be estimated via probit or logit (Mackenzie, 1993). For multi-level response with outcomes i , for $i=1, 2, \dots, c$, the probability, p_i , or of observing l_i is:

$$p_j = R + (1-R) Z(xb)$$

$$p_2 = (1-R) (Z(a_2 = x'b) - Z(x'b)) \quad p_j = (1-R) (Z(a_j = x'b) - Z(a_{j-1} = x'b))$$

$$p_c = (1-R) (1 - Z(a_{c-1} = x'b)) \dots \dots \dots (1)$$

Where = vector of parameter estimates; Z = normal cumulative distribution function of response; R = response rank. The c -level response produces $c-2$ additional parameters, a 's, denoted 'inter' (SAS Institute Inc., 1989).

The ordered probit model was specified as: $PREF = Pr [Z] \dots \dots \dots (2)$

Where:

$Z = I + \delta_1$ Lack of knowledge about AI (high=1 and otherwise=0; medium=1 and otherwise =0) δ_2 Breed type (high=1 and otherwise=0; medium=1 and otherwise =0) δ_3 Cost Artificial Insemination (high=1 and otherwise=0; medium=1 and otherwise =0)

δ_4 Economy on land (high=1 and otherwise=0; medium=1 and otherwise =0)

$\delta_1, \delta_2, \delta_3, \delta_4$, are parameter estimates (embed in the vector b); and I represents the conventional intercepts and appropriate interval dummies.

To examine the value of disaggregated conjoint analysis across location and distance from the veterinary and income groups, 8 models were estimated for: all respondents in Bojanala District, below 1 acre of land, respondents with more than 1 acre of land, respondents with off-farm income and access to artificial insemination off-farm income (Daidu-Forson, 1996, 1997).

The relative importance of each attribute to respondents can be computed by using estimates from equation (1), (for example, how important is one attribute relative to all other characteristics?) The formula for the relative importance is:

$$\Psi_a = [(\max(v^*_{ga}) - \min(v^*_{ga}))] / \sum \omega_a \dots \dots \dots (3)$$

Where v^*_{ga} is the marginal value of the g^{th} level of the a^{th} attribute; Ψ_a represents the relative importance of the a^{th} attribute; $\sum \omega_a$ is the sum of the ranges, $[(\max(v^*_{ga}) - \min(v^*_{ga}))]$ across all attributes (Tano et al 2003). Jain *et al.*, (1979) argue that Ψ_a for a consumer may be normalized to ascertain its relative importance with regard to the other attributes and across consumers.

3.9.3 Method of analysing objective 3

The Tobit regression model will be used to analyse factors influencing the willingness to adopt AI in Bojanala District. Independent variables are shown in Table 2. This analysis uses the same broad approach as used by many, but the emphasis here is on introducing technology (Artificial Insemination) attributes that were found to be important to farmers from the farmers' points of view.

The empirical form of the Tobit regression model is given:-

$$\ln \{P / (1-P)\} = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + \epsilon_i$$

Where: $\ln \{P / (1-P)\}$ = Dependent variable (1= Adopter of AI technology; 0= Otherwise)

b_0 = Intercept term of the model. $b_1, b_2, b_3, b_4, b_5, b_6, b_7$ and b_8 are the parameters that need to be estimated.

Table 3.1: Definition of explanatory variables for the Tobit Regression Model

Variable	Type	Description
Age	Continuous	Age in years for cattle farmers
Gender	Dummy	(1= male;0= female)
Level of education	Continuous	Number of years in schooling
Farming experience	Continuous	Number of years in cattle production
Land size	Continuous	Ha of land being accessed for cattle production (in numbers)
Income	Continuous	Income generated through cattle farming
Access to extension	Dummy	Technical services for AI (1= accessible;0= otherwise)
Distance from AI services	Continuous	Physical length between farmers' households and technological centres
Access to credit	Dummy	Amount of money accessed from financial institutions for improving breeding method (1= accessible;0=otherwise)

Member of farmer organization	Dummy	Whether the farmers are part of farmer organisations
Herd size	Continuous	Number of cattle owned

3.9.4 Method of analysing objective 4

- Descriptive statistics was used.
- This method is useful because it allows you to make sense of the data.
- It further helps in exploring and making conclusions about the data in order to make rational decisions.
- This will involve describing, summarising and organising data so that it can be easily understood.
- Graphical displays are often used along with quantitative measures to enable clarity of communication.

3.10 Chapter summary

This study entailed methodologies of the study, starting with the description of the study area where research was conducted, research approach, research design, the population of the study and sampling size, as well as the procedure which was inclusive of the data collection methods.

A semi structured questionnaire that was developed was administered by the researcher and the enumerator by moving from one sub-district to the other. SPSS and Stata 15 computer software were used to analyse data that were collected. Then, the commercialisation index and Tobit regression model were discussed in detail. As such, the following chapter addressed the results and the discussions of this study.

It should be noted that data collected were captured in a data spreadsheet and a codebook was developed. Each theme was allocated a code or a particular number which represented the outcomes of cattle farmers on AI. Thus, themes were developed (theme building) to come up with the results, and codes were allocated to themes thereafter.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results of data obtained from the questionnaires administered to Bojanala farmers to investigate the perceptions and willingness to adopt Artificial Insemination (AI) Technology by cattle farmers as an alternative to the traditional bull-to-cow breeding method. Data is presented and analysed according to the research objectives presented in Chapter One. Specifically, the first section of this chapter discusses the nature and demographic characteristics of farmers in Bojanala District. The second part discusses the awareness of AI, and the last part focuses on the perceptions towards AI, as well as the general challenges.

4.2 The nature and demographic characteristics of cattle farmers in the study area

This section of the study presents the results of data analysed as per objective one. It further provides frequencies, percentages, standard deviation and averages. Variables analysed in this section include gender of the household head, number of years in formal education, household size, age of the household head and number of years farming on the land amongst others.

4.2.1 Gender of the household

The gender and age of the interviewers are important because of power relations and social norms in different contexts. Gender is an important consideration in development. It is a way of looking at how social norms and power structures impact on the lives and opportunities available to different groups of men and women. According to the World Development Report (WDR) (2012), gender is defined as socially constructed norms and ideologies which determine the behaviour and actions of women and men. Understanding these gender relations and the power dynamics behind them is a pre-requisite for understanding individuals' access to and distribution of resources, the ability to make decisions and the way women and men, boys and girls are affected by political processes and social development.

Table 4.1: Gender of the household head

Variables	Frequency	Valid Percent
Female	40	24
Male	127	76
Total	167	100

Source: Based on STATA/SPSS processing of field data, 2022

Table 4.1 above depicts that the majority (76%) of the farmers are males, while 24% of farmers are females. The results show that the Bojanala cattle farming community is mostly dominated by males. The results are in line with the findings by Musemwa *et al.* (2007) and Oladele, Antwi and Kalawole (2013) who revealed that the majority of the sampled livestock farmers were men (65%), with only 35% being women. According to Gurunga and Lama (2008), women usually own small stock (sheep, goats and poultry), and men own large stock (cattle).

According to Meinzen -Dick *et al.* (2011), gender equity in the ownership of productive resources such as livestock is considered key to improving agricultural productivity, food security and livelihoods of the rural poor. Ownership of such an important asset is skewed in favour of men. Empowering women with high-value assets (such as cattle) has been shown to have positive outcomes, not only for women but for the entire household (Meinzen-Dick, Johnson, Quisumbing, Njuki, Berman, Rubin and Waithanji, 2011).

4.2.2 Age of the household head

From the point of view of experience and decision-making capacity, age is counted as one of the most important variables in the analysis of smallholder households, and it is a continuous variable measured in years. Older farmers will behave differently from younger farmers regarding actions that promote or hinder the transition from home gardening to market-oriented agriculture based on irrigation use. According to FAO (1983), age affects farmers' preferences and attitudes. Likewise, the way a person is treated often affects their age; young people may be treated with less respect than older people.

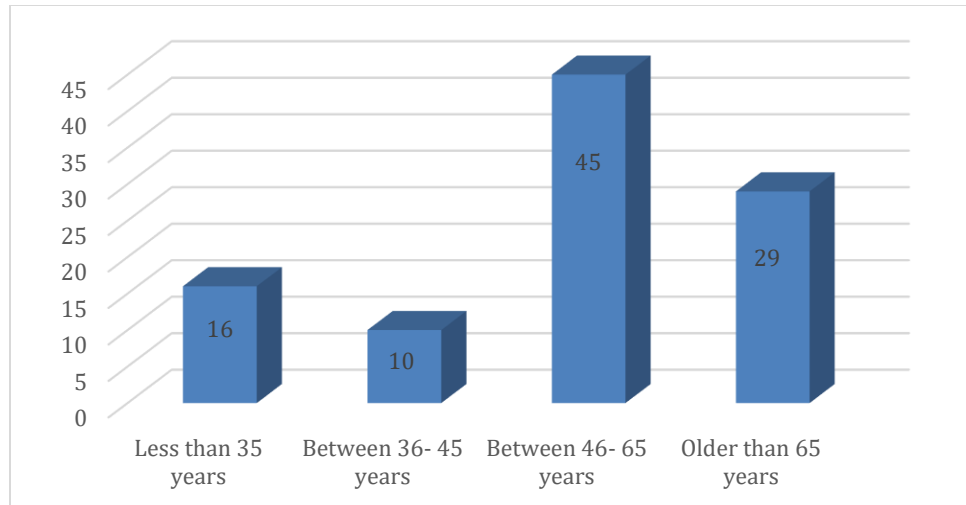


Figure 4.1 Age of the household head

Source: Based on STATA/SPSS processing of field data, 2022

According to Figure 4.1, the majority (45%) of the respondents' ages range from 46 to 65, followed by the farmers older than 65 years at 29%, and the minority are farmers ranging between 36 - 45 years at 10%. Basically, this finding implies that farmers in the Bojanala region are getting older. This is in concurrence with the study conducted by Hlatshwayo *et al.* (2021) noting that young people are not interested in farming as they prefer other occupations.

4.2.3 Level of education

Another important variable for agricultural decisions is education level. Theoretically, the more educated would be more receptive to the latest ideas expressed in extension messages aimed at farmers to influence adoption decisions. This study collected information from household heads about the level of education they attained or the number of years they attended formal education. This was a categorical variable where farmers were asked to indicate the category in which they fall within. The results are shown in Table 4.2. below.

Table 4.2: Highest Educational Level

Variables	Frequency	Valid Percent
None	2	1
Primary Level	28	17

Secondary Level	88	54
Tertiary Level	45	28
Total	163	100

Source: Based on STATA/SPSS processing of field data, 2022

Table 4.2 represents the highest qualifications that farmers obtained. Of the respondents, 54% had completed high school level, followed by farmers who completed tertiary level (28%) and only (1%) with no formal education. This implies that the Bojanala farmers obtained basic education. The results indicate that education level does not necessarily influence one to embark on farming activities. Even though there are farmers with tertiary qualifications (28%), the majority of cattle farmers have basic secondary school level qualifications and are doing profoundly well in farming. The willingness to adopt technology by those who do not have tertiary qualifications is very positive with that enthusiastic behaviour to adopt it even tomorrow should resources be availed or be at their disposal. Even if it is like that, education illuminates the person's mind and thinking.

Paltasingh and Goyari (2018) purport that a minimum threshold level of education is significantly influencing the adoption of modern varieties of paddy therefore the farm productivity of adopters only. The study further finds evidence in support of Schultz's (1975) hypothesis that says education enhances farm productivity in the case of adopters of modern technology. Schultz (1975) argued that education plays a significant role in modernised farm environments rather than traditional ones.

In contrast, the ability to deal with the disequilibria caused by the adoption of modern technology is largely a function of the farmers' education. Thus, more educated farmers adjust better and quicker than less educated or illiterate farmers (Ali and Byerlee, 1991; Hojo, 2004).

4.2.4 Household size

Household size has a significant influence on intensive and labour-intensive agriculture. According to Christian (2014), the large size of households discourages sales because they have large households, and most of them grow crops for household consumption. In addition, food insecurity was identified as a major problem in rural areas; this is because most people in rural areas work in agriculture. However, most of them do not have access to the land for farming.

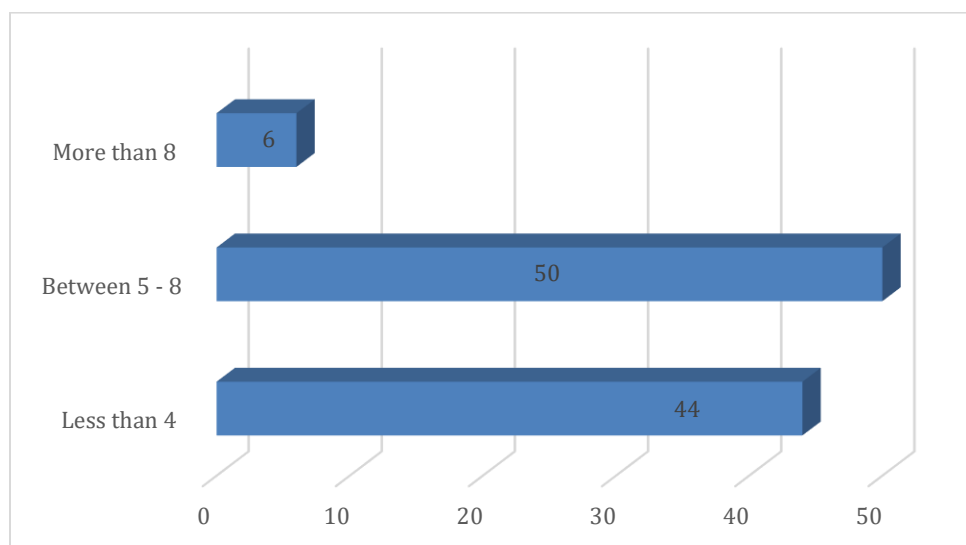


Figure 4.2 Number of persons within the household

Source: Based on STATA/SPSS processing of field data, 2022

Figure 4.2 represents the number of household members of farmers. The majority (50%) of respondents' households range between 5 to 8, followed by the farmers with household members less than 4 at 44%, and the minority are farmers with household members more than 8 at 6%. Data indicate that Bojanala District consists of farmers with big household members.

4.2.5 Respondent's main occupation

Occupational preferences of surveyed households are the only way to better understand rural communities and the survey. Thus, people's job preferences and choices determine the economic pressures and opportunities of the region and the nature of the incentives they respond to. It is also important to understand the nature of people's motivation in seeking opportunities to address their most pressing constraints and whether they are willing to take advantage of available opportunities.

Table 4.3: Farmer's main occupation

Variables	Frequency	Valid Percent
Farmer	153	92

Informal employment	10	6
Formal Employment	3	2
Total	166	98,8

Source: Based on STATA/SPSS processing of field data, 2022

According to Table 4.3, the majority (92%) of respondents' main occupation is farming, followed by the respondents who are informally employed at 6%, and the minority were formally employed at 2%. Data revealed that Bojanala consists of the respondents who are full time in farming.

As technology requires that a farmer be full time to observe the signs of oestrus and manage the entire process very well inclusive of synchronisation, the study reflects a positive aspect of full time farming of cattle farmers around Bojanala District as their main source of occupation. It would not be a challenge for the technology to be implemented as cattle owners will be based full time at a farm.

4.2.6 Household source of income

A variety of sources of income could be regarded as a positive factor contributing to the adoption of AI because it poses a potential opportunity for investment in farming. The results from the surveyed farmers are presented in Figure 2.3 below.

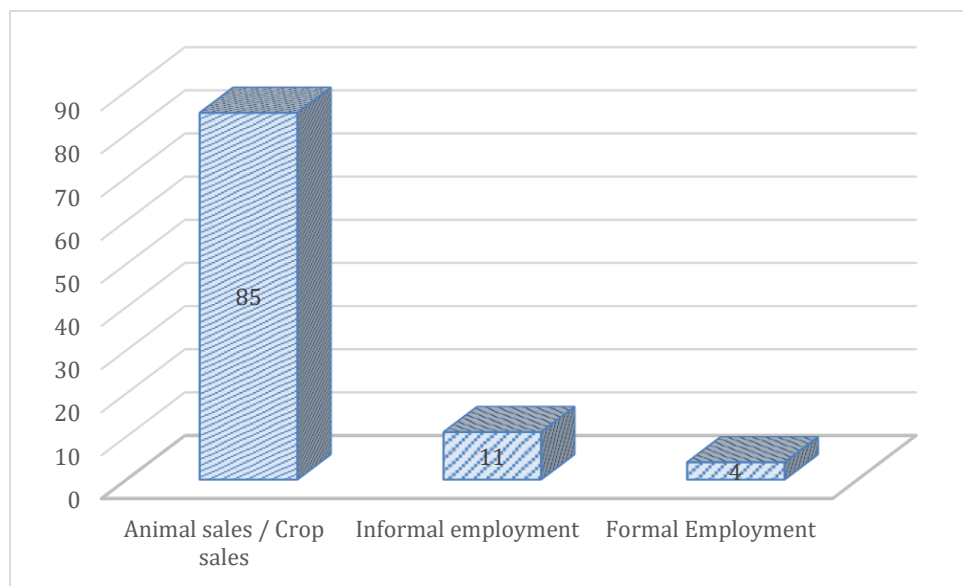


Figure 4.3: Farmer's source of income

Source: Based on STATA/SPSS processing of field data, 2022

Figure 4.3 above shows that the majority (85%) of respondents' source of income is animal sales/crop sales, followed by the respondents who are informally employed at 11%, and the minority are formally employed at 4%. Data indicates that the Bojanala District consists of respondents who are full time in farming.

Source of income: the results indicated that the source of income for Bojanala cattle farmers comes from cattle, and this is a very unique and important factor to note. Weaners will improve when AI is practised as there will be the use of better sperms from stud breeds, leading to a better size, body structure and price during auctions.

The study also reflects that 54% of cattle farmers in Bojanala Platinum District completed high school levels of education. They can adapt quickly even in training as far as procedures and techniques of AI are concerned. Therefore, for them to do better in their income generation, they must adopt AI to improve their breed.

According to Shahaideh *et al.* (2001), of the farmers interviewed in his study, 69% of all households report that farm income is their most important source of income, and this proportion does not appear to be smaller for smaller or poor farmers. Thus, that manifests the importance of farm incomes among farm households in rural areas. Farming is still a profitable business for most farm households, but a lack of own funds for expansion is a major constraint to expansion.

Table 4.4: Income Range (in Rands)

Variables	Frequency	Valid Percent
Less than R42 000	113	71
R42 000 – R84 000	28	18
R84 000 – R126 000	9	6
More than R126 000	9	6
Total	159	100

Source: Based on STATA/SPSS processing of field data, 2022

Table 4.4 above shows that the majority (71%) of the respondents had received income less than R42 000, followed by respondents with income ranging between R42 000 – R84 000 at 18% and lastly, respondents with an income ranging from R84 000 – R126 000 and more than R126 000 at 6%.

Farmers with relatively higher gross margins per livestock unit were more likely to use AI than farmers with relatively lower gross margins. It could be that relatively more profitable farms recognise the benefits of using AI as a reproductive technology and are therefore more likely to use this as opposed to natural mating. It must be noted, however, that this variable at least to some degree may be capturing the fact that farmers who use AI are more likely to have a higher gross margin. They further urged that farmers with relatively higher stocking rates are also more likely to use AI, although this variable is not statistically significant (Howley *et al.*, 2011).

4.2.7 Farm size

The availability of farmland is also one of the socio-economic variables that are vital for agricultural practice and livelihood creation. According to Ngqangweni and Delgado (2003), land that is available to smallholder farmers in South Africa is usually shared between residential and farming purposes. Figure 4.4 below shows the percentages of farmers with respective categories.

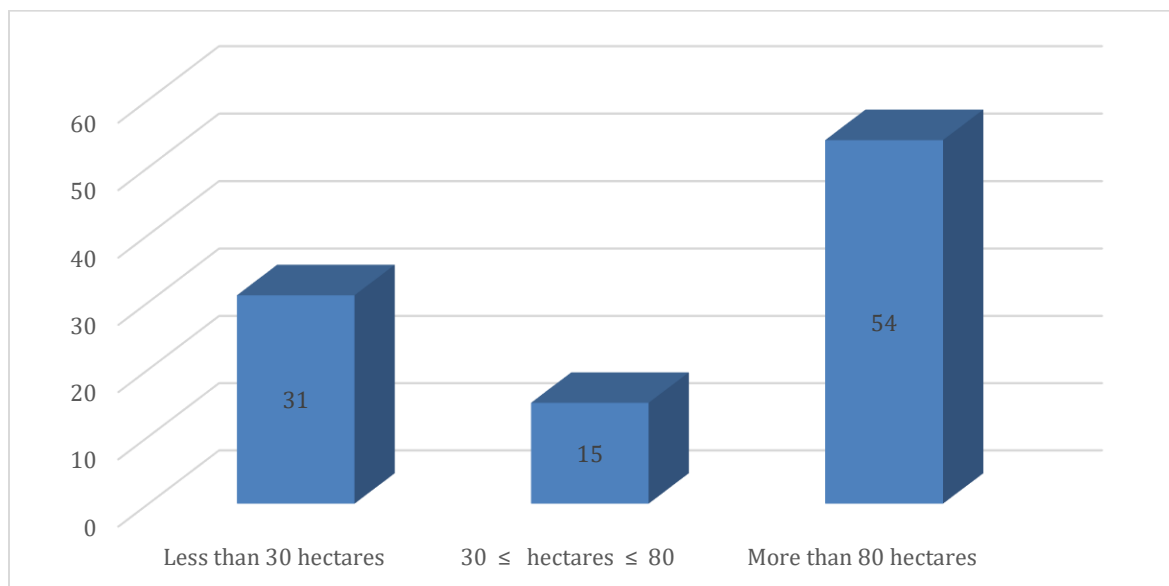


Figure 4.4: Farm size (in Hectares)

Source: Based on STATA /SPSS processing of field data, 2022

Figure 4.4 above shows that the majority (54%) of respondents own more than 80 hectares of land, followed by the respondents who own less than 30 hectares of land at 31%, and the minority own between 30 to 80 hectares of land at 15%. Data indicate that in Bojanala District, most of the respondents own more than 80 hectares of land. They practice farming on communal shared land, although they have less than 5 hectares and handling facilities for their stock.

The studies conducted by Howley *et al.* (2011) further reflected that farm size was negatively associated with the use of AI. It could be that once they control for cross margin and stocking rate that the variable might be capturing the effect of being in a more extensive rather than intensive farm enterprise.

Table 4.5: Respondents owning the farm

Variables	Frequency	Valid Percent
Yes	68	42
No	92	58
Total	160	95,2

Source: Based on STATA/SPSS processing of field data, 2022

Table 4.5 above depicts that the majority (58%) of the respondents do not own the farm, and 42% of the respondents own the farm. The results indicated that Bojanala District is dominated by communal farmers who use shared communal grazing land without proper classification of hectares owned by individual farmers.

It should be noted that even if the cattle farmers own a piece of land, they do not have title deeds, and several of them share hectares allocated to them by the tribal authority. Where there could be a cooperative mutual agreement, farmers could cluster themselves and have shared kraals and handling facilities for the conduction of Artificial Insemination. This study reveals that the farmers have working relations when it concerns cattle farming because share a bull, while they are 20 or 30 on one piece of land.

4.2.8 Respondents leasing the farm

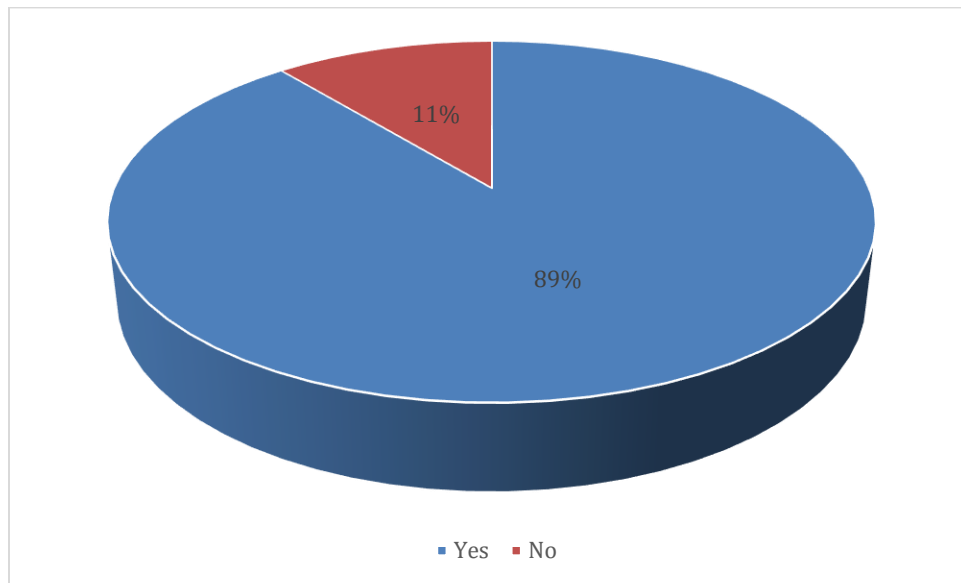


Figure 4.5: Respondents on leasing the farm

Source: Based on STATA/SPSS processing of field data, 2022

Figure 4.5. above depicts that the majority (89%) of the respondents are leasing land from the communal property association or traditional leaders, and 9% of the respondents are not paying lease money for the land. The results indicate that Bojanala farmers are leasing grazing land from communal property associations or traditional leaders.

Comparing breed and availability of land: Seeing that the majority of Bojanala farmers rely on traditional lands to farm, this had a great opportunity to increase livestock in terms of cattle farming. They are not leasing grazing lands and use them free of charge. The majority have land where they can farm and breed cattle of their choice. This method of sharing the land makes sure that there is control in communal grazing land for these farmers to practise Artificial Insemination

There is no roaming of bulls as the camps are well fenced with several hectares. When there is a lack of bulls, it assists and gives farmers an opportunity to exercise Artificial Insemination. The lack of bulls for the majority of farmers who are breeding cattle also indicates that the implementation of the AI method will benefit many, and no transmission of diseases will be

realised. This type of communal cattle farming leads to cluster farming, which will be easy to practise the newly envisaged technology.

4.2.9 Farming experience

In this study, variable farming experience measured the number of years a farmer has been engaged in cattle farming. It can be hypothesised that farmers with more experience are likely to allocate resources efficiently, which then can result in the adoption of innovations. Table 4.6 below shows the results of the surveyed farmers.

Table 4.6: Farming experience (in years)

Variables	Frequency	Valid Percent
Less than 5 years	37	23
6 – 15 years	74	46
More than 15 years	50	31
Total	161	100

Source: Based on STATA/SPSS processing of field data, 2022

According to Table 4.6, the majority (46%) of respondents had 6 – 15 years of farming experience, followed by the farmers with more than 15 years at 31%, and the minority are farmers with less than 5 years at 23%. Data indicate that the Bojanala District consists of farmers with good experience in farming.

Whether farming experience enhances or discourages agricultural technology adoption remains unclear in existing studies (Knoler and Bradshaw, 2007). However, definite answers are essential for policymakers, especially those promoting the adoption of agricultural technologies and participation in field farmer schools (Duveskog, Friis-Hansen and Taylor, 2011).

It is argued by Arow (1962), Dosi (1982) and Feder, Just and Zilberman (1985) that as farmers accumulate experience over time, they progressively switch from traditional agricultural technologies to improved technologies based on observed performance and learning by doing. Accordingly, farming experience might be a cherry on top as cattle farming requires good and proper management practices. One could have a very good experience in terms of the number of

years in farming and have poor record systems in place and always respond based on experience even when taking decisions. Farmers who just joined cattle farming might perform better than those with more experience as far as years are concerned and have good and better management systems and records in place. This will determine the willingness to adopt Artificial Insemination, as one would be able to compare the two methods (mating and Artificial Insemination technology) when applied and their negative impact or positive impact on cattle productivity levels.

Both education and extension appear to unambiguously enhance technology adoption (Asfaw and Admassie, 2004; Birkhaeuser, Evenson and Gershon, 1991; Holloway and Ehui, 2001), and the relationship between the adoption of agricultural technologies and farming experience remains mixed. The study is in agreement with Ainembabazi and Mugisha (2014) who found a weak significant link between the adoption of new technology and education.

Farming experience is more useful in the early stages of adoption of a given technology when farmers are still testing its potential benefits, which later determine its retention or non-adoption over time (Ainembabazi and Mugisha, 2014).

4.2.10 Type of cattle breed owned by farmers

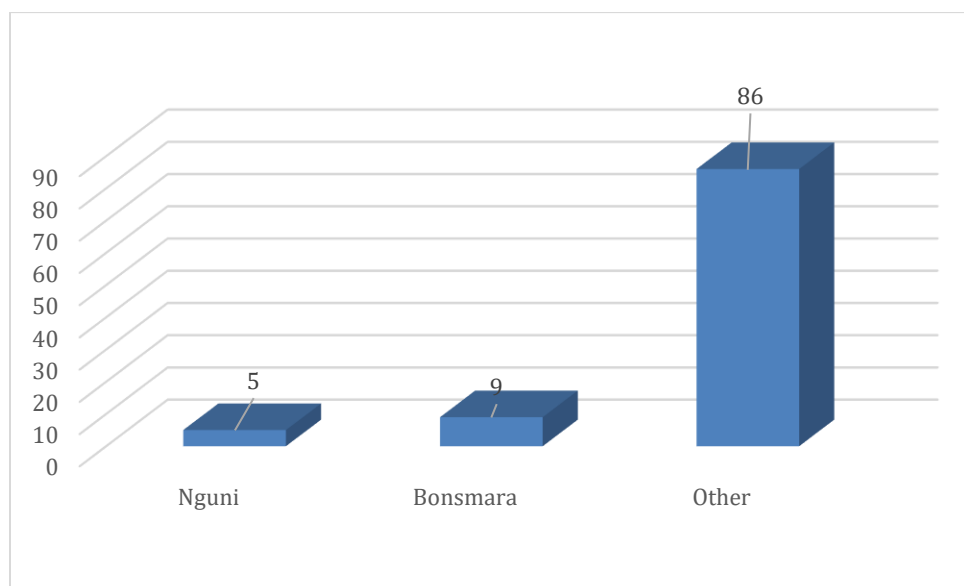


Figure 4.6: Breed of cattle owned by farmers

Source: Based on STATA/SPSS processing of field data, 2022

According to Figure 4.6, the majority (86.6%) of the respondents have other cattle or mixed breeds, followed by the farmers who farm with Bonsmara breed at 8.7%, and the minority re Nguni at 4.7%. Data indicate that the Bojanala District is still farming with mixed breeds.

Cattle breed: - Most of the communal farmers are farming with mixed breeds, and they need to improve their livestock so that they can have better returns from their sales. Most indigenous breeds' qualities are not having better returns from the auction and are losing prices because they sell them without much weight, and buyers take them to feeding lots. AI will improve their offspring thus bringing them their returns, using weaners from stud breeds by AI.

The importance of livestock improvement (2020/2021): - Most of the farmers are also sharing livestock facilities like cattle handling facilities and water points, as a result, there is no control over the use of bulls, which poses threats of disease transmission. The use of shared land has the advantage of collective use of AI techniques, as they will work as a cooperative and encourage cluster farming that will result in reduced costs and the risk of an expensive bull. It is a fact that Artificial Insemination as a technology that needs to be adopted is very expensive, and most of the farmers are unable to adopt it, hence no one can dispute that cluster farming will result in reduced cost of Artificial Insemination.

4.3 Awareness and level of understanding of farmers on Artificial Insemination

4.3.1 Mating method used by cattle farmers

Table 4.7: Mating method

Variable	Frequency	Valid Percent
Natural	160	98
Artificial Insemination	4	2
Total	164	100,0

Source: Based on STATA/SPSS processing of field data, 2022

Table 4.7 above depicts that the majority (98%) of the respondents are using the natural method for mating (bull), and 2% of farmers are using AI as a mating technology. The study reflects that cattle farmers around Bojanala District depend on natural mating for their production or breeding purposes. This indicates less knowledge and information about the technology, as it is very clear that they are not conversant with the method. Those with the knowledge do not implement AI due to various reasons advanced during the research. The adoption of the AI technology would improve on their profitability when selling their cattle, as they would be able to sell large and reasonable numbers of heifers and steers. The disadvantage of the natural mating method is that sometimes the heifers do not find a bull, and they stay for a year or two without giving birth to young calves, which is a waste for cattle farmers. Farming is a business, therefore no cattle should skip a year without giving birth to a calf.

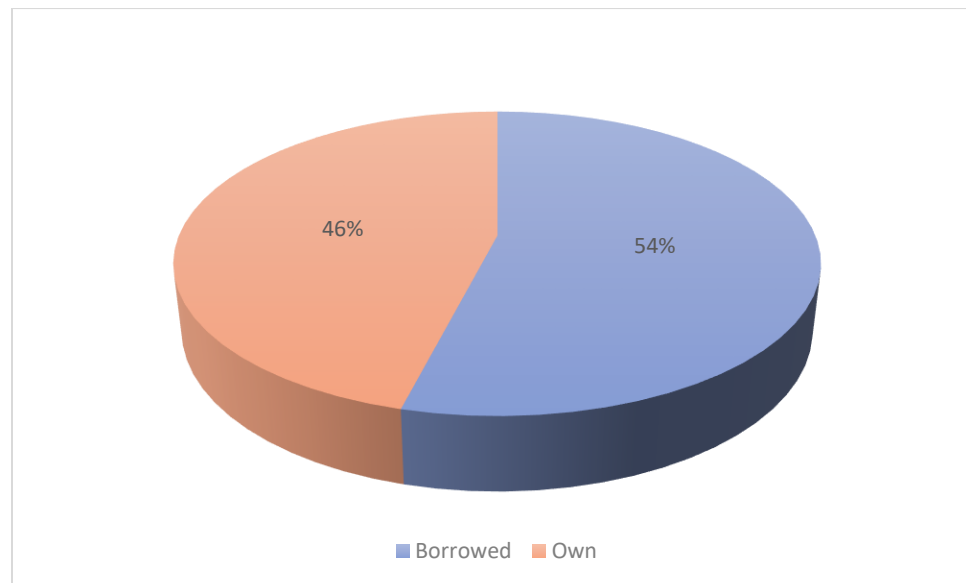


Figure 4.8: Source of the bull

Source: Based on STATA/SPSS processing of field data, 2022

Figure 4.8. above depicts that the majority (54%) of the farmers borrowed the bulls, and 46% of the farmers above own the bulls. In terms of borrowing, most cattle farmers in Bojanala District depend on roaming bulls in the field to service their cattle and as such, their animals are prone to diseases. The implementation and adoption of Artificial Insemination Technology will assist in

reducing the risk associated with borrowing bulls, as they are not tested for venereal diseases. The worst risk is that they know the after effects of borrowing bulls but because they do not have any choice, they rely on them to service their cattle. On the other hand, the cost of keeping a bull is sky rocketing and as such, affordability is low as they depend on cattle sales for a living.

4.3.2 Farmers' awareness of diseases

Table 4.8: Awareness of diseases associated with bulls

Variable	Frequenc y	Valid Percent
No	31	19.0
Yes	132	81.0
Total	163	100.0

Source: Based on STATA/SPSS processing of field data, 2022

According to Table 4.9, the majority (81%) of the farmers are aware that borrowed bulls can cause diseases, and 19% of the farmers are unaware that borrowed bulls can cause diseases. The high costs of bulls in the market and even at auctions make it difficult for cattle farmers to afford one. Roaming bulls are susceptible to diseases as they are not controlled and can service various cattle belonging to almost ten different farmers at the same time. As such, cattle farmers are prone to a very high risk of losing a number of their large stock should there be an outbreak of sexually transmitted diseases at that given point.

4.3.3 Awareness of artificial insemination

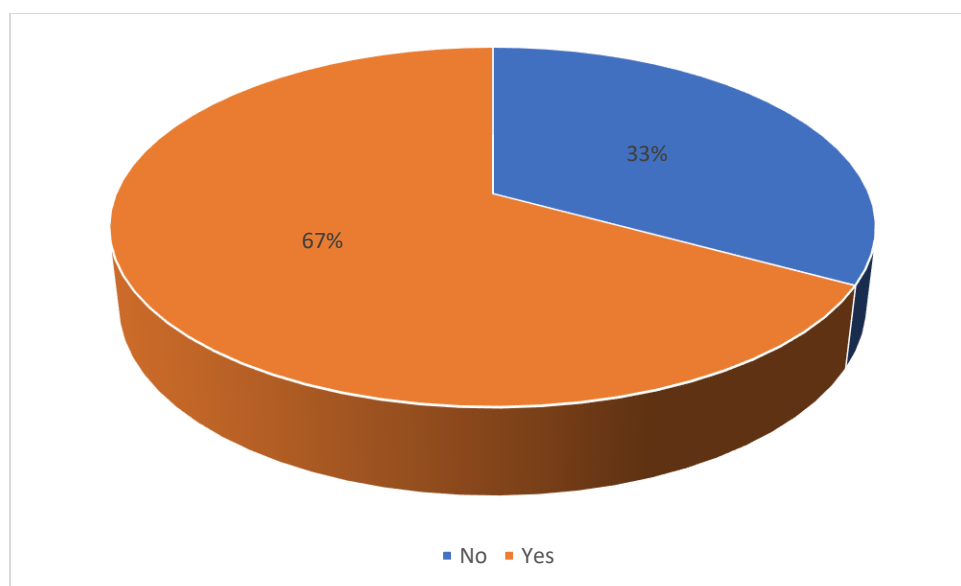


Figure 4.9: Farmers awareness of Artificial Insemination (AI) and its effects

Source: Based on STATA/SPSS processing of field data, 2022

According to Figure 4.9, the majority (67%) of the farmers are aware of Artificial Insemination (AI) and its effects on cattle fertility and productivity, and 33% of the farmers are unaware of Artificial Insemination (AI) and its effects on cattle fertility and productivity. Regarding in-depth advocacy on Artificial Insemination as a technology that could improve breeding, both fertility and productivity should be conducted around the area. Looking at how they made profitability after sales, if the method of AI could be adopted, an improvement on the living standards and food security around the area would be enhanced.

Table 4.9: Willingness to utilise the Artificial Insemination technology

Variable	Frequenc y	Valid Percent
Yes	156	94.5
I am not sure	9	5.5
Total	165	100

Source: Based on STATA/SPSS processing of field data, 2022

According to Table 4.9, the majority (94.5%) of the farmers are willing to utilise the Artificial Insemination technology, and 5.5% of the farmers are unsure to utilise the Artificial Insemination

technology. If 95,5% of cattle farmers are willing to utilise Artificial Insemination, this is a good sign that they are not resistant to change. More intensive training and workshops on Artificial Insemination should be provided, as others are more than willing to buy semen on their own for the technology to be applied on their cattle.

4.3.4 Use of AI for breeding

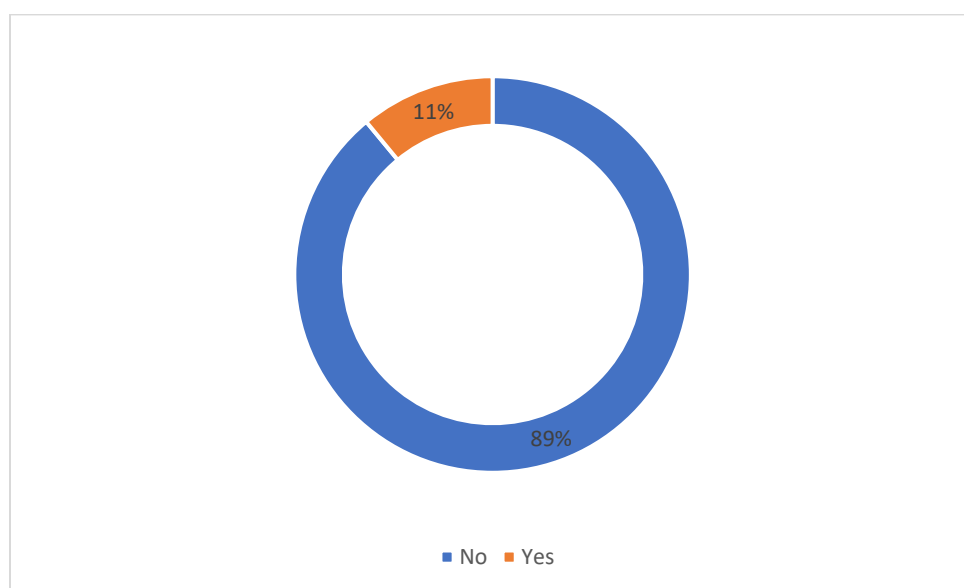


Figure 4.10: How farmers have used Artificial Insemination for breeding

Source: Based on STATA/SPSS processing of field data, 2022

Based on Figure 4.10, the majority (89%) of the farmers have not used Artificial Insemination for breeding, while 11% of the farmers have used Artificial Insemination for breeding. This indicates that there is a gap between the Extension Officers and the Department of Agriculture and Rural Development as far as livestock improvement is concerned. A deliberate programme should be derived or devised to make sure that Artificial Insemination is practised for breeding by cattle farmers.

Table 4.10: Number of years using AI

Variable	Frequency	Valid Percent
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1-2 years	9	90
5 years or more	1	10
Total	10	100.0

Source: Based on STATA/SPSS processing of field data, 2022

According to Table 4.10, the majority (90%) of the farmers practised Artificial Insemination for 1 – 2 years, and 10% of the farmers practised Artificial Insemination for 5 years or more.

Cattle farmers who indicated that they have practised AI are those who were in a pilot for a year and thereafter, they did not even bother to continue with the method, as it is not cost effective. They think the AI system is lacking. The majority of them are inexperienced, hence they could not afford to implement it on their own after the pilot project. The high cost of the technique and not affording the high cost of private Veterinary (VET), Animal Health Technicians or officers in the department have no requisite skills, knowledge and equipment to carry out this. Subject Matter Specialists also have little knowledge and skills, and they need to be re-trained to be able to assist cattle farmers with Artificial Insemination-related matters.

4.4 The perception towards Artificial Insemination by cattle farmers

4.4.1 Farmers' perceptions

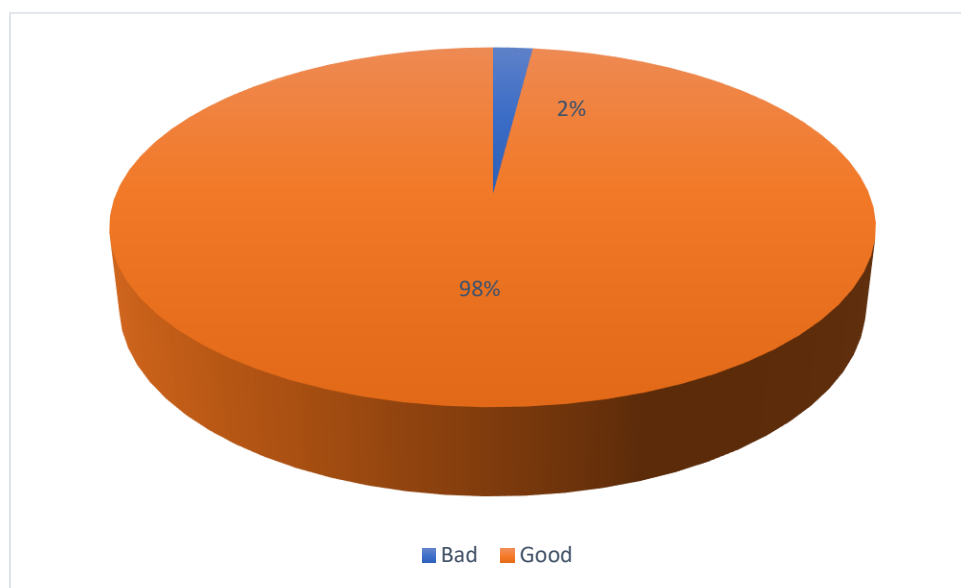


Figure 4.11: Perceptions of farmers towards the Artificial Insemination technology

Source: Based on STATA/SPSS processing of field data, 2022

According to Figure 4.11, the majority (98%) of the farmers perceived the use of Artificial Insemination as good, while 2% of the farmers perceived the use of Artificial Insemination as bad technology.

4.4.2 Presentation of AI by government officials

In terms of the presentation of Artificial Insemination by Extension Officers (Government officials), farmers indicated that it was never presented to them before, even if they had shown keen interest in using Artificial Insemination on their cattle. That is 99% indicated that. Extension officers are not visiting them regularly as expected to provide extension services for them to improve on their farming techniques. This is in line with Howley *et al.* (2011) who indicated that it could be that advisory services help make farmers more aware of the potential benefits of using AI as a reproductive technique. They argued that, in particular farms, advisory services could provide useful advice on the impact of using AI over other reproductive technologies and the most efficient method of using AI. It was further noted that there is a potential endogeneity problem with the inclusion of the variable in that those who involve themselves with advisory services may be more likely to adopt best management practices irrespective of any advice or help they receive

4.4.3 Distance to the AI service centre

Cattle farmers around Bojanala Platinum District indicated that their long distance hampers the implementation of AI as those who are hired to perform the technology mostly travel from Pretoria as they are Private Vets (Veterinarians). The Department of Agriculture and Rural Development does not provide this important service, hence it become the most expensive for them as rural communal cattle farmers.

4.4.4 Contact with extension officer and number of visits

There is contact with Extension Officers around the area though the number of visits.

Conradie (2020), indicated that contact with the Extension services is best captured with simple dummy variables for visits, training or extension club membership, although there are several good examples of studies that successfully incorporated the quality of service provided. Quality seems to be more effectively captured with a series of adoption indices, some of which can be quite simple, such as the presence of a disease outbreak, but detailed enterprise-specific technical

information is needed to this well. The advice for an extension services that wishes to embark on this type of monitoring is that it should begin by programming the technical information to be transferred and to use the development of activity charts to build technical skills amongst extension agents. Each activity should include an observable measure of adoption. Delivery should be planned around activity charts and ought to include at least 30% of visits aimed specifically at observing adoption and should devote at least one in 10 meetings to leading a farmer through a process of self reflection, which includes reflection on the farm's financial performance

Conradie further argues that quality extension is recognized as an important enabler of technical progress and efficiency gains in agriculture (Dinar, Karagiannis, Tzouvelekas, 2007; Hoag, 2005). Research continues to develop more sophisticated models of how productivity growth is enhanced by extension, however, progress has been limited thus far. For example, Dinar et al. (2007) have interacted with the number of visits from public and private extension agents with inputs and inefficiency variables to measure how visits affect performance but do not control for the quality of visits or for self-selection into accessing private or public extension services.

The above arguments clearly show how important Extension is to farmers and in implementing and adopting new technologies. Their responsibility is to transfer knowledge and skills to farmers in order to improve on their productivity which will lead to better living standards, better profit making and better production in s far as quality breeds are concerned.

4.4.5 Membership to cattle organisations

As per the follow-up questions during interactions, it was deduced that the majority of cattle farmers around Bojanala Platinum District do not belong to cattle organisations while very few do. It is important for producers to get connected with at least one association so that they do not get left out of anything critical to the business or pleasure of farming as in many instances they are left out of the loop. According to Oregon State University - Extension services, the benefits of belonging to an association are business networking and marketing, cooperative working relationships, advocacy for special interests and problems, educational programs and many more.

4.5 The socio-economic factors influencing farmers' willingness to adopt AI technology

The Tobit regression model was performed to analyse the factors influencing the willingness to adopt Artificial Insemination in Bojanala Platinum District. The results from the Tobit Regression Model indicated that out of eight (08) variables that were considered to influence the willingness

of cattle farmers to adopt Artificial Insemination technology, four (04) of them were found to be statistically significant, while the other remaining four (04) were said to be statistically insignificant,

This section discusses the results of the Tobit regression form factors influencing the willingness to adopt Artificial Insemination (AI) technology outlined as objective four of the study.

Table 4.11: Factors influencing the willingness to adopt AI

Variable	Coefficient	Std. Error	z-Statistic	
Age	-0.054792	0.055812	-0.981731	NS
Gender	-0.078790	0.029428	-2.677353	***
Level of education	0.019961	0.035106	0.568604	NS
Farming experience	-0.053449	0.035182	-1.519201	*
Farm size	0.072902	0.029842	2.442953	***
Income range	0.075494	0.032744	2.305572	***
Income range	-0.012447	0.004549	-2.735952	***
Constant	1.298147	0.191853	6.766360	***

Where ***, ** and * represents significance at 1%, 5% and 10% level respectively an NS-Not Significant

Source: Based on STATA/SPSS processing of field data, 2022

The results from the Tobit Regression Model are presented in Table 4.13 above of farmers' factors influencing the willingness to adopt Artificial Insemination (AI) in Bojanala District.

Age: - The coefficient of farmers' age indicates an insignificant negative influence on the willingness to adopt AI technology. The gender of farmers had a significant negative influence ($P < 0.01$) on farmers' willingness to adopt AI technology. The education level had an insignificant positive influence on farmers' willingness to adopt AI technology.

Farming experience had an insignificant negative influence on farmers' willingness to adopt AI technology. The coefficient of farm size indicates a significant positive influence ($P < 0.01$) on the willingness to adopt AI technology. The income range of farmers had a significant positive

influence ($P < 0.01$) on farmers' willingness to adopt AI technology. The number of cattle had a significant negative influence ($P < 0.01$) on the willingness to adopt AI technology.

Gender: - The results revealed that the coefficient of gender is negative and significant at 10%, which implies that gender affects the farmer's willingness to adopt the Artificial Insemination technology. The negative sign of the coefficient implies that males are relatively more willing to adopt and use the AI Technology as compared to their female counterparts.

Educational Level: - The coefficient of educational level was found not to be significant but positive. This implies that educational level does not affect the willingness to adopt the AI technology by farmers in the study area. This is in contradiction with the study done by Amuge (2019) which posits that the level of education influences the willingness to adopt technology by smallholder farmers (Adoption of Artificial Insemination was significantly influenced by education level ($p < 0.01$)).

Farming experience: - The coefficient of farming experience measured in the number of years was found to be negative and significant at 10 percent, which implies that farmers who have more experience in farming are more willing to adopt AI Technology as compared to farmers who have lesser experience. This is in contract with Amuge (2019) who stipulated that AI adoption is not influenced by farming experience

Farm size: - The coefficient of farm size is positive and significant at 1% level of significance. This implies that farmers with larger land sizes are willing to adopt the AI technology. The reason could be that their livestock-to-land ratio is small, and these farmers would like to fast track their livestock production. This is in contradiction with Amuge (2019) who stated that Artificial Insemination is not influenced by family size.

Income range: - The coefficient of income range was found to be negative but significant at a 1 percent level. This implies that farmers in a higher income range are less willing to adopt Artificial Insemination as compared to farmers who earn less (on and off farm) income. This is in contradiction to a study by Gebre *et al.* (2022) which stated that farmers who earn more are willing to adopt technology as compared to those who earn less because they can afford to purchase agricultural technology.

4.6 General challenges of artificial insemination listed by cattle farmers

The following were cited as a few main challenges hindering Bojanala Platinum District Cattle farmers from adopting AI without which they would be in a position to adopt and implement it without any hesitations.

- Lack of information, less information, no relevant information, limited information.
- Lack of funding and financial constraints.
- Resources (fencing, handling facilities and AI equipment).
- Very expensive AI equipment.
- Land availability, vast and open communal land that is not demarcated.
- Lack of knowledge.
- Techniques for AI unknown to cattle farmers.
- Camp system.
- Old cows.
- Natural drought.
- Feeding/supporting animals.
- Experience in AI.
- Lack of interest.

4.7 Willingness to adopt Artificial Insemination Technology

Most cattle farmers in Bojanala Platinum District indicated a willingness to adopt Artificial Insemination for their cattle breeding system. Even though they indicated their willingness, they also posed challenges that hindered them to practise it. A few of those farmers practised it through the use of private veterinary services which were very expensive. Over and above the charges for the technology, they were expected to pay for the kilometres travelled by the private VETs and in most cases services were from Gauteng Province but with no guarantee positive outcomes. This indicated that they behaved like capitalists whose main intention was to maximise profit at the expense of vulnerable cattle farmers who believed in the technology itself. That channelled them to reduce the number of cattle which were to be inseminated to cover other hidden costs when using private VETs, including the fact that there was no guarantee given by the private VETs in achieving the results.

Their willingness was displayed when making follow-up questions during deliberations prior to filling up the questionnaires. They indicated that they liked to start at the earliest convenience, as this relieved the stress of using or relying on other people's bulls as these had their challenges too.

4.8 Chapter summary

The chapter examined and presented empirical data results of the study. Data were analysed to answer the research questions presented in Chapter One of the study. Data were processed through the Statistical Packaging for Social Sciences (SPSS), and the SPSS output was put as input into tables and graphs. Further analysis such as the Tobit Regression Model estimated to study the relationship between values. The next chapter discusses the findings of the study, conclusion and recommendations.

CHAPTER 5: SUMMARY, MAJOR FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The purpose of this study was to investigate the perceptions and willingness to adopt Artificial Insemination (AI) Technology by cattle farmers as an alternative to the traditional bull-to-cow breeding method.

This is the last chapter (Chapter 5) of this research study. It captures the summary of the major findings of the study, and the conclusion of the study is presented as well. These are followed by major recommendations which will assist other researchers, government officials and policymakers for future reconsiderations in implementing developmental programmes, especially where livestock improvement as a programme will be preferred.

5.2 Summary of research methods

The aim of this study was to investigate the perceptions and willingness to adopt Artificial Insemination (AI) Technology by cattle farmers as an alternative to the traditional bull-to-cow breeding method.

The research questions of the study were as follows:

- What is the nature of cattle farmers in Bojanala District, North West Province?
- What are the perceptions of cattle farmers towards Artificial Insemination?
- Are cattle farmers in Bojanala District willing to adopt AI technology?
- What are the awareness and understanding levels of farmers of Artificial Insemination?
- Which challenges prevent cattle farmers from adopting AI Technology?
- Which socio-economic factors influence the farmers' willingness to adopt AI technology?

The multistage sampling method was used, and a sample of 167 respondents was used in the study. A semi-structured questionnaire was formulated and administered by the researcher and the two (02) enumerators. A face-to-face scheduled interview and focus group discussions were conducted on the ground in all five sub-districts of Bojanala Platinum District (Moretele, Moses Kotane, Madibeng, Rustenburg and Kgetleng) in order to collect data for this study. Where there was a

higher number of farmers/cattle registered in terms of the Provincial Farmer Register (PFR): 2021, more sampling was done in that area to balance the equation. Thereafter, data were sorted and recorded in an Excel spreadsheet and a codebook. Data were then analysed using the SPSS and Stata 15 computer software. Later on, tables, graphs, charts and pie charts were used in order to explain the information in understandable terms.

Descriptive statistics was used, as well as the Probit model. The ranking of 1 - 5 was taken as the dependent variable, while the levels present in the combinations were regarded as the independent variables. The Tobit Regression Model was used to measure the socio-economic factors influencing the farmers' willingness to adopt the Artificial Insemination technology. Multi-stage sampling was used to calculate the sample size of the study, with a sample calculation done from the entire population.

5.3 Summary of the results

The findings revealed that smallholder cattle farming in Bojanala is relatively practised by older farmers, as shown by the average farmer age of 44 years. However, there are farmers with a minimum age of 25 years and a maximum of 74 years. These results suggest that younger people are starting to show farming interest, as opposed to the olden days when farming was perceived to be for old people. Furthermore, a clear indication that old people still practise agriculture is depicted, as they must provide for their families. It was further revealed that 60.22% of the farmers live in a household that has a household size of between 1 and 5 people, while other farmers indicated that they live in a household of 6 or more members. Besides, it was indicated that the mean of children of the respondents is 2.53, with a minimum of none (0) and a maximum of 7, which suggests that there is a high likelihood of these farmers participating in the adoption of technology, as this will not be any hindrance. These results suggest that farmers in the sampled area have higher chances of using family labour. Moreover, it was shown that the average mean of years spent in school is 6.40. The maximum years spent in school by cattle farmers in Bojanala Platinum District is 17 years, with a minimum of 0 years spent in school.

The summary of the gender distribution of the smallholder cattle farmers was presented in this study. Of the sampled households, the majority (50.54%) of them were males, while 49.46% were female-headed households.

Although the results show that only 6.45% of the farmers have contact with the extension agents, while 93.55% of the farmers do not have contact with an extension agent, a particular degree of commercialisation level was determined. From the classification undertaken in this study, the majority of the farmers were semi-commercial at 51.61%, while 7.53% were considered subsistence, and 40.86 % were commercial. The results indicate that most of the farmers are characterised as semi-commercial with a significant number of farmers being subsistence. Semi-commercial means that these farmers are commercially operating at a small scale with some operations operating at subsistence level.

The Tobit analysis depicted that gender is statistically significant though with a negative coefficient at negative 0,07%, with a farming experience of negative coefficient and slight significance at negative 1,5%. This meant that they are the factors affecting the adoption of technology as far as Artificial Insemination is concerned. The results further showed that farm size has a positive relationship with the adoption of Artificial Insemination as technology and is statistically significant at 2,4%. The income range had a negative relationship with the adoption of the technology but is highly significant as household income has a positive coefficient and is statistically significant at 2,3%.

5.4 Conclusion

This study acknowledged the level of adoption and willingness to participate and or the degree of commercialisation. The study revealed that the average number of years for the farmers in the study area is 44 years, indicating that youth participation in the study area is low. Also, the results showed that as the number of years increases, the farmers will participate less in the adoption of technology, implying that youth participation can increase Artificial Insemination participation and later a higher degree of commercialisation. In addition, the study showed that most of the smallholder cattle farmers depend on selling them for improved livelihood throughout the year. This can be attributed to the lack of extension services in the study area as most of the farmers (93.55%) indicated that they do not have access to extension services or are lacking in terms of sharing information on Artificial Insemination. Furthermore, extension services are essential to smallholder cattle farmers as agents or revolutionary foot or ground soldiers to provide farmers with appropriate knowledge, accurate information about Artificial Insemination and information about improved methods of production or technology (Kinyanjui, 2012). Therefore, the lack of

extension services leads to a lack of appropriate information about the importance of technology usage by smallholder cattle farmers. As shown in the study, the majority of cattle farmers bought their cattle at auctions or inherited them, and this can be associated with the cost of reaching distant AI centres.

According to the study results, 51.61% of the farmers are semi-commercialised, indicating the willingness of farmers to participate in the Artificial Insemination technology, resulting in low production due to a lack of extension services. Additionally, the study also showed that 41% of the farmers in the study area are subsistence orientated. The Tobit regression revealed that years in farming and land (Ha) have a negative relationship with technology adoption. This indicates that as a farmer gets older, the less likely he/she will participate in the technology and as the land size of the smallholder increases, the less the farmers will participate in the adoption of technology.

On the issue of gender, when one needs to be patriotic, this is one element that needs to be taken into consideration in order to respond to the national question. Women need to be seen leading in agriculture, as they are given a greater opportunity as far as the transformation of the sector is concerned. The sector still indicates the dominance of males. Females need to be encouraged to take farming as a business or enterprise as government funding is more skewed towards women (females), and policies are deliberately intended towards women (females) and the youth. These were done to address the imbalances of the past that were experienced in the sector. These pose more advantages to them as beneficiaries who must benefit and change the sector due to more funding opportunities with clearly stipulated percentages (%) in all policies that are meant for development, for example, CASP and Ilema letsema.

Schultz (1975) argued that education plays a significant role in modernised farm environments rather than traditional ones. It simply implies that rural cattle farmers do not value education as they still use traditional methods of farming or breeding and therefore do not see any value that is been added by education in the sector. This has been proven during this study as well.

Lastly, in terms of household members, the study depicts that Bojanala District cattle farmers have big household members. The improvement in livestock will bring better returns, and they will be food secure when practising Artificial Insemination. Improvement in their cattle breed will bring more returns during sales due to improved breed in terms of quality and size.

5.5 Policy recommendation

The study recommends the following:

- There should be skills transfer and knowledge transfer.
- Training the DARD personnel to assist farmers in capacity building.
- Age is a limiting factor even if there is a willingness to adopt AI. Old farmers should involve their unemployed children/youth to learn and prepare them to take over in the future.
- Borrowing/lending of bulls should be discouraged to reduce disease transfer especially Contagious abortion (CA).
- The perceptions of cattle farmers indicated that AI is a good method, and the limiting factor is the high costs. DARD should partner with farmers who are willing to implement and adopt the technology.
- DARD to buy AI equipment for each district and ensure that Subject Matter Specialists, VET Officials and Extension Officers are trained in the subject matter so that they can transfer skills and assist farmers to bring about livestock improvement in cattle herds in North West province.
- Deliberate funding basket is to be considered by the Department of Agriculture and Rural Development (DARD) for each financial year to ensure implementation across the board.
- Extension Officers must share Artificial Insemination information with cattle farmers as well as its importance in livestock improvement and food security.
- Formal training should be given to Subject Matter Specialists and Veterinary Services to reduce Artificial Insemination failures that might demoralise farmers in using it.
- The Department of Agriculture and other relevant stakeholders to join hands in order to come up with mechanisms that will increase participation and involvement in activities related to Artificial Insemination as a technology.
- To have funding for women in agriculture and call it “Women in Artificial Insemination Technology”.

5.6 Implication for future research

This research was strictly based on smallholder cattle farmers around Bojanala Platinum District and did not consider other types of livestock within the said district. The research findings may help other researchers when exploring other municipalities in the same province, other provinces and the country at large on other types of livestock farming. Further studies on the perceptions and willingness to adopt artificial Insemination and its impact on livestock improvement could be conducted. The research can help other researchers when exploring technology of the smallholder and commercial cattle farmers as this was not explored in this study. Moreover, this research was mainly focused on the Bojanala Platinum District and can be used by other researchers when focusing on the entire province. This research can also be used by different stakeholders in the agricultural sector when formulating policies for their different entities and the government when formulating policies for smallholder cattle farmers in the study area.

5.7 Limitations of the study

Study limits are its defects or deficiencies, which could be due to a lack of resources, a limited sample size or faulty methodology, among other things (Cooper and Schindler, 2008). There is no such thing as a perfect study or one that covers all potential aspects. As a result, addressing the limitations of your study demonstrates honesty and integrity, as well as a thorough comprehension of the subject (Cooper and Schindler, 2008).

Due to time constraints, the geographical scope of this study was limited to Bojanala Platinum District in North West province as the primary target of the research, therefore, the results cannot be generalised for the entire North West province. Additionally, the other challenge was to get all farmers in the sample size to participate in the study because some of them were not willing to participate as they thought the government was trying to get incriminating information from them, while others were unavailable due to a lack of access to farms – bad infrastructure such as roads during rainfall. Some of the farmers were illiterate, while others based their responses on mere memory, a clear sign of a lack of cattle record keeping systems.

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APPENDICES

Appendix A: Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1 ^a	Gender	60.514	52015.596	.000	1	.999	190887449273093 40000000000.00
	Age (in years)	33.818	40832.908	.000	1	.999	486583622873962. 0
	Highest Educational level	66.370	60337.817	.000	1	.999	666672119008810 500000000000.00
	Number of Household members	-44.492	46042.665	.000	1	.999	.00
	Main occupation	66.252	113796.689	.000	1	1.000	592734219122373 000000000000.00
	Source of income	22.312	24217.993	.000	1	.999	4899181615.39
	Income range (in Rands)	-38.635	55782.259	.000	1	.999	.00
	Farm size (in Hectares)	63.225	16894.207	.000	1	.997	287381871412298 000000000000.00
	Ownership of the land	-12.447	153426.612	.000	1	1.000	.00
	Paying rent for the farm	-69.302	223436.357	.000	1	1.000	.00
	Farming experience (in years)	-11.338	61033.977	.000	1	1.000	.00
	Since when did you start keeping cattle?	3.532	3337.902	.000	1	.999	34.19
	Breed of cattle	-10.783	19867.354	.000	1	1.000	.00

Why do you keep the cattle?	-6.196	23301.820	.000	1	1.000	.00
Where did you get your cattle?	-16.088	29086.968	.000	1	1.000	.00
How many cattle did you start with?	-1.960	3830.658	.000	1	1.000	.14
How many cattle did you sell?	2.014	12129.806	.000	1	1.000	7.49
How much did you make from the sale?	-.001	2.985	.000	1	1.000	.99
If natural, where do you get the bull?	-51.988	34110.499	.000	1	.999	.00
AWARDS	26.684	86646.301	.000	1	1.000	387905230655.00
AWARAI	-84.073	56784.321	.000	1	.999	.00
EXPAI	-16.910	112210.207	.000	1	1.000	.00
PERCEPT	135.807	247409.232	.000	1	1.000	9.560E+5
ADOPTION	141.706	178818.212	.000	1	.999	3.485E+6
CHALLENGES	-9.140	5687.336	.000	1	.999	.00
Constant	-556.550	581381.880	.000	1	.999	.00

a. Variable(s) entered on step 1: Gender, Age (in years), Highest Educational level, Number of Household members, Main occupation, Source of income, Income range (in Rands), Farm size (in Hectares), Ownership of the land, Paying rent for the farm, Farming experience (in years), Since when did you start keeping cattle, Breed of cattle, Why do you keep the cattle, Where did you get your cattle, How many cattle did you start with, How many cattle did you sell, How much did you make from the sale, If natural, where do you get the bull, AWARDS, AWARAI, EXPAI, PERCEPT, ADOPTION, CHALLENGES.

Appendix B: RESEARCH QUESTIONNAIRES



PERCEPTIONS AND WILLINGNESS TO ADOPT ARTIFICIAL INSEMINATION: A CASE OF CATTLE FARMERS IN BOJANALA PLATINUM DISTRICT

Dear participants

The purpose of the questionnaire is to collect data that would help in assessing the perceptions and willingness to adopt Artificial Insemination in Bojanala District. We appreciate your help in providing this crucial information. The information gathered in this research will remain confidential, and anonymity will always be maintained. Participation in this study is completely voluntary, and you are allowed to withdraw anytime. The outcome of this study will be shared with all farmers involved.

Yours faithfully

Researcher: LERATO TEME

Tel (work):

Mobile: 082 532 6041

E-mail: motshabiteme@gmail.com

Instructions for completion

1. Please answer all questions honestly
2. You are allowed to tick more than one box, where applicable

--	--

Questionnaire No:

Consent to participate in the study

Please read and understand the form below. Should you be willing to participate in the study, please date and sign on the provided space.

1. I agree that this study was properly explained to me by the student verbally/ in writing, and I was offered an opportunity to ask questions.
2. I am aware that the study involves socioeconomics, demographics, perceptions- and willingness to adopt Artificial Insemination.
3. I fully understand that I will not receive any direct benefits from taking part in this study.
4. I am aware that I can withdraw my participation from this study at any given time, even if I have already agreed to take part with no consequences thereafter.
5. I also understand that I may refrain or refuse to answer any question that I do not want to answer with no consequences to follow.

6. I understand that my information will be kept entirely confidential and will be used solely for the purpose of this study.

I.....hereby, freely agree to take part in this study.

Signature of the farmer..... Date.....

I agree that the farmer is giving consent to take part in this study with the understanding that their information will be kept entirely confidential.

Signature of the student..... Date.....

Section A: Demographic information of farmers

1. Gender:

☐ Female ☐ Male

2. Age (in years):...

☐ ≤35

☐ Between 36- 45

☐ Secondary 46- 65

☐ > 65

3. Highest educational level:

☐ None

☐ Primary Level

☐ Secondary Level

☐ Tertiary Level

4. Number of Household members:....

☐ ≤ 4

☐ Between 5 – 8

☐ > 8

Section B: Socio-economic characteristics of farmers

5.What is your main occupation?:

☐ Farmer

☐ Informal employment

☐ Formal Employment

6.What is your Source of income?:

☐ Animal sales / Crop sales

☐ Informal employment

☐ Formal Employment

7.Income range (in Rands):

☐ $< R42\ 000$

☐ $R42\ 000 - R84\ 000$

☐ $R84\ 000 - R126\ 000$

☐ $> R126\ 000$

8.Farm size (in Hectares): (this is due to the recommended grazing capacity (average of 10ha/LSU on natural grazing

☐ < 30 ha

☐ $30 \leq \text{ha} \leq 80$

☐ > 80

9.Do you have proof of ownership of the land that you are farming on?

☐ Yes ☐ No

10.If no, do you have to pay the lease for the farm?

☐ Yes ☐ No

11. Farming experience (in years):.....

☐ ≤ 5

☐ 6 - 15

☐ > 15

12. When did you start farming with cattle?.....

13. What type of breed do you farm with?

☐ Nguni

☐ Bonsmara

☐ Other

14. For what purpose do you keep the cattle?

☐ Main economic enterprise

☐ Supplementary enterprise

☐ Other reasons

15. Where did you source your breeding stock?.....

16. How many breeding stocks did you start with?.....

17. In the last 12 months, how many cattle did you sell?.....

18. How much did you realise from those sales?.....

Section C: Investigating perception and willingness to adopt Artificial Insemination

19. Which mating method do you use?

☐ Natural ☐ Artificial Insemination

20. If natural, where do you get the bull?

☐ Own ☐ Borrowed

21. Are you aware that borrowed bulls can transmit disease to your herd?

☐ Yes ☐ No

22. Are you aware of Artificial Insemination (AI) and its impact on cattle fertility and productivity?

☐ Yes ☐ No

If yes, please motivate

.....

.....

.....

.....

23. If you are aware of AI, are you willing to utilise the Artificial Insemination technology?

☐ Yes ☐ No ☐ I am not sure

If not, please state a reason

.....

.....

.....

.....

24. Have you experienced any breeding regarding Artificial Insemination? Have you used artificial insemination for breeding?

☐ Yes ☐ No

.....

.....

.....

25. If yes, how often have you experienced complications with Artificial Insemination? For how long did you practise the AI procedure or technique, and how many times did your realise difficulties when administering the technique?

☐ 1-2 years

☐ 3-4 years

☐ 5 years or more

26.How do you perceive the use of the AI technology?

.....

.....

.....

.....

27.Would you adopt the use of Artificial Insemination technology if it is cost effective?

.....

.....

.....

.....

28.What are the challenges which hinder you from Adopting Artificial Insemination?

.....

.....

.....

.....

End of survey message:

Thank you for taking the time to participate in the survey. If you have questions, would like to see the results, or want to know more, please contact either the North West University or the student.



Private Bag X2046, Mmabatho

South Africa 2735

Tel: 018 3982746

Fax: 018 398 2748

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Agricultural Economics and Extension

TO WHOM IT MAY CONCERN

RE: PERMISSION TO CONDUCT RESEARCH TEME L.M.M

Ms Lerato Motshabi Maria Teme (student no 162 597 69) is a registered MSC Agricultural Extension student with the North West University, Mafikeng campus.

Permission is herewith requested for her to conduct research in your area of jurisdiction (Bojanala Platinum District) which will assist in fulfilling her dissertation. Consent forms will be signed by all participants in the study.

The outcome of the study will be shared with the institution and farmer participants in the research study.

Your approval to conduct this study will be greatly appreciated

Yours sincerely



Prof S. S. Letsoalo Head of Department and Land Bank Chair

Department of Agricultural Economics and Extension

Original details: (24061433) C:\Users\Simon Letsoalo\Desktop\DEPARTMENT ECONOMICS AND EXTENSION\HR\ 29 September 2022

APPENDIX D: CONSENT FORM



PERCEPTIONS AND WILLINGNESS TO ADOPT ARTIFICIAL INSEMINATION: A CASE OF CATTLE FARMERS IN BOJANALA PLATINUM DISTRICT - NWP

Student Name : Teme Lerato Motshabi Maria

Email & Contact : motshabiteme@gmail.com /082 532 6041

Degree : MSC Agricultural Extension

Affiliation : North West University

CONSENT TO TAKE PART IN RESEARCH QUESTIONNAIRE

I hereby affirm that:

➤ I voluntarily agree to participate in this study without being coerced or without any material gains

➤ I fully understand that even if I agree to participate now, I can withdraw at any given time or refuse to answer any questions without any consequences of some sort

➤ I have had the purpose and nature of the study explained to me and I have had the opportunity to ask questions about the pertaining study

➤ I understand that participation involves being asked questions verbally with a semi-structured questionnaire and that the data will be used as part of the research.



➤ I understand that I will not benefit directly from participating in this research.



➤ I understand that the information provided will be treated confidentially.

➤ I understand that in any report on the results of this research, my identity will remain anonymous



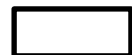
➤ I understand that under Freedom of Information Act or legalisation (PAIA & PAJA) I am entitled to access the information I have provided at any given period while it is in storage and accessible.

➤ I understand that I am free to contact the researcher to seek further clarification and information on the study

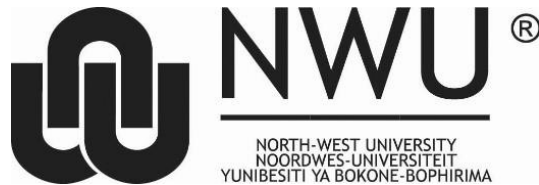
➤ I am therefore declaring that I am not coerced to participate in the study

Signature of the participant: ____

Date: __



APPENDIX E: ETHICAL CERTIFICATE



Private Bag X1290, Potchefstroom South Africa 2520

Tel: 018 299-1111/2222

Fax: 018 299-4910

Web: <http://www.nwu.ac.za>

Senate Committee for Research Ethics

Tel: 018 299-4849

Email: nkosinathi.machine@nwu.ac.za

ETHICS APPROVAL LETTER OF STUDY

Based on approval by the **Faculty of Natural and Agricultural Sciences Ethics Committee (FNAS- REC)**, the Faculty of Natural and Agricultural Sciences Ethics Committee hereby **approves** your study as indicated below. This implies that the North-West University Senate Committee for Research Ethics (NWU-SCRE) grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the study may be initiated, using the ethics number below.

Study title: Perceptions and willingness to adopt artificial insemination: A Case of cattle farmers in Bojanala Platinum District - NWP

Study Leader/Supervisor: Prof SS Letsoalo
Student: LMM Teme

Ethics number:

N	W	U	-	0	1	4	4	7	-	2	2	-	A	9
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Institution Study Number

Year

Status

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Application type: Single

Risk Category:

Commencement date: 27/10/2022
Expiry date: 31/01/2024

Minimal

Approval of the study is initially provided for a year. after which continuation of the study is dependent on receipt

Special in process conditions of the research for approval (if applicable):

- The following documentations are archived by FNASREC and should be complete and kept up to date:
 - Research proposal
 - Signed approval from the scientific committee indicating the proposed risk category
- All researchers involved in the study should submit signed NWU code of conduct statements annually.
- All researchers of low-risk studies should submit proof of relevant ethics training every two years.
- All researchers that take part in activities that pose a safety and security threat to the researchers or the environment should submit a risk assessment form annually.
- All research involving human interaction should follow best ethical practise and keep documents as proof. This includes informed consent, questionnaires, incorporation of risk-benefit, and responsible data management.
- Any research at governmental or private institutions, permission must still be obtained from relevant authorities and provided to the FNASREC. Ethics approval is required BEFORE approval can be obtained from these authorities.

APPENDIX F: LANGUAGE CERTIFICATE

Registered with the South African Translators' Institute (SATI)

Reference number 1000686

SACE REGISTERED

03 July 2023

Perceptions and willingness to adopt artificial insemination: A case of cattle farmers in Bojanala Platinum District

This serves to confirm that I edited substantively the above document including a Reference list. The document was returned to the author with various tracked changes intended to correct errors and to clarify meaning. It was the author's responsibility to attend to these changes.

Yours faithfully



Dr. K. Zano

Ph.D. in English

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+27631434276