AN INVESTIGATION OF THE SOCIO-ECONOMIC IMPACT OF BOVINE BRUCELLOSIS IN THE MABESKRAAL COMMUNITY OF MOSES KOTANE MUNICIPALITY, NORTH WEST PROVINCE OF SOUTH AFRICA

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Dissertation submitted in fulfillment of the requirements for the degree Magister in Science in Agriculture in Animal Health at the Mafikeng Campus of the North West University

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Graduation April 2019

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This dissertation is dedicated to my wife Dipuo, late daughter Gomolemo, my son Mothusi, and his wife Masego and my wonderful grandchildren, Odirile and Gopolang

ACKNOWLEDGEMENTS

I wish to express my deepest gratitude to all the people who assisted in the realization of this piece of work. My sincere gratitude goes to:

Prof. Mulunda Mwanza at the University of the North West for his guidance and patience, my colleagues at the Department of Agriculture, Forestry and Fisheries both in the North West Province and in Kwazulu-Natal Province. Special thanks to Drs Alicia Cloete, Emmanuel Midzi and Songe Chisi for their assistance in the realization of this work and Messrs. Reuben Masimong and Tsholofelo Mahahlane for helping with data collection.

I am also grateful to Ms Janine September for capturing the data and to Ms Sandra da Camara for typing the report.

Last but not least, I am very grateful to my wife Dipuo for being so understanding during the entire period of my studies

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LIST OF ABBREVIATIONS

Abbreviation	**Full Description**
CA	Contagious Abortion
C-ELISA	Competitive ELISA
CFT	complement fixation test
DAFF	Department of Agriculture, Forestry and Fisheries
DPME	Department of Monitoring and Evaluation
ELISA	Enzyme-Linked Immunoasorbent Assay
FAO	Food and Agriculture Organization of the United Nation
FPA	Florescent Polarization Assay
HH	Household
IQR	Interquartile Range
LPS	Lipopolysaccharide
MRT	Milk Ring Test
OIE	International Office of Epizootics [Office Internationale des Epizooties] / International Animal Health Organisation / World Organisation for Animal Health
RBT	Rose–Bengal test
SA	South Africa
SAT	Serum Agglutination Test
SES	Socioeconomic status
WHO	World Health Organization

ABSTRACT

The study intended to determine the socio-economic impact of bovine brucellosis in the Mabeskraal village and surrounding communities in the Moses Kotane local municipality in the North West Province of South Africa and assess the knowledge, awareness and understanding of the farmers and the community on the disease, its causative factors and ways to avoid the disease. The study also intended to identify the risk factors contributing to the prevalence and spread of the disease, conduct a socio –economic assessment and impact of the disease on the community and recommend strategies to arrest the spread of the disease.

Two Animal Health Technicians collected, distributed and helped to fill in the questionnaire with the randomly selected cattle farmers in their respective wards. There was intention to fill in at least 288 questionnaires from a similar number of farmers. A total of 126 responses were finally received from the Animal Health Technicians.

The median number of household members was five with slightly more than 50% of the members being over 50 years old. Just below 50% of the members had matriculated. The farmers owned up 213 cattle each even if there were those that owned less than 5. The farmers kept cattle for a variety of reasons including cultural purposes and for trading. Only one farmer from those interviewed owned land and the rest were rearing cattle on a communal basis.

The biggest contributor to livelihood to the farmers was a combination of formal employment, cattle farming, small ruminants farming and poultry production depicting the importance of agriculture to the livelihoods of this community.

The prevalence of brucellosis village level in the study area is very high (76%). The within herd prevalence which in this case looks at individual animal owners is within acceptable levels of 0% but was as high as 31% in some kraals.

There are a significant number of risk factors depending on reasons for keeping of cattle which seemed to be contributing to non-observance of biosecurity measures. The risky practices by the community include grazing their animals communally with minimal movement control, lack of vaccination of heifers, not having dedicated camps in which

cattle could calf, non-removal of aborted tissues, keeping of cattle that have aborted and indiscriminate buying or selling of their cattle without asking questions on vaccination history or general health of the animals.

The knowledge of farmers on the status disease was found to be very low and their attitudes and practices on buying and selling could easily lead to the spread of the disease. The practices were influenced by the socio cultural and economic circumstances of the study population.

Although low calving rates could be caused by a variety of other conditions, the number of calves at foot in the study area was found to be very low and constituted only 12% of the total herd. The farmers in this community are potentially losing opportunities for producing sufficient calves to improve their lives as a result of these diseases and other conditions.

The study recommended that awareness campaigns be commenced and that test, slaughter and vaccination campaigns be started in an effort to control the disease and lead to better productivity of the cattle in the village. It is believed that by so doing, productivity may be increased and lead to improved benefits for the community.

Key words: Brucellosis; Prevalence; Socio-economic factors; Risk factors; Zoonosis; Knowledge; Attitudes; Practices

CHAPTER 1
INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

Bamaiyi *et al*. (2015) state that brucellosis is a highly contagious disease of mammals that has serious socioeconomic implications as it adversely impacts production and reproduction efficiency among affected animals. It is a well-known fact that brucellosis may affect cattle, sheep, goats, buffaloes, wild ruminants and other mammals, causing various syndromes like massive abortions, low survival rates of calves, orchitis in males and hygromas in cattle. The above –mentioned fact proves that the bacterium is versatile and warrants that health professionals and animal health regulatory authorities, farmers world-wide and communities, give it attention (Radostits *et al*. 2000).

As a result of its versatility, ability to infect different species of animals and its wide-spread occurrence in different parts of the world, the disease is known by many different names even in one species. In cattle alone, the disease is referred to as “contagious abortion” (CA) or “bovine brucellosis” and Bangs disease. The disease is often referred to in the context of the predominant language of the population in which it is experienced (Yumuk and O’Callaghan, 2012)

Despite many scientific studies on the disease, there is still no effective treatment. Once an animal is infected, it often suffers relapses and continuous shedding of the bacteria to the environment (Corbel, 2006). It is therefore apparent that, this shedding of the bacteria will only stop when the infected animal is killed.

Many authors including Corbel (2006) emphasised that humans may acquire infection through different ways including through the consumption of raw milk from infected animals and handling of infected material associated with abortions and the placenta. Since the disease is known to reduce productivity in livestock substantially, it is in the interest of farmers and regulatory authorities to reduce the impact of this disease and this is done by reducing susceptibility of heifer calves through vaccination employing vaccines like Strain 19 and Rb51 at four to eight months of age. (Neta *et al*. 2010). This vaccination has helped in reducing the rate of infection in herds.

Because the disease has zoonotic potential and causes so much damage to the economy particularly in most Sub Saharan countries (John *et al.* 2010), it certainly needs to be understood better and needs concerted efforts to be managed successfully.

1.2 STATEMENT OF THE PROBLEM

The Department of Agriculture, Forestry and Fisheries (DAFF) of South Africa (SA) and the National Animal Health Forum (NAHF) of South Africa have reported an apparent increase in the prevalence of bovine brucellosis in the cattle population of SA in the past 10 years (National Animal Health Forum, 2016).

There is concern from the Department of Agriculture, Forestry and Fisheries and the livestock industry that prevalence of brucellosis in areas where communal grazing is practiced is increasing and that this adversely impacts the livelihoods of these communities as it reduces reproductive capacities of the livestock mainly by reducing calving rate and milk production (National Animal Health Forum, 2016).

Risk factors for perpetuating the disease may be influenced by cultural issues and lack of understanding by community members. Improving the understanding of this disease will help communities to improve on the management of the disease.

There is also very little understanding of the factors that perpetuate the prevalence of brucellosis from the socio-economic and cultural perspective of the farmers in the communal areas particularly in South Africa.

1.3 BACKGROUND

The North West Province of SA is one of the nine (09) Provinces of the Republic of SA, situated in the North Western part of the country. The Province borders a large portion of the Republic of Botswana, the Province of Limpopo, Gauteng Province, the Free State Province and the Province of the Northern Cape.

The area under study, Mabeskraal, is a village in the Moses Kotane Municipality of Bojanala District in the North West Province of SA. The village is situated approximately 72km from the town of Rustenburg and half an hour’s drive away from the Sun City

complex. The map indicating the location of Mabeskraal is attached below as figure 1:

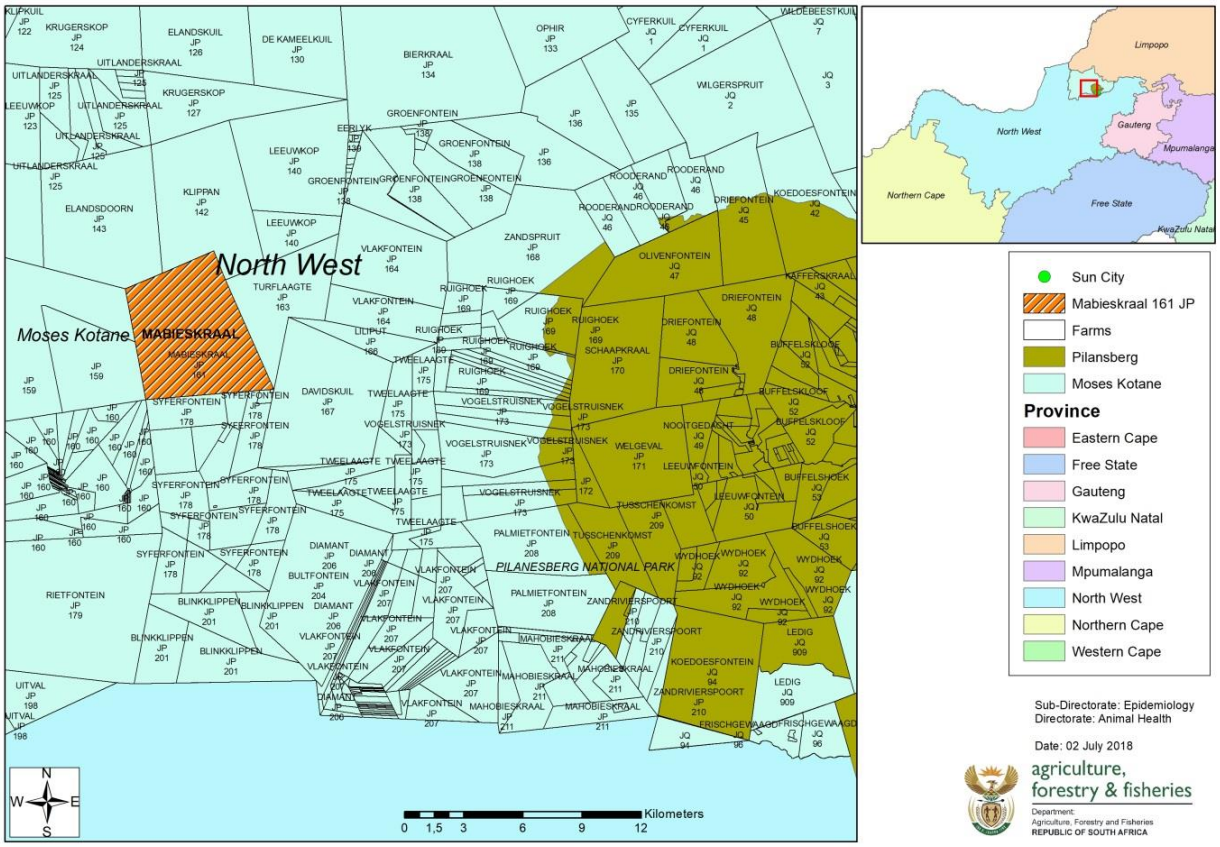


Figure1. - Map depicting the borders of the North West Province in the Republic of South Africa and the relative location of Mabeskraal.

According to the 2011 population statistics, there are approximately 10 000 people, mainly Setswana speaking, who live in Mabeskraal (Mail and Guardian, 2013). The geographic coordinates of Mabeskraal are (25.198.S) and (26.804.E). The study will also consider other villages in the municipality of Moses Kotane because ownership of cattle extends beyond the borders of the village, with cattle posts established beyond the borders of the village in a communal approach to grazing.

The study will therefore concentrates on the western part of the magisterial districts of Mankwe and the eastern part of magisterial district of Madikwe.

An evaluation of the prevalence of brucellosis will extend beyond the study area and will include majority of the local municipality of Moses Kotane, the area that is serviced by one state veterinarian handling the two magisterial districts.

1.4 REPORT FORMAT

This study report consists of six (6) parts. This introduction is the first part of the report. The literature review is the second part and is followed by a discussion of the materials and methods showing the approach taken in this investigation and the tools used to analyse the data collected. The fourth part of the report presents the results and the analyses thereof. The discussion of the results follows and in this section, some inferences are made where possible. The sixth part of this report will be the conclusions and recommendations.

In addition, there will be a list of references and annexes attached to the report.

1.5 TERMS OF REFERENCE

1.5.1 Aims and objectives

The main objective of the study was to estimate the socio-economic impact of bovine brucellosis in the Mabeskraal area of Moses Kotane local municipality of the North West Province of SA and to assess the knowledge, awareness and understanding of the causative factors and preventive measures of the disease among the farmers and the community. Another objective was to estimate the impact of the disease on the livelihoods of the community of Mabeskraal and surrounding villages in the Moses Kotane local municipality of the North West Province particularly in Mabeskraal village and the immediate surroundings.

1.5.2 Specific Objectives:

The specific objectives of this study are to:

a) Estimate and describe the prevalence of bovine brucellosis in the cattle population in the study area.
b) Identify the risk factors and socio economic factors contributing to the spread of bovine brucellosis in the study area.
c) Estimate economic losses due to brucellosis and other related diseases in cattle

and the economic impact in the study area. Determine if there is any association between socio economic status and the spread of the disease

d) Propose a strategy to decrease prevalence of disease considering the risk factors contributing to spread of the disease thereby contributing to reduction of the losses from bovine brucellosis.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

Many diseases may be classified as neglected diseases, including, among others, black fever, yellow fever, leptospirosis, brucellosis, anthrax, bovine tuberculosis, equine encephalitis, leishmaniasis, Chaga's disease, schistosomiasis, taeniasis or cysticercosis particularly (*Taenia solium),* trichinellosis, hydatidosis and fascioliasis (B Lopes *et al.* 2010).

As seen above, brucellosis is among these neglected diseases. It is a well-studied disease, which continues to cause problems particularly in developing countries. The World Health Organization (WHO), the World Organization for Animal Health commonly known as the OIE (OIE) and the Food and Agriculture Organization of the United Nations (FAO) have all declared brucellosis as an important neglected disease (Centre for food security, 2018)

This literature review intends to explore this disease further to determine the extent of prevalence and possible socio economic issues that may be influencing its continued prevalence in the developing world to inform the study of the Mabeskraal community and its vicinity in the North West Province of South Africa.

2.2 BOVINE BRUCELLOSIS

2.2.1 Introduction

In general, bovine brucellosis is understood to be a disease that can cause abortions and infertility in cattle and can be transmitted to humans making it an important candidate for a "One Health" approach (Martins *et al*., 2009). Bovine brucellosis commonly caused by the bacterium *Brucella abortus*, remains a common bacterial infection in the developing world despite the advances in veterinary studies. The disease is most prevalent in areas with poorly established domestic animal and public health programmes, particularly, as the disease may not be considered important by the health professionals of the country in question as the disease may be unapparent.

Some regions and countries in the world have controlled the infection and some have succeeded in eradicating the disease. In some countries like Egypt, brucellosis has been reported in almost all types of domesticated animals including buffaloes (Refai, 2002).

South Africa has still not eradicated brucellosis. It is particularly prevalent in rural community herds. The prevalence of the disease country-wide is said to be increasing mainly because of the lack of enough vaccination coverage of heifers at the correct age, and other factors like communal grazing practices as alluded to by (Manoto, 2016).

Brucellosis, particularly that caused by *Brucella melitensis*, can be transmitted to humans, leading to serious debilitating and sometimes chronic and fatal infections that may affect a number of organs (Alusi, 2014). If humans consume products like contaminated, unpasteurized dairy products, they may ingest the *Brucella* organism and become infected. Humans may also be infected when they handle tissues from infected animals or by contamination of mucous membranes and abraded skin (Centre for Food Security, 2018).

Farmers, people who live in rural areas and have infected animals, veterinarians and labourers can be exposed to the disease in many ways including drinking unpasteurized milk, handling *Brucella* infected animals and mishandling animal samples (Baumgarten, 2002).

The main symptom in humans is recurrent bouts of high temperatures, giving the disease the name “Undulant Fever”. It is also known as Malta fever or Mediterranean fever. Other common symptoms in humans include chills, depression, weakness, headache, joint pain, generalized aches and sweating (Alusi, 2014).

As a result of these symptoms being so unspecific, there is a tendency to mis-diagnose this disease. Brucellosis is an old disease with minimal mortality, yet it remains one of the most common zoonotic disease worldwide with more than five hundred thousand new cases annually (Alusi, 2014).

2.2.2 Aetiology

The common causative agent for bovine brucellosis is a facultative, gram negative coccobacillus or short rod that occurs intracellularly known as *Brucella abortus* (Martins *et*

al. 2009). This bacterium causes substantial economic losses to the cattle industry wherever it occurs. The bacterium occurs intra-cellularly in mammalian hosts and it causes a highly contagious disease of cattle (Ficht, 2003). The disease in cattle is less frequently caused by other *Brucella* species namely *Brucella melitensis* and *Brucella suis* (Radostits *et al.* 2000 & Hadush and Pal 2013).

There are eight recognized biotypes of *B. abortus* and these are (biotypes 1, 2, 3, 4, 5, 6, 7 and 9) (Bishop *et al.* 1994). The differentiation of these biotypes is done by phage typing, mono-specific antisera, biochemical reactions and growth inhibition tests. The biotypes are deemed to be equally pathogenic (Bishop *et al.* 1994).

2.2.3 Epidemiology

Brucella abortus is commonly transmitted through ingestion of contaminated pastures, feed, fodder, infected milk water and licking afterbirth but may easily also be transmitted by contact with infected placenta, aborted foetuses, foetal fluids and vaginal discharges (Radostits *et al.* 2000). Cattle and other animals lick their young, aborted foetuses, placentae and genitalia after parturition. These mentioned above may contain large numbers of *Brucella abortus* bacteria and the animals easily get infected this way (Radostits *et al.* 2000).

There are possibilities of other routes of infection, including inhalation, or through the conjunctiva. In Utero calves irrespective of whether they are males of females may be infected whereas newly born calves may be infected by ingesting infected colostrum or milk immediately after birth. Calves infected in these ways may perpetuate the disease when they become adults (Bishop *et al.* 1994).

With regard to female calves infected with *Brucella*, the role they play in the spread of the disease during adulthood has been sufficiently demonstrated. These calves may commence spreading the disease at the first parturition with abortions or normal parturition. It is common that these heifers only abort once but not uncommon that they abort more than once (Fulasa, 2004).

On the environment, *Brucella abortus* can easily be killed by high temperatures such as pasteurization which is commonly used to inactivate the bacterium in milk and milk

products (Centre for food security, 2018). Studies have shown that wet, cool environmental conditions with favourable chemical composition will determine the survival of the *Brucella* bacterium outside the host (Alton and Forsyth, 1996).

It has been sufficiently demonstrated that the removal of *Brucella* infected animals from contaminated premises for one month with proper disinfection is sufficient to prevent infection. In addition, it has been reported that lactating cows following abortion are an important source of infection, particularly in milk and colostrum and the bacteria may be excreted intermittently in milk throughout the lactation period (Bishop *et al*. 1994 & Radostits et al. 2000).

Chronic infections with *Brucella* in cattle may lead to the development of hygromas with copious amounts of highly infective fluid containing large amounts of *Brucella* organisms. These organisms are however restricted to the lesion (Bishop et al. 1994 & Franc *et al.* 2018).

The organism is so versatile that it may infect humans by direct inoculation through cuts and abrasions in the skin or via the conjunctivae of the eyes, or through inhalation of infectious aerosols and ingestion of unpasteurized milk or other dairy products from infected animals (Martins *et al.* 2009 & Alusi, 2014).

2.2.4 Pathogenesis

According to Galinska and Zagórski, (2013), penetration of the *Brucella* bacteria occurs through mucous membranes, such as those of the pharynx and alimentary tract, and survives and multiplies particularly in cells of the reticulo-endothelial system. The ability of this bacterium to survive and multiply in whole cells such as macrophages and other cells of the reticulo-endothelial system and in trophoblasts in the placenta are a key aspect of its virulence (Cooke and Slack, 2017).

Neta *et al. (*2010) further explained the process of infection by explaining how neutrophils and macrophages phagocytize the bacteria and carry them to the regional lymph nodes where they multiply and induce a lymphadenitis, which may persist for months. This action is, according to Galinska and Zagórski, (2013), facilitated by the fact that the bacteria enter cells via lipid rafts which help in the avoidance of defence mechanisms of the body.

Intracellular replication occurs facilitated by the bacterium's lipopolysaccharide and periplasmic cyclic b-glucan, which are essential for the first steps in the establishment of an intracellular replication niche, in which *Brucella* survives and multiplies (Galinska and Zagórski, 2013).

Yumuk and O'Callaghan, (2012) elaborated on the pathogenesis by explaining that the bacteria may grow to very high density, introducing a massive inflammatory response with the aborted placenta and foetus containing a high number of infectious bacteria per gram of tissue or liquid. Infected animals effectively remain carriers for the rest of their lives even though they may abort only once. (Yumuk and O'Callaghan, 2012)

Organisms are carried intra-cellularly in neutrophils and macrophages, or free in the plasma and localize in various organs, especially the gravid uterus, udder and supra mammary lymph nodes. Localization may also occur in other lymph nodes and in the spleen. (Galinskaand Zagórski, 2013). These bacteria may also be forced into the synovial structures, leading to inflamed bursae, arthritis and hygromas (Bishop *et al.* 1994). The bacteria may be carried to testicles and surrounding tissues in bulls during the bacteraemic stage (Galinska and Zagórski, 2013).

All these help in understanding the preferred organs for the bacteria, clinical signs and mode of transmission of the disease.

2.2.5 Clinical signs

As one of the most obvious observations in *Brucella* infected animals may be abortion storms particularly midway through the gestation period, this disease is sometimes called "Contagious Abortion" ((Mai *et al.* 2012)). Sheep, goats and wild life may also abort in high numbers if infected by *Brucella* (Godfroid *et al.* 2010).
In DAFF (2018) it is indicated that many factors including age at infection, management practices, the severity of the challenge, the period which the herd has been infected with *Brucella*, and various environmental factors such as the quality of pastures which may affect cattle density, the climate and the topography may determine abortion rates (DAFF, 2018).

Cattle that abort from brucellosis and some that may seem to have produced normal

calves have a tendency to retain placentae and often these cattle develop metritis, which may lead to fly strike in fly prone environments (Cheville *et al.* 1998).

Bulls often develop orchitis, epididymitis and seminal vesciculitis. hygromas of the carpal joints are a common sight (de Alencar Mota *et al.* 2016).

2.2.6 Diagnosis

In South Africa, the main objective of the Bovine Brucellosis Manual (DAFF, 2016) is to guide the veterinary officials and private practitioners with the diagnostic approach to brucellosis in individual animals and also at herd level. Tests are grouped into two categories; namely, tests to demonstrate the presence of the pathogen, commonly known as direct tests, and tests to demonstrate the presence of specific antibodies in blood, milk or semen, commonly known as indirect methods.

The manual further classifies these tests as smears and cultures for direct diagnosis, and antibody detection using different methods for indirect tests.

In the diagnosis of brucellosis, as for many other infectious diseases, it may be necessary determine whether demonstrated antibodies are due to infection or vaccination. It is therefore important to ensure that heifers are vaccinated with appropriate vaccines at suitable ages to help with this differentiation as heifer calves vaccinated with strain 19 after eight months of age, may complicate the differentiation. Veterinary officials should use good quality vaccines in preventing the disease or in controlling it (Lalsiamthara *et al.* 2015).

Bacterial culture and identification of bacteria is an acceptable standard for diagnosis of *Brucella abortus* (OIE Terrestrial Manual, 2016). Cultures sometimes yield negative results and in other instances, culturing becomes impractical due to large herds and huge number of animals (Chisi *et al.* 2017). Furthermore, culture and identification take at least two weeks from sample submission and *Brucella* cultures need to be handled by trained staff in laboratories with appropriate biosafety (Chisi *et al.* 2017).

Under such circumstances, serological tests offer a more practical means of diagnosing brucellosis. Infection with *Brucella* is confirmed using more than one serological test (Chisi

et al. 2017).

A combination of culture, serological tests and Polymerase Chain Reaction (PCR) may give a definitive diagnosis. According to (OIE Terrestrial Manual, 2016) serology remains the most practical method available to screen herds and confirm diagnosis.

In accordance with guidelines provided in the Bovine Brucellosis Manual (DAFF, 2016) of the Department of Agriculture, Forestry and Fisheries of South Africa (2016), veterinary laboratories have traditionally used Rose–Bengal test (RBT), complement fixation test (CFT), serum agglutination test (SAT) and milk ring test (MRT) in brucellosis diagnosis. RBT and CFT are used in combination to confirm bovine brucellosis in many countries including SA. RBT is used for a higher sensitivity, whereas CFT is used for its high specificity (DAFF, 2016).

SAT is regarded as an unreliable test and unsatisfactory for the purpose of international trade. It is essential to identify diagnostic tests for brucellosis that are reliable, specific, cost effective and easy to perform, which will ensure that no uninfected animals are destroyed or that no infected animals remain in the herd because of misclassification (Chisi *et al.* 2017).

Gall *et al.* (1998) further indicated that gamma binding assays include enzyme- linked immune-absorbent assays like, ELISA, competitive ELISA (C-ELISA), Florescent Polarization Assay (FPA), that employ purified lipopolysaccharide (LPS) antigen reagent and tend to yield very good results in the diagnosis of brucellosis giving the interpreter a better chance not to miss the disease or to obtain false positives. The fact was also emphasised by Rahaley *et al.* (1983).

A large number of tests have been developed recently and some are more sensitive and specific alternatives to conventional tests (Ducrotomy, Conde Alvarerez, Blasco, Moriyo, 2016). The primary binding acid tests are robust and very simple to perform with a minimum of equipment and the i-ELISA is recommended by the World Organization for Animal health commonly known as OIE as a suitable screening test (Chisi *et al.* 2017).

The conventional serological tests, which are the SAT, RBT and CFT, and i-Elisa are unable to distinguish between antibodies elicited by vaccine strain 19 and those elicited by

natural infections. The C-Elisa was developed to overcome this problem. Further, the C-Elisa is simpler to perform than the CFT and can readily be standardized by the use of purified smooth lipopolysaccharide (S-LPS) antigen and normal global antibody (Chisi *et al.* 2017).

In the Bovine Brucellosis Manual (DAFF, 2016) clear guidelines are provided on the most important aspects of sample collection, transportation, conducting of microscopic tests and interpretation of results. The manual emphasises that when interpreting or assessing the status of each reactor and herd, reactor identification, history of the herd, possible contact of cattle or animals with other neighbouring animals and previous serological tests should be considered. According to the manual, the truthfulness of the information provided by the owners is very significant.

2.2.7 Control and Treatment

Since identification of animals and control of animal movement represent a major obstacle in many countries (Seimenis, 2012), livestock infected with brucellosis are not easily identifiable. The control of bovine brucellosis is complicated by the fact that there is no effective economic treatment for the disease in livestock in general. Vaccination of uninfected cattle; particularly at recommended ages, is one of the most effective control strategies in avoiding infection. Strain 19 vaccine is the vaccine most commonly used but RB51 was later introduced and found to be very effective too.

In order to avoid interference with diagnostic tests, strain 19 must be administered to heifers between four and eight months of age. RB51 can be used at ages above eight months as it has been proven that it does not interfere with diagnosis (Chisi *et al.* 2017).

Vaccination for brucellosis should be used in conjunction with other measures. These measures include: removing infected cattle; disinfecting areas in which abortions have taken place; practising proper biosecurity; proper disposal of aborted foetuses; proper disposal of placentae and many more (Aparicio, 2013), for successful control of a disease like brucellosis. To help with the successful control of the disease, it is important to begin by establishing the different epidemiological contexts within a country or region or district. Aparicio (2013) also emphasised the necessity for collaboration between the veterinary authorities, the farmers and all other organisations that may be involved in order to control

or eradicate the disease. Early warning systems are also important. These provide ways of detecting a problem in time and attempting to reduce or eliminate future problems (Carpenter *et al.* 2007).

Rapid elimination of all infected animals is essential in the control or eradication of brucellosis. Calves in infected herds especially female calves born from known infected cows should be regarded as potential sources of infection and removed (Bishop *et al.* 1994).

2.3 BRUCELLOSIS AS A ZOONOSIS

According to the Food and Agriculture Organization (FAO), the World Health Organisation (WHO), and the Office International des Epizooties (OIE), brucellosis is still one of the most important widespread zoonosis in the world (Yumuk and O'Callaghan, 2012). The authors emphasised that *B. melitensis, B. abortus* and *B. suis* are the three species generally associated with human disease and that rare cases of infection with *B. canis, B. ovis* and *B. neotomae* may occur.

LeJeune and Kersting (2010) indicated that people at high risk are veterinary officials, abattoir and laboratory personnel, farmers and farm workers. According to John *et al.* (2010) and LeJeune and Kersting, (2010), the zoonotic implications of brucellosis in humans are mainly an occupational hazard through contact with or exposure to the infectious material from infected animals. Other infections result from the consumption of infected animal products such as un-pasteurized milk or milk products. This fact was further emphasised by Arimi *et al.* (2005). Arimi *et al.* (2005) when they showed that consuming un-pasteurized milk products is common in rural communities, exposing the vulnerable rural population to the risk of contracting diseases due to poverty related considerations, which places a high load on health services in these communities. Although brucellosis is known for affecting people and animals, it is also as all food borne diseases are, well known for causing additional losses with the opportunity cost of depletion of resources that in the absence of disease could be allocated to alternative purposes (McDaniel *et al.* 2014).

According to Wojno *et al.* (2016), in humans, definitive diagnosis of *Brucella* infection is established by isolating the organisms from blood, bone marrow, cerebral spinal fluid,

tissue, plasma, pus or other relevant samples. A presumptive identification of the culture isolate can be made using basic biochemical tests.

Brucellosis in humans is under treated and in most cases goes undiagnosed, leading to considerable suffering of those affected (McDermott and Arimi, 2002).

Brucella melitensis remains one of the most common zoonotic diseases worldwide with more than 500,000 human cases reported annually (Seleem *et al*. 2010).

Zoonoses caused by the *Brucella* species cause major economic losses as well as considerable human morbidity (Boschiroli *et al.* 2001). The disease in humans may have an acute or subacute onset but has the propensity to become chronic and relapsing (Wojno *et al.* 2016).

Brucellosis does not necessarily induce abortions in humans but some abortions have been reported in patients presenting with fever, chills, sweating and malaise with discrete manifestations in the brain and joints, as was reported in Saudi Arabia by (Kiel and Khan, 1989). This was in patients with a history of consuming large quantities of unpasteurized milk and or large quantities of unpasteurized cheese, particularly derived from goats or camels.

A substantial number of patients present with hypersplenism, or bone marrow suppression resulting in thrombocytopenia and purpura haemorrhagica, which is complicated by hepatomegaly. When the disease become chronic, a wide range of pathological conditions may occur affecting nearly all organs in the body including spondylitis, endocarditis and meningoencephalitis (Pappas *et al.* 2004). In addition, neurological complications may also occur (Mantur *et al.* 2007).

The recommended treatment is a long course (at least 6 weeks) of combinations of antibiotics, notably rifampicin and tetracycline or gentamicin or (parenteral) streptomycin (Mantur *et al.* 2007). A combination of other antibiotics is still being tested. The tetracycline administered trials consisting of one therapy were less effective than combination therapy (Skalsky *et al.* 2008). Antibiotic resistance is not encountered with *Brucella* and testing isolates for antibiotic sensitivity is discouraged due to the risk of laboratory infections (Yumuk and O'Callaghan, 2012)

2.3.1 Mode of transmission in humans

Infections in humans result from direct or indirect contact with animal sources (Center for Food Security, 2018). Laboratory personnel, veterinarians, farmers, Animal Health Technicians and other professionals may accidentally inoculate themselves with vaccine and or bacteria and get ill from this action (Alusi, 2014).

Brucella melitensis presents the greatest hazard (Seleem et al. 2010). The milk of infected sheep and goats may contain large numbers of viable organisms, which become concentrated in products such as soft cheese. Indeed soft cheese has been acclaimed as one of the major vehicles of infection in Turkey (Yumuk and O'Callaghan, 2012)

2.3.2 Reporting and multidisciplinary approach to handling of brucellosis in humans

In South Africa, human brucellosis is under diagnosed and underreported mainly because many clinicians have little or no experience in managing affected patients and in part because of the non-specific and insidious nature of the disease (Wojno *et al.* 2016).

According to Degeling et al. (2015), it is important to have a comprehensive, multi-sectoral approach between the health sector and other sectors particularly agriculture, environment education and local administration in a "One Health Approach" to contain and effectively control zoonotic and foodborne diseases like brucellosis that affect mainly the poor.

2.4 RISK FACTORS FOR BOVINE BRUCELLOSIS

A common observation in many rural communities is that grazing is shared by members of the community generally organised in the village within the ward. Because the rangeland is shared, extensive overgrazing is observed in these common farming areas (Hervé-Claude *et al.* 2011). Multiple species ownership is also common. Frequently, a combination of cattle, goats, sheep, pets, poultry and sometimes horses and pigs are kept.

In these communities, animal ownership is an important indicator of social status as observed by Hervé-Claude *et al.* (2011). In most rural cultures in South Africa, these animals are also an important source of food and income. In addition, sometimes in study areas, for purposes of livestock ownership, grazing and water resources, villages

themselves may not be properly described.

Over-exploitation of resources becomes a reality when people are using common resources with eventual degradation of these resources (Feeny *et al.* 1990). Studies by Feeny *et al.* (1990) indicated that in many cases, in study areas it is often difficult to restrict access to resources like grazing and water or to establish rules for sustainable use of these resources for these communities.

The risk of cattle exposure and infection to bovine brucellosis is considerable and influenced by many factors, which include lack of movement controls, sharing of farm land, lack of vaccination and bigger herd sizes (Al-Majali *et al.* 2009). Lack of knowledge among farmers and farm workers has also been proved to be a significant risk factor (Tesfaye *et al.* 2011).

There is a strong presence of bovine brucellosis in the herd or in herds that are constantly meeting and grazing communally (de Alencar Mota *et al.* 2016). If there is increased frequency of animal replacement and lack of individualized handling of animals particularly in problems related to sanitary control, there is a tendency for increased contact of many animals and this may facilitate the transmission of brucellosis. (de Alencar Mota *et al.* 2016).

Patel *et al.* (2014), several factors related to the provision of facilities such as calving camps, quarantine camps for the animals especially as it relates to the breed and type of animal is a significant risk factor for the development of brucellosis in animals. The authors also emphasised the knowledge of farmers as a significant risk factor.

Muma *et al.* (2012) stated that the indiscriminate buying and selling of animals and bringing them to the herd has been proved to act as a risk factor in terms of an increased risk of bringing brucellosis into the herd from infected cattle. It is therefore important that when farmers purchase even from other farmers, they must give enough attention to the disease status of the animals they are bringing in. Even if the farmers are said to be buying from disease accredited herds they should still demand assurances that the animals are not infected with *Brucella*. Muma *et al.* (2012) further elaborated on risk factors such as insufficient vaccine coverage, indiscriminate or insufficient movement controls and irrelevant policies for brucellosis control contributing to the spread of the disease.

(Godfroid *et al.* 2013) have demonstrated that wildlife may play a role as a reservoir for *Brucella* strains. Since there is no vaccine for wildlife, the prevalence of this disease in wildlife may play a role in prevalence of the disease in cattle particularly where buffaloes are present.

Addis, (2015) clearly categorized the risk factors for brucellosis into four categories that include the environment, the reservoirs, host factors and management. Infected animals contaminate the environment and the bacteria survive well in suitable conditions. Infected animals serve as the reservoir for the bacteria. Host factors include the spread of the disease within the herds or susceptible animals and management factors include issues of prevention and movement control.

2.5 MANAGEMENT AND CONTROL OF BRUCELLOSIS WORLD-WIDE

McDermott *et al.* (2013) summarized the prevalence of brucellosis in Africa and depicted that in Southern Africa the prevalence is as high as 14.2%. In North Africa, the authors indicated that the prevalence is 13.8%. East and West Africa are said to be respectively 8.2% and 15.5%. South Asia has a prevalence of 16% while East Asia has a prevalence of 2.9%. Despite these comparisons, the prevalence of the diseases at country level could differ significantly from the gross figures. Similarly, the prevalence of the disease at household, kraal or dip-tank level could also be different.

From this analysis, it, can be seen that Southern Africa has the third highest prevalence of 14.2%, just below 16% in South Asia and 15.5% in West Africa. (Manoto, 2016) examined the records over a five-year period starting from 2009 until 2013 in the Bojanala district of the North West Province which included Moses Kotane, the local municipality in which the Mabeskraal village is situated, and came up with observations that indicated prevalence brucellosis at individual animal level of 4.1% in Moretele magisterial district,1.9% in Madibeng magisterial district, 4.1% in the Rustenburg magisterial district, 2.3% in the Kgetleng river magisterial district, 7.4% in the Moses Kotane magisterial district. Moses Kotane district has the highest prevalence at individual animal level from Manoto's observations. Manoto further indicated that the overall prevalence at individual animal level is 3.2%. Manoto (2016) however also indicated that the prevalence at herd level could be

as high as 66% and as low as 0%. It is at this level that the impact of the disease is often not seen or felt particularly by the farmers themselves. The average prevalence of brucellosis at herd level was found by Manoto (2016) to be 33.3%

The planning and management of control or eradication programmes for Brucellosis have been investigated in many countries. Major sources of the disease should be eliminated, otherwise the disease will occur and recur constantly as it did in Malta where the causative agent was discovered in 1887 (Wyatt, 2013 & Good *et al.* 2010).

The successful eradication of bovine tuberculosis in Australia was with special reference to surveillance and managing the risk of animals exposed to tuberculosis, a model that was also used for the eradication of bovine brucellosis. The eradication was successful because of the involvement of industry in the eradication process (Radunz, 2006). The model of joined industry and government funding and decision-making, first used during the brucellosis and tuberculosis eradication campaigns, has been successfully incorporated into subsequent livestock disease control programmes in Australia (Radunz, 2006).

France also was successful as a result of good collaboration between farmers and veterinarians. The farmers who helped the veterinarians associated themselves in an organisation to help with the eradication efforts (Bronner *et al.* 2015)

In Chile, a combination of strain 19 and Rb51 used to vaccinate female bovines helped in the eradication of the disease as the vaccine used as coverage was very good (Rivera *et al.* 2002). The eradication in Chile was verified by a decrease in incidence in brucellosis infected herds.

Portugal had eradication programmes for more than six years with little impact in three of the nine provinces until they employed the use of RB51 (Martins *et al.* 2009). Before the employment of the use of RB51 farming on the Portuguese islands areas, particularly in dairy, was said to be extensive and difficult because of brucellosis.

Brazil controlled brucellosis by studying the risk factors and thereafter making policies to eliminate the risk factors to brucellosis. The studies included large scale case studies of the prevalence of the disease and existence of the risk factors in order to support strategic decision making (de Alencar Mota *et al.* 2016).

2.6 BRUCELLOSIS IN SOUTH AFRICA

In South Africa, the prevalence of Brucellosis is based mostly on non-structured surveillance, which is not scientifically justifiable. This may have led to either underestimation or overestimation of the prevalence of brucellosis. Surveillance is also complicated by uncoordinated calfhood vaccination with Strain 19 (DAFF 2017).

South Africa introduced a Brucellosis Eradication Scheme under the Animal Diseases Act, 1984 (Act 35 of 1984) and the corresponding regulations in 1984 and the Bovine Brucellosis Scheme (R. 2483 of 9 Dec 1988). As in most countries world-wide, .the objectives of the scheme clearly sought to promote the eradication of bovine brucellosis in South Africa in order to advance human and animal health. The scheme intended to eradicate brucellosis through subjecting all bovines in the Republic to a brucellosis test, identifying and slaughtering all infected bovines, isolating all infected herds until bovine brucellosis has been eradicated in such herds, isolating any bovine suspected of being infected with bovine brucellosis until a final diagnosis can be made, preventing contact between any infected bovine or any bovine suspected of being infected with bovine brucellosis and any other bovines, and informing all responsible persons and other interested persons of the control measures relating to bovine brucellosis contained in the regulations, and of the measures set out in this scheme.

The current SA legislation mandates that cattle infected or suspected to be infected with brucellosis be reported to the responsible state veterinarian (Act 35 of 1984). The animals and the herds may then be dealt with under the Act 35 of 1984 particularly under the brucellosis scheme.

Despite these regulations, brucellosis continues to be a serious problem in South Africa as depicted in Fig. 2.1 which provides a bird’s eye view of reported cases of bovine brucellosis in South Africa.

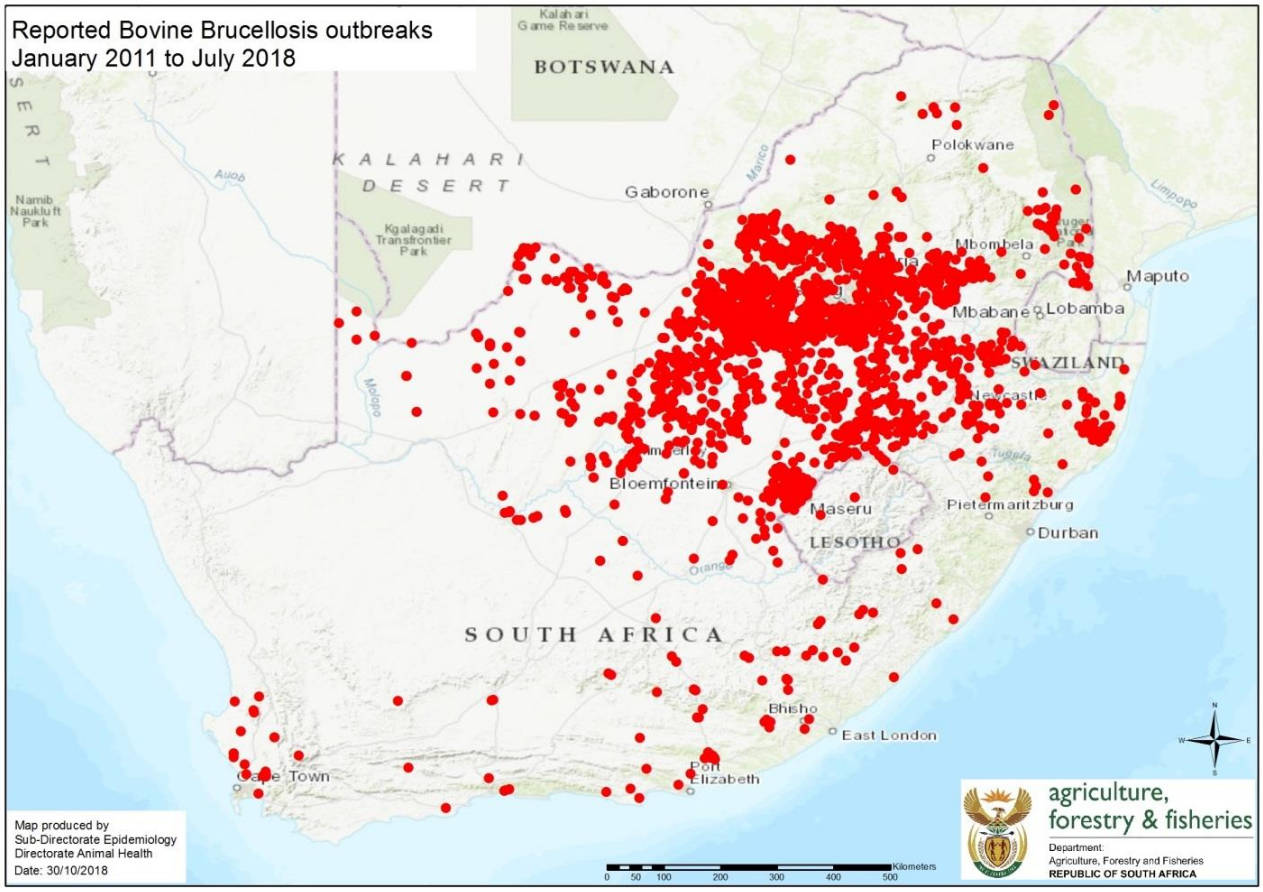


Figure 2.1 - Map of Bovine Brucellosis reported outbreaks between 2011 and 2018 (Map provided by the Department of Agriculture, Forestry and Fisheries)

Hesterberg *et al.* (2008) conducted a serological survey of *Brucella abortus* in cattle of rural communities in the province of Kwazulu-Natal and found the prevalence in that province to be below 1% in most districts. The North-Eastern parts of the Province were found to have a prevalence of between 2.4% and 15%.

Mokantla *et al.* (2004) in the investigation of the causes of low calving percentage in communally grazed cattle in Jericho, North West Province however estimated that prevalence of brucellosis in the Province was 0.75 to 2%. Mokantla emphasized that, brucellosis is not the only cause of low calving percentage in the area he studied.

Manoto, (2016) presented a good argument on the challenges of implementing the current Brucellosis Scheme in South Africa, explaining why the prevalence of the disease could be so high in the district he studied. Amongst other issues, he pointed out that although the scheme is based on compulsory immunization of all heifers between 4 and 8 months of age with an approved vaccine, serological testing of the animals and branding and slaughter of all infected cattle that are detected are not implemented as envisaged

(Manoto, 2016). He further stated that the scheme is still being implemented as a voluntary program where farmers are persuaded to have their animals tested. Routine testing is not compulsory, nor can the immediate slaughter of infected cattle be enforced because the policy does not provide for appropriate compensation.

Manoto, (2016) summarized the challenges related to implementation of this scheme as follows:

a) Loss of control over compulsory vaccination: Since the responsibility for vaccination of cattle against brucellosis was shifted to the owners in the early 1990's, the use of *B. abortus* s19 has decreased steadily and only a minority of farmers vaccinates heifers. This has resulted in a large percentage of adult breeding animals that are not immunized.
b) Restriction of vaccination to heifers: Until recently, it was difficult and not recommended to immunize and protect adult cows on a routine basis as only diluted strains 19 could be prescribed. In addition, the extensive farming systems without clear calving seasons were the main reason for cattle owners in large areas of the country failing to administer the compulsory S19 vaccination to heifers. Nowadays, the *B. abortus* RB 51 vaccine may be used in adult cattle but owners find the cost of the vaccine prohibitive.
c) Movement of possibly infected cattle: There is inadequate movement control of cattle that may be infected with brucellosis, because many animals are not tested at all.

Because of the many factors that are to be taken into consideration when applying the scheme, the DAFF has seen it fit to amend the Brucellosis Scheme particularly after following the OIE evaluation of veterinary services in South Africa. The Department has subsequently drafted and published a discussion document (Daff, 2018), to solicit input from the general public and obtain good buy in from farmers on the process of moving forward in the control of this economically important disease. The discussion document outlines the principles, objectives and proposed direction for reviewing the approach to the control of bovine brucellosis in the Republic.

The discussion paper on bovine brucellosis in South Africa (DAFF 2016) elicited many consultations with stakeholders and many comments. The records obtained from the office

of the Directorate of Animal Health in 2018 reveal the comments made by stakeholders in table 2.1:

Table 2.1 - Highlights/ summary of the public comments on the "Discussion paper on the review of bovine brucellosis control in South Africa"

Point	Comments/ input
1	**Compulsory testing for bovine brucellosis of all bovines within South Africa** Farmers agreed to compulsory testing of all cattle and agreed that testing intervals should be every 2 years testing should be conducted at owner's costs
2	**Prohibition of the movement of live animals from herds infected with bovine brucellosis other than for purposes of slaughter** Farmers agreed to this prohibition. The farmers also agreed to a compulsory C branding to identify positive animals.
3	**Improved implementation of compulsory heifer vaccinations for brucellosis** Farmers agreed to the suggested protocol of vaccination and identification of vaccinated animals. There was a debate as to whether restrictions to vaccinate animals should be by Veterinarians and / or Animal Health Technicians; others were of the opinion it would be difficult due to lack of manpower. Improve record keeping: Improving compliance if owners are still allowed to vaccinate requires deliberation.
4	**Optimization of the test and slaughter control measures for bovine brucellosis in infected herds** Some farmers felt that incentives for testing are required; others felt that testing is in the best interests of all as production is higher if the disease is absent.
5	**Compulsory abortion notification** Some farmers are in favour of compulsory notifications whereas some are not.
6	**Diagnostic reporting format for laboratories** The stakeholders suggested a standard format of sample submission, a standard testing protocol and a centralised database. Laboratory submission forms need to be completed properly.

Point	Comments/ input
7	**Establishment of a fair, equitable and sustainable "responsibility and funding system" for bovine brucellosis control** Farmers proposed that government pay for testing in laboratories for state veterinary testing. Routine testing should be done at accredited private laboratories. Good databases are essential for control at both provincial level and centrally.
8	**Establishment of a fair, equitable and sustainable funding system for slaughtered animals** Stakeholders proposed that a levy system be introduced, for example a compulsory levy for all animals slaughtered at a registered abattoir.
9	**Availability of manpower and other resources to test for bovine brucellosis and to apply the control measures** Stakeholders proposed that manpower be increased to cater for increased numbers of samples that will be collected.
10	**Opportunity to use the required testing for brucellosis to pilot the proposed national (Animal Identification Recording and Traceability (AIRT) for tested and vaccinated animals** The stakeholders indicated that an increased activity on *brucella* testing and vaccination will provide an excellent opportunity for South Africa to pilot the animal identification and traceability system for South Africa. They indicated that the AIRT/ (livestock Identification and traceability System (LITS) programme needed to be streamlined with the brucellosis control programme.
11	**Resources for rural assistance and general information and education campaigns.** The stakeholders proposed that government should involve industry in education campaigns and training of veterinarians and para-veterinary professionals. Industry, communities, cattle farmers and keepers, public, veterinary staff all needed education.
12	**Minimisation of the risk of transmission at the livestock-wildlife interface** Stakeholders proposed that cattle surrounding wildlife farms should all be vaccinated.
13	**Incorporation of industry initiatives to control Brucellosis**

Point	Comments/ input
	Stakeholders proposed that organised industry should be involved e.g. Studbook, sales yards, auctioneers, feedlots, abattoirs. Levies to be collected to help fund the brucellosis control programme. Co-operation between role-players is required.

These comments indeed summarise the challenges and propose solutions to the challenges.

Despite stakeholder input on the discussion paper (DAFF, 2016), a socioeconomic impact assessment needs to be conducted in line with the guidance of the government of SA, using a particular template provided by the government. The guiding template examines at least 13 important areas, ranging from describing the problem to monitoring and evaluation.

Cloete (2018), recently studied the knowledge, attitudes and practices of cattle keepers in the Eastern Cape Province of South Africa and concluded that there was a positive association between better understanding of the disease, better practices and higher level of education and those that owned more than 20 cattle. She further concluded that it is necessary to address poor knowledge of cattle keepers to give the state a better chance of controlling the disease.

2.7 SOCIO-ECONOMICS OF BRUCELLOSIS

Bovine brucellosis negatively impacts livestock productivity (de Alencar Mota *et al.* 2016). As is the case in many countries, Mookaneng (2001) emphasised the importance of livestock in the social lives of people either as a source of food, status and acceptance with a community. Indeed, this significance applies not only to Batswana people but to other groups like the Zulu people, the Venda people and many more. This importance of livestock in the lives of rural communities is supported by the fact some cultures encourage keeping more animals of a particular kind, for instance in some cultures, goats may be preferred to other animals because of the belief that they are more intelligent than other animals, hence making it easy for them to avoid being predated upon (Mookaneng, 2001). Although sheep and goats fulfil the same uses as cattle, they do not elicit the same emotional impact in people as cattle do (Mookaneng, 2001).

In some Provinces in South Africa, more than 65% of the human population live in communal areas where poverty and food insecurity levels are very high (Nqeno *et al.* 2011). In these provinces in particular, most communal areas farmers keep various livestock species as a result to combat poverty and these livestock include cattle, goats, sheep and chicken (Ngeno *et al.* 2011). Of these, cattle are the most valuable due to their multiple functions and roles (Mookaneng, 2001). As a result, any disease that causes reduced productivity would be efficiently controlled for these communities to improve on the livelihoods of these communities.

The situation of finding this many rural dwellers in provinces was probably perpetuated by the homeland system which existed in South Africa until recently dismantled by in the new democratic system (Shackleton *et al.* 2001). As a result of the circumstances these communities find themselves having to improve their livelihoods through agriculture, particularly livestock farming.

It is reported that the calving percentage of cattle in rural communal areas is often as low as 35% whereas if management is improved, it can go as high as 83% as proven by Nowers *et al.* (2013). This low calving percentage is often the result poor management including feeding and animal disease management of proven by (Nowers *et al.* 2013). As shown by Mokantla *et al*. (2004), diseases like brucellosis and others like trichomoniasis and low bull to calve ratio may be implicated for causing low productivity. In their study, they placed the calving rates in the some rural North West Province communities at 37.7% and lower.

The acceptable bull cow ratio is 1 bull to 20 to 30 cows (average 1 bull to 25 cows) (Day, 1999) and is often difficult to adhere to as bulls may be wandering in different kraals resulting in poorer reproductive rates in these communities.

Stärk & Häsler, (2015) emphasised that in economic terms, rural food production systems in this case animal production systems exists to provide people with goods such as food, wool and leather. Animals also serve as companions and are useful in sports, for work and for research. Rural food production is important and with proper advice better yields could be realized (Jacobs et al, 2010). The true economic contribution of non – monetised resources like livestock referred to above is often unknown or underestimated (Cousins, 2008).

Animal diseases, particularly those that threaten human health, erode or reduce the economic benefits of animal farming systems (Otte *et al.* 2004).

Stärk & Häsler (2015) emphasised the importance of rural food production and that proper advice provided to rural communities could bring about better yields. Brucellosis does affect rural meat and other products production and in the opinion of the author, besides advice provided, the veterinary services of countries world-wide should play an important role to ensure that the disease is controlled sufficiently contribute to improvement of production of food of animal origin.

The impact of endemic animal diseases is mainly found at farm level, with mortalities or production losses. Livestock diseases also exert a broader economic impact through the restriction of trade in livestock and their products (Otte *et al.* 2004).

Within a livelihood analysis framework in rural areas, the variety of uses to which cattle are put make them more valuable than other livestock (Shackleton *et al.* 2005). The cattle keeping enterprise is therefore very significant in rural communities.

Despite this, Seimenis, (2012) has indicated that animals belonging to poor people are particularly vulnerable to diseases because of cost, absence or unsuitability of assistance from the animal health sector. Seimenis, (2012) further emphasised that the majority of these diseases do not lead to dramatic epidemiological emergencies, which normally attract major media, official and private sector attention. The financial sector and the multi-national pharmaceutical companies do not consider these diseases candidates for good investment. This severely hampers the development of corresponding diagnostic tools, drugs and vaccines. Consequently, these diseases become endemic in poorer communities. Since zoonoses, emerging and re-emerging diseases are included in this category, these communities end up shouldering a heavy burden of disease.

The economics and cost of animal diseases are of growing concern as they have led to increasing changes in international trade and in production practices fuelled by changes in lifestyle across the world and by changing environmental conditions (Stärk & Häsler, 2015).

Diseases of livestock constrain production and productivity (Otte *et al.* 2004). These

constraints often goes unfelt or unobserved because rural livestock owners are often oblivious of the impact animal diseases have on productivity of their livestock, leading to extensive losses (Otte et al. 2004).

The losses due to animal diseases with special emphasis on brucellosis are multifactorial. Clinical signs of brucellosis include abortions; longer inter calving periods, lower fertility, orchitis, and chronic joint conditions, among others. All these could lead to direct or indirect losses (Jemberu *et al.* 2014). Direct losses consist mainly of loss of milk production, loss of draft power, mortalities, especially in young animals, and retardation of growth. According to Jemberu *et al*. (2014), the indirect losses are related to market restrictions, use of suboptimal production technologies and costs of control.

The economic impact for animal diseases differs from country to country but may be influenced by the livestock dynamics and grazing systems of the country in question (McDermott *et al.* 2013).

The socio- cultural factors that lead to the persistence of diseases that are endemic with zoonotic potential, as well as the economic impacts and other social ramifications are often not investigated enough (Otte *et al.* 2004 & Shackleton *et al.* 2005). These socio-cultural and economic issues, if properly understood could lead to better management of diseases and help uplift the standard of living among rural livestock owners (Cousin, 2009).

Brucellosis has multiple economic impacts on agricultural production and its zoonotic potential also impacts on human health and other broader social developmental areas (McDermott *et al.* 2013). Developing countries need to carefully evaluate the approaches they employ in controlling the disease and not just copy control measures employed in countries that have successfully controlled or eradicated the disease.

Developing countries have unique challenges, which may interfere with swift control of brucellosis (McDermont *et al*. 2013). These include the burden of disease from a wide variety of other pathogens. In addition, animals in developing countries fetch far less in monetary value compared to the prices in developed countries (McDermott *et al.* 2013).
Other factors for consideration include less public investment on veterinary services and the competing needs for economic growth and job creation. Investment arguments for animal disease control programmes in these countries will have to support the competing

needs, making it difficult for veterinary services to adopt programmes that would deal with such diseases as a matter of urgency (McDermott *et al.* 2013).

(McDermott *et al.* 2013) developed the framework for the economic assessment of brucellosis in low-income countries with the following basic building blocks at three levels involving:

a) The burden of brucellosis in different systems including epidemiology and transmission dynamics of the disease. This may involve the prevalence of the disease and the impact of the disease on the animals. The level of dependency of the people on the livestock for their livelihood and the burden of the disease in question on the health and economic health of the affected communities.
b) Sector specific impact of the control measures. This may involve the control measures employed by the responsible authorities including both industry and government. The cost of the control measures and the cost benefit analyses outcomes of the control measures.
c) Integrated programme- impact analyses. The benefits of controlling the diseases are evaluated against the costs and the intended outcomes. These will include the health benefits of the affected communities and the benefit to the rest of the world.

Livestock are important in supporting the livelihoods of poor farmers, consumers, traders and labourers throughout the developing world and enhancing of livestock production systems has a great impact on the improvement of lives (Seimenis, 2012). Some animal diseases like brucellosis easily afflict animals belonging to poor people for whom production inputs are unavailable or unaffordable. Such major diseases follow poverty indicators regardless of how highly these animals are priced by these communities. Seimenis, (2012) summarized factors contributing to disease occurrence in in poor communities, such as:

a) Marginalization from the health sector.
b) A disproportionately high share of the disease burden.
c) A broad range of viral, bacterial, mycotic, chlamydia, rickettsial and parasitic diseases with their major impact on the health and social economic development of populations.

CHAPTER 3
MATERIALS AND METHODS

3.1 INTRODUCTION

Bojanala Platinum District Municipality is situated in the north-eastern part of the North West Province. The local Municipalities of Kgetleng River, Madibeng, Moretele, Moses Kotane and Rustenburg fall within the district (Figure 3.1).

The population of Bojanala Platinum District is estimated to be 1 323 921. This is approximately 38% of the total population of the North West Province (Manoto, 2016). The majority of the area can be classified as rural with very low population densities that makes the provision of basic services very difficult and expensive. The study was carried out only in Mabeskraal village and surroundings in Moses Kotane local municipality.

Mabeskraal was chosen for the study because there were concerns emanating some communal farmers in Mabeskraal that first time pregnant heifers were aborting unborn calves roughly when they were close to calving. According to one farmer, at least one adult cow had swellings on the both front knees which may have been suggestive of chronic brucellosis. According to the farmer, he was advised to get the cow slaughtered but he did not understand why he had to do it as the cow was calving normally and in his opinion, the calves were all healthy. The adult cow with swellings on both front knees was according to him the foundation of his herd and a significant contributor to his livelihood which helped him educate his whole family through the income he obtained from selling particularly the male off spring from the cow. The farmer indicated that he introduced the cow into his heard of five a few years before as a first time pregnant heifer, but it aborted soon after arrival.

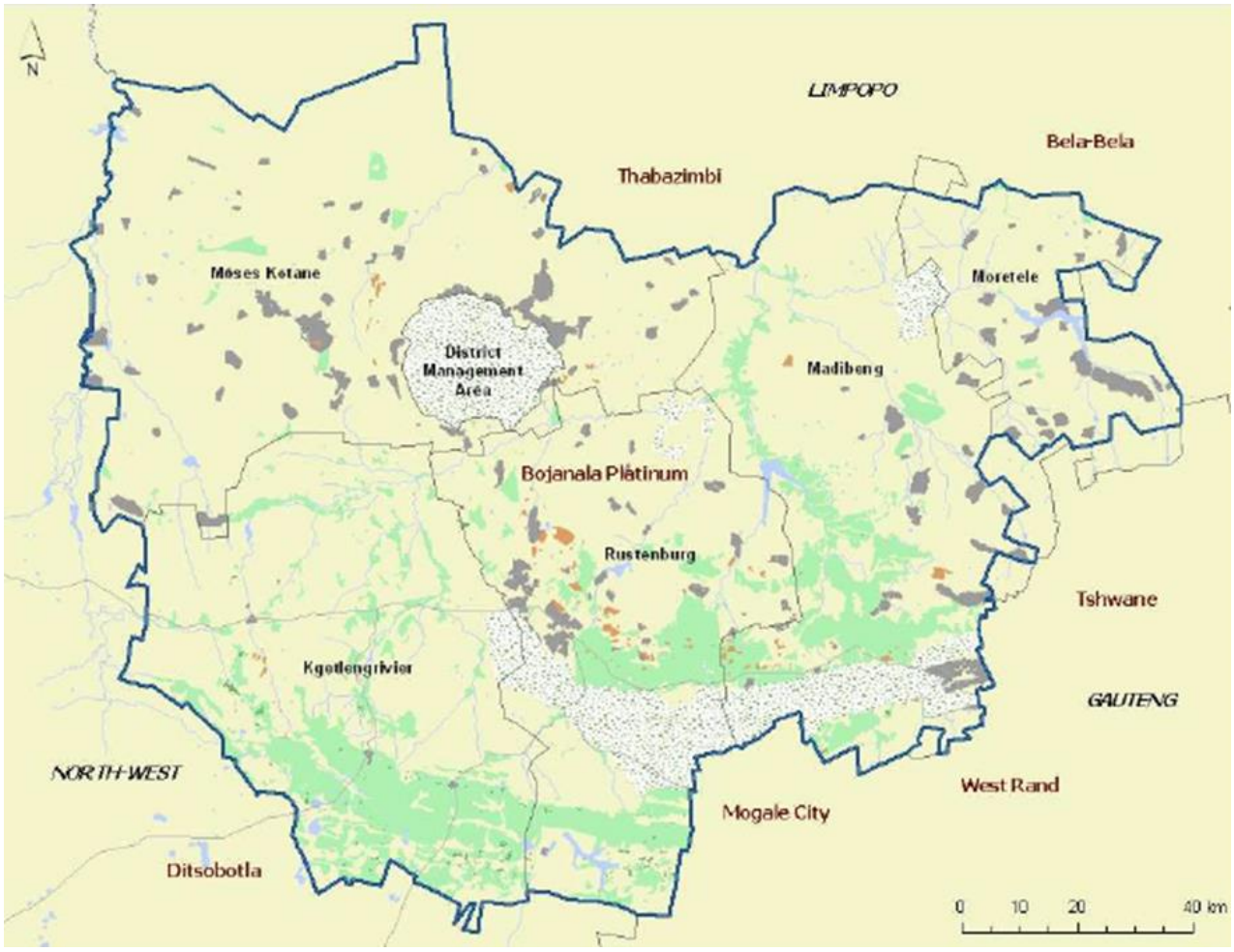
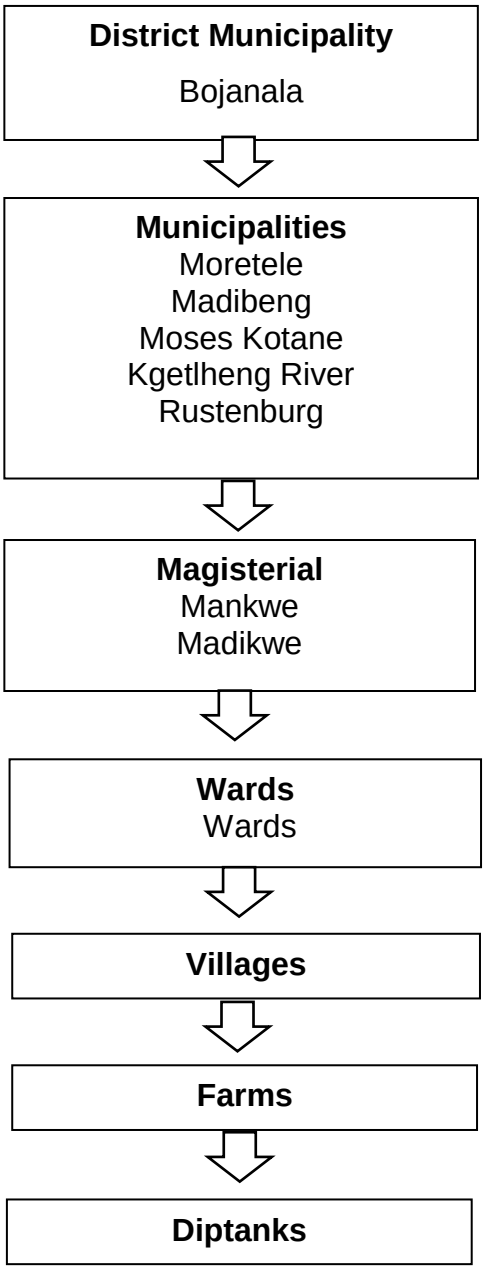


Figure 3.1 - Map illustrating the structure of Bojanala district.

The flow chart below Chart 3.1, illustrates the relationship between district municipalities and cattle rearing areas within the study area:



Flow Chart 3.1 The relationship between the district municipality and cattle rearing areas in the Bojanala district municipality

In this study, in order to bring out more understanding of ownership patterns and the socio-cultural and economic factors, an attempt was made to look at some of these factors hoping a clearer understanding of brucellosis will ensue. This was also influenced by the fact that brucellosis is not only caused by *Brucella abortus,* but other *Brucella* spp. may play a role.

3.2 TARGET POPULATION

The study area is located in Bojanala District (Figure 3.1), one of the four district municipalities of the North West Province of South Africa. This district municipality has five local municipalities namely, Moretele, Madibeng, Kgetleng River, Rustenburg and Moses Kotane. The Moses Kotane local municipality is the study area, which is divided into two magisterial districts, namely Mankwe and Madikwe.

There are 31 wards in Moses Kotane Local municipality see (figure 3.2 below). Wards are made up of villages and villagers may keep their cattle within the villages, farms or at respective cattle posts, which may or may not be proximal to their homes.

Mabeskraal, surrounding villages and cattle posts of the North West Province, in the Moses Kotane District Municipality is located are approximately 220 km North West of Pretoria, the Political Capital city of South Africa.

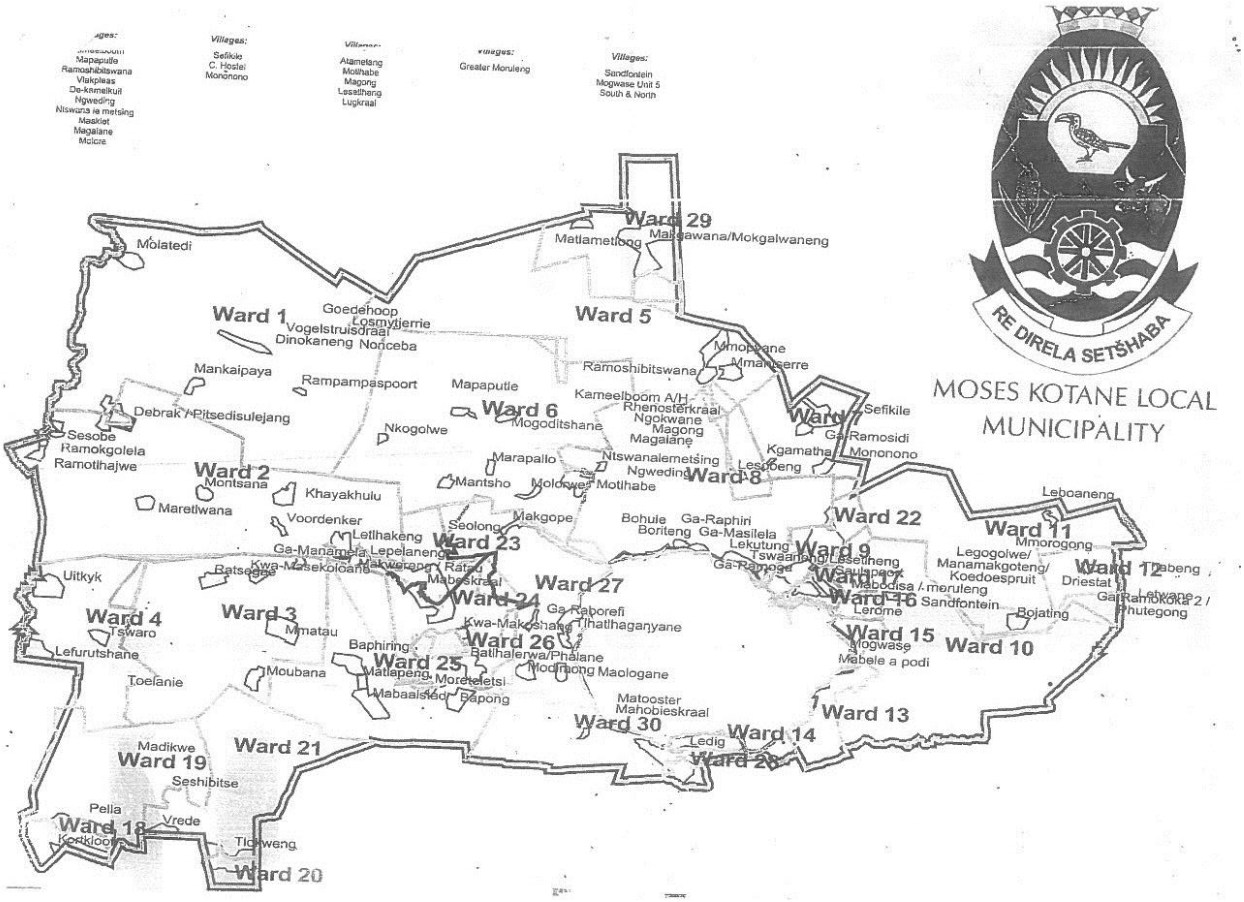


Figure 3.2 - Map of wards in the Moses Kotane municipality

The study area has a total of approximately 7 000 cattle kept extensively in the communal livestock production system (Records obtained from the office of the state veterinarian Mogwase during 2016). The livestock famers own mostly Nguni, Brahman and crossbreeds. Within the Mabeskraal area and vicinity, one animal health technician covers a number of villages. For the distribution of the questionnaires, the area serviced by two animal health technicians in the Mabeskraal area and surrounding villages of the Moses Kotane District of the North West Province of SA was targeted.

Grazing of cattle is not strictly controlled in the communal areas and cattle may walk long distances particularly during times of scarce water availability. Animals share many resources including water and grazing. There are no fences that can restrict cattle within certain areas as those that exist are not always in a good state of repair. The epidemiological unit is therefore vast.

3.3 STUDY POPULATION

Two magisterial districts, Mankwe and Madikwe, allocated to local animal health technicians were targeted and partially covered. For the prevalence of bovine brucellosis, existing testing records in the state veterinarian area of Moses Kotane was used. These records do not necessarily correspond to the cattle owners that were interviewed as the basis was to ascertain if indeed brucellosis was present in the study area. Where possible, linkages could be made at ward, village or dip tank levels.

3.4 SAMPLING AND COLLECTION OF DATA

A standard questionnaire was designed taking into consideration possible risk factors and other contributors to the prevalence of brucellosis (Annexure 2). Socio economic and cultural factors were included in the questionnaire. Structured interviews of the farmers were conducted by the animal health technicians.

The animal health technicians selected from a list of farmers they are servicing in their respective wards .which are divided into villages and further divided into crush-pens, camps or dip-tanks, the smallest unit of which is a kraal or household. The names of the farmers' were all placed in a list and every third farmer was selected for interview. If the farmer was u available, he or she was replaced with another in the same camp or dip-tank. These structured random interviews were conducted from September 2016 to October 2017 by the two animal health technicians of the wards. To augment the data, two other animal health technicians were requested to assist particularly for the village of Mabeskraal and smaller surrounding villages. The questionnaires were filled in by the animal health technicians during the interviews with the farmers or owners of the animals and the results were captured in an Excel spread sheet.

The results were computed into a data base and Stata 11.0 was used to conduct an analysis.

3.5 METHODS OF INVESTIGATION

3.5.1 Study area population profile

3.5.1.1 Use of questionnaire

A questionnaire was developed to obtain answers to specific questions to assess the understanding of the community of cattle owners about the causes of abortions in their cattle.

3.5.1.2 Specific questions

The questionnaire also sought answers to specific questions on their understanding of the clinical signs of Brucellosis.

3.5.1.3 Economic values of commodities

The answers obtained from the farmers coupled with the economic values of commodities were used to estimate the impact of bovine brucellosis on livelihoods.

3.6 SAMPLE SIZE

The initial intention was to select 5 cattle from every 5^{th} farmer in the farm register of Mabeskraal and the surrounding villages and test those cattle for brucellosis. The number of farmers was supposed to be 280. From a population of close to 10 000, around 1000 villagers are cattle owners.

Two hundred and eighty questionnaires were divided between the two animal health technicians of the area to help the farmers by recording their responses.

3.7 SAMPLING METHOD

3.7.1. Selection of participants

The targeted population for the study was cattle farmers in the Mabeskraal area and the surrounding villages in the Moses Kotane Municipality. They were selected as explained above.

3.8 ESTIMATION OF PREVALENCE

Available information on bovine brucellosis testing and results in the State veterinary office of Mogwase, Moses Kotane Municipality of the Bojanala District municipality in the North West Province were evaluated and the information used to estimate the prevalence of the disease in the area. This information covered a period from the year 2011 up to and including the year 2017. A simple proportion of the number of animals testing positive divided by the total number of animals tested, expressed as a percentage, was used to estimate prevalence of brucellosis over the years in the municipality under study as well as at magisterial district, ward and herd level.

3.9 STATISTICAL ANALYSIS

All factors with a p-value 0.05 or less will be considered significant and will be included in multivariate logistic regression that will identify factors sustaining bovine brucellosis in this community. All these statistical approaches were operated in Stata version 11

3.10 SOFTWARE

3.10.1 Calculation of prevalence including other parameters

3.10.1.1 Prevalence was computed as follows:

a) Number of animals testing positive/total number of animals tested

The number of individuals with each characteristic was calculated, using the tabulate command of Stata 11.0. The medians of continuous variables were assessed, using the summarize command of Stata 11. Tables and figures were constructed using Microsoft Office and Excel 2010 to show the distribution of various variables. The tab command of Stata 11.0 was used to compute the percentages and numbers of variable characteristics.

b) Chi Square analysis was used to identify possible risk factors for brucellosis sero-

positivity for categorical variables. This was done by assessing relationships between categorical variables and sero-positivity status of households. The Stata command of "*tab var1 var2*, chi e". The exact option was used to assess relationships in cases where categories had responses less than 5. If a relationship produced a P-value of 0.05 or less then this particular variable was deemed to be a significant risk factor.

3.10.1.2 Socio economic status (SES) of study participants was assessed as follows:

Each animal was allocated monetary value based on current South African market prices. The total number of animals per household was then ascertained and overall monetary value was then computed. This was done for each animal species. Then an aggregate monetary value based on total number of animals owned in a household was computed. All households with a value below the 25th percentile were included in the Lower I SES, those whose value was between the 25th percentile and 50%'th percentile were allocated into Lower II, whilst those between 50'th and 75'th percentile into the Middle SES and those above 75'th percentile were categorized as belonging to the upper SES.

Chi –Square analysis was used to assess the relationship between SES and brucellosis status. If the P-value was 0.05 or less a significant statistical relationship between SES and brucellosis was present.

Quantification of economic losses was assessed using milk production levels. Milk production per cow in cow's not experiencing brucellosis was determined. Then milk production in a cow not experiencing abortions was computed. The difference between the two was used as a proxy to estimate economic losses due to brucellosis.

Determination of economic losses due to cattle theft was conducted by taking the total numbers of animals per year and the losses per year. Losses were determined by computing the total number of animals stolen multiplied by the current market value of cattle.

Independent variable and other variables were converted to mean “No” to facilitate ease of running and interpreting the logistic command.

All variables with a P-value of 0.05 or less and the main independent variable in the uni-variate analysis were included in the final bi or multi-variate analysis. All variables with a P-value of 0.05 in the multi-variate analysis were consequently considered to be statistically significant to be regarded as challenges.

3.10.2 Description of prevalence

An evaluation of data from the state veterinarian’s office of Mogwase was conducted in conjunction with the state veterinarian by going through the records in the office.

3.11 SOCIO - ECONOMIC FACTORS SUSTAINING BOVINE BRUCELLOSIS

A standard questionnaire was administered to each study participant. Initially, 280 questionnaires were distributed. The questionnaire contained questions on various aspects of the farmer’s social and economic profile. In addition, the questionnaires intended to assess the knowledge of the farmers on the subject of brucellosis .The relationship between prevalence of bovine brucellosis and socio economic factors was established using multivariate logistic regression and factors responsible for sustaining bovine brucellosis in communal cattle in Mabeskraal village and surroundings.

CHAPTER 4
STATEMENT OF RESULTS

4.1 INTRODUCTION

This part covers the statement and analysis of the results. The results obtained are explained.

A total of one hundred and twenty six cattle farmers were interviewed. In addition to the responses to the questionnaire, the data viewed and captured in the State Veterinary Office included data from 77 farms stretching from 2011 up to 2017. These farms were not necessarily linked to those cattle owners who were interviewed but fell in the same study area.

The data obtained from the state veterinarian had at least one hundred and ten farmers in the study area and beyond the study area which was used to compute prevalence. It is important therefore to note that there may be few study participants whose cattle were not bled for brucellosis and that there may be others whose cattle were tested but could not participate in the survey.

4.2 RESULTS

4.2.1 Family structure

A description of the family structures of the study participants follows in the discussion below. The number of individuals per household, the ages of the household members and the level of education is noted in Table 4.11 below.

The median number of household members per household participating in the study survey was 5 (IQR3-6) as depicted in Table 1. Fifty one percent (n=19) of the family members of the study participants aged less than 10 years were females whilst 55.8% (n=101) of those aged above 50 years were males as shown in Table 1. Among family members related to those study participants who had matriculated, 47.6% (n=89) were females whilst 52.4% (n=98) were males.

Table 4.1 - Description of study participants and their families

Characteristic	Males (%)	Females (%	Total
Median Number of people in household: 5 (IQR*; 3-6)			
Population characteristics by age category			
Less than 10	18 (48.6)	19 (51.4)	37
10-13	0 (0)	18 (100)	18
14-16	20 (43.5)	26 (56.5)	46
17-50	149 (55.4)	120 (44.6)	269
Above 50	101 (55.8)	80 (44.2)	181
Level of education			
None	16 (42.1)	22 (57.9)	38
Primary	67 (56.3)	52 (47.3)	119
Secondary	120 (66.7)	60 (33.3)	180
Matriculated	98 (52.4)	89 (47.6)	187
Tertiary	36 (51.4)	34 (49.6)	70

** IQR= Interquartile range*

4.2.2 Current livestock ownership

When asked how many cattle each of the interviewed farmers owned, the farmers responded by indicating that they owned up to 213 cattle. The herd composition for the entire study area is as depicted in the table below. There were a total of 316 calves with a total of 447 heifers and 29 immature bulls. The bull to cow ratio was 0.048 as indicated in table 4.2 below:

Table 4.2 - Total herd composition in the study area

Oxen	Cows	Bull	Heifers	Calves female	Calves male	Immature bulls	Total
102	1466	71	447	187	129	29	2377
		Total calves					316
		Bull to cow Ratio					0.048

4.2.3 Farming experience of the interviewed farmers and their gender

When asked for how long they have had the herds of cattle, 11% (13) indicated that they have below five years' experience, 20% (23) have between 5 and ten years' experience and a similar number has 15 to 20 years , 19% (22) have ten to fifteen years' experience and 31% (37) had more than 20 years' experience. These are represented in Table 4.3 below:

Table 4.3 - Table representing farming experience according to gender

Gender	**Years of Farming experience**					
	<5 years	**5-10 years**	**11-15 years**	**15-20 years**	**>20 years**	**Total**
Male	10	23	18	19	35	105
Female	3	0	4	4	2	13
Total	**13**	**23**	**22**	**23**	**37**	**118**

4.2.4 Reasons for livestock ownership.

When asked why they keep cattle, among the 110 respondents who reacted to this question, 69 (63 %.) said they did it for income. This was closely followed by those keeping animals for petty trade at 64 (58%) and for breeding purposes. Fifty five (55) (50%) indicated that they kept animals for breeding. A display of the responses by the farmers on reasons of keeping cattle is captured below Table 4.4 below and displayed in figure 4.1 below. In addition, the summary of these responses is captured in table 4.5 below:

Table 4.4 - Reasons for keeping cattle by respondents in the study area

Variable	Observations
Income	69
Savings	39
Breeding	55
Meat consumption	38
Milk consumption	19
Cow manure	12
Prestige	17
For cultural purposes	51
Petty trade	64
Tradition	52
Other	1

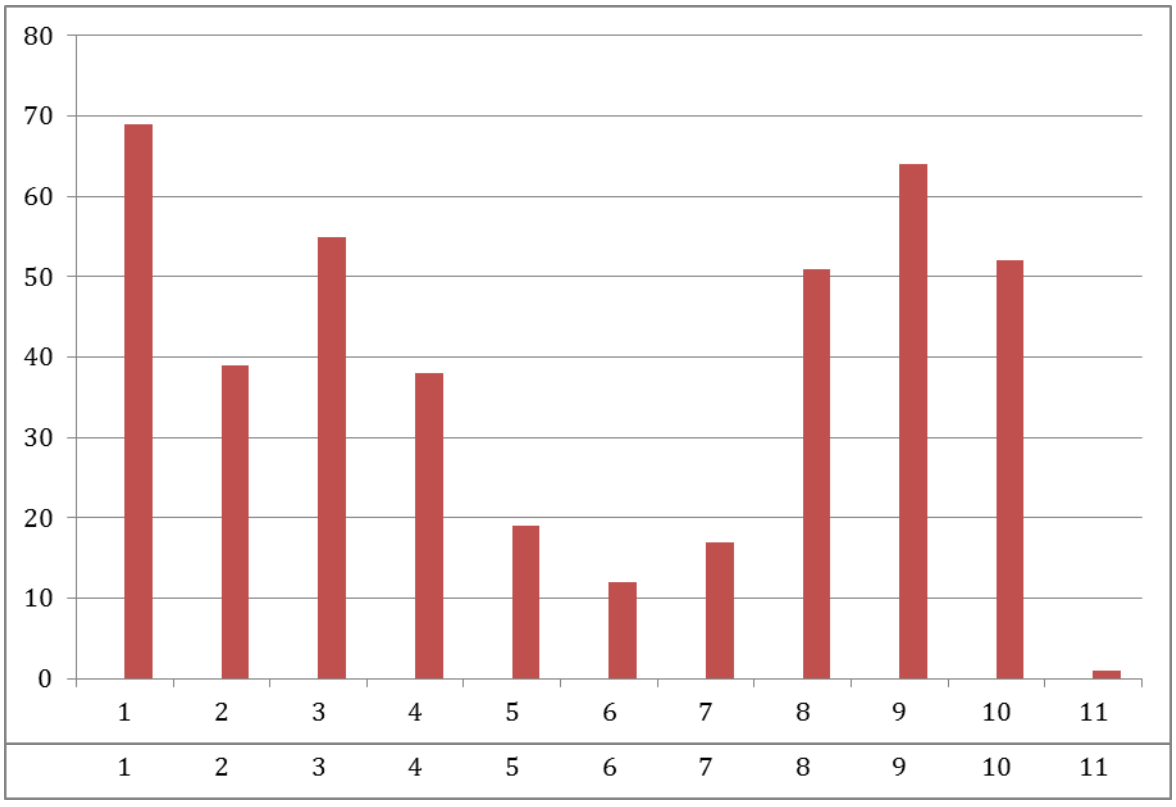


Figure 4.1 - Graph representing respondent's reasons for keeping livestock in the study area

Table 4.5 - Display of responses to questions pertaining to reasons for livestock ownership (Summary)

Importance (n,%)	Manure	Prestige	Culture	Petty Trading	Cere-monies	Others
1	0	0	0	0	0	0
2	16 (32.0)	0	0	0	0	0
3	5 (10)	11 (22.0)	21 (42.0)	0	21 (32)	0
4	0	0	0	16 (32.0)	0	0
5	0	16 (32.0)	6 (12.0)	23 (46.0)	0	6 (12.0)
6	0	0	0	0	0	27 (54.0)
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	11 (22.0)	0	0
11	29 (58.0)	23 (46.0)	23 (46.0)	11 (22.0)	29 (58)	11 (17.0)

Codes – 1=Most important, 2, 3, 4, 5, 6, 7, 8, 9, 10=Less to lesser important, 11=Not among the important

When asked if owners kept livestock for cultural events 42% (n=21) considered it very important whilst 46% (n=23) indicated that it was not important at all as depicted in Table 4.5 above.

When asked if owners considered it important to keep cattle for petty trade, 78% (n=39) considered keeping livestock for petty trading as very important as depicted in Table 4.5 above.

4.2.5 Land ownership

When asked where the farmers graze their cattle and whether these farms are self-owned or whether they graze in communal grazing areas, 123 farmers responded. Of those who responded only 8% (1) owned the land on which they are grazing the cattle. The majority of the cattle farmers (62%) (77) grazed their animals on communal land and a reasonable number (45) (37%) grazed their animals on rented land. This is displayed in Table 4.6 below:

Table 4.6 - Display of land ownership in the study area

Land Status	Freq.	Percent	Cum.
Own land	1	0.81	0.81
Communal land	77	62.60	63.41
Rented land	45	36.59	100.00
Total	**123**	**100.00**	

4.2.6 Household main livelihoods

When the farmers were asked to indicate what their household's main livelihood activities were, a total of 70 farmers responded and among the 70 respondents, 28.5% (20) indicated that cattle production and sales was the main livelihood activity. Another 15, 7% (11) indicated that employment was the main livelihood activity, followed by small ruminant production 10 % (7) and small businesses at 7%(5). Other livelihood activities were not that significant. The chart below (Figure 4.2) summarizes the responses of the participants. In summary, from figure 4.2 below, 19% (13) attribute formal employment, cattle farming , small ruminant farming and poultry farming to be contributing significantly to their livelihoods, followed by cash remittance, cattle farming and small business 13% (9). Another significant contributor is cattle farming and small ruminants. The responses of the farmers on activities contributing to livelihoods are depicted in tables 4.7, 4.8 and in Figure 4.2 below:

Table 4.7 - A display of household main livelihood activities and contributors for the area under study

Activities	Freq.	Percent	Cum.
10_11_4_13	1	1.43	1.43
10_5	1	1.43	2.86
10_5_13	1	1.43	4.29
10_5_4_11	3	4.29	8.57
10_5_6_5	2	2.86	11.43
10_5_6_7	13	18.57	30.00
10_5_6_8	3	4.29	34.29
10_5_7_6	4	5.71	40.00
10_5_8	1	1.43	41.43
11_5_8_14	4	5.71	47.14
15_13_5	1	1.43	48.57

Activities	Freq.	Percent	Cum.
15_1_5	1	1.43	50.00
15_5	2	2.86	52.86
1_5_15	4	5.71	58.57
1_5_4	1	1.43	60.00
1_5_8	9	12.86	72.86
1_5_8_10	2	2.86	75.71
4_7_10_9	4	5.71	81.43
5_6	7	10.00	91.43
5_9_11_6	4	5.71	97.14
9_5_6	1	1.43	98.57
	1	1.43	100.00
Total		**70**	**100.00**

1= Remittance, 2= Food crop production/sales; 3= Cash crop production/sales; 4 = Vegetable production/sales; 5= Cattle production/sales; 6= Small ruminant production/sales; 7= Poultry production/sales; 8= Small business (non-agricultural rural based); 9= Skilled labour; 10= Formal salary/wages; 11 = Casual agricultural labour; 12 = Casual non-agricultural labour; 13= Child social grant; 14= Disability grant; 15= Pension

4.2.7 Proportional activity contribution to livelihoods

Table 4.8 - A display of the proportional activity contribution to livelihoods

Activities level of importance	Freq.	Percent	Cum.
2_2_6	3	4.29	4.29
2_2_7	2	2.86	7.14
2_6	1	1.43	8.57
2_6_2	5	7.14	15.71
2_6_2_6	2	2.86	18.57
2_6_4	2	2.86	21.43
3_3_5	1	1.43	22.86
3_4_5	1	1.43	24.29
3_5_3	1	1.43	25.71
4_2_2_2	2	2.86	28.57
4_3_3	2	2.86	31.43

Activities level of importance	Freq.	Percent	Cum.
4_5	1	1.43	32.86
5_2_2	1	1.43	34.29
5_2_2_2	7	10.00	44.29
5_2_2_3	3	4.29	48.57
5_2_3_2	4	5.71	54.29
5_2_6_2	4	5.71	60.00
5_3_2_2	4	5.71	65.71
5_3_3_2	1	1.43	67.14
5_3_3_3	4	5.71	72.86

1= Remittance, 2= Food crop production/sales; 3= Cash crop production/sales; 4 = Vegetable production/sales; 5= Cattle production/sales; 6= Small ruminant production/sales; 7= Poultry production/sales; 8= Small business (non-agricultural rural based); 9= Skilled labour; 10= Formal salary/wages; 11 = Casual agricultural labour; 12 = Casual non-agricultural labour ; 13= Child social grant ; 14= Disability grant ; 15= Pension

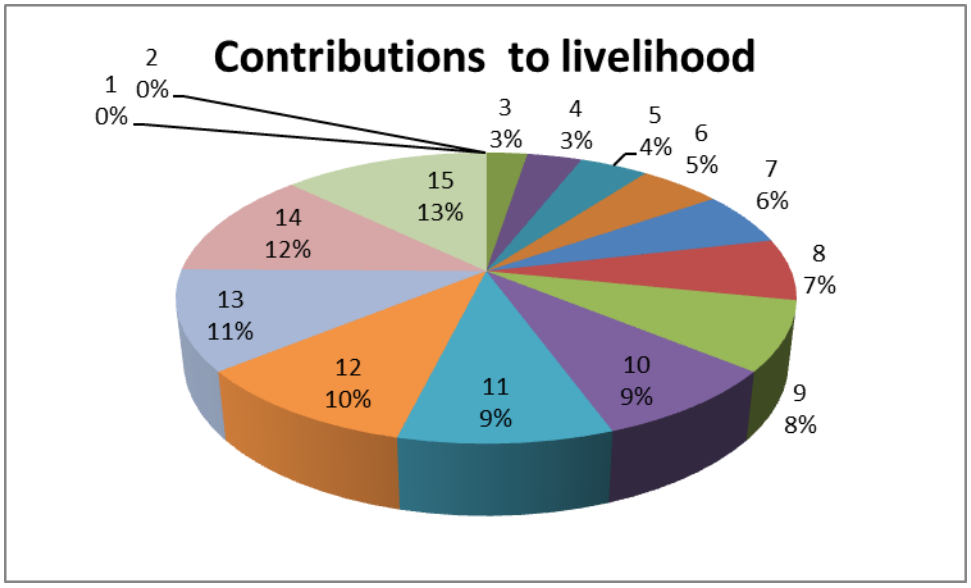


Figure 4.2 - A display of the contributions to livelihood of the community

1= Remittance, 2= Food crop production/sales; 3= Cash crop production/sales; 4 = Vegetable production/sales; 5= Cattle production/sales; 6= Small ruminant production/sales; 7= Poultry production/sales; 8= Small business (non-agricultural rural based); 9= Skilled labour ; 10= Formal salary/wages ;11 = Casual agricultural labour ; 12 = Casual non-agricultural labour ; 13= Child social grant ; 14= Disability grant ; 15= Pension

4.2.8 Sero-prevalence of bovine brucellosis in Mabeskraal

Out of the farmers that participated in the survey, 10 were among those whose animals had earlier been tested and results captured at the State Veterinarian's office. Using these results, it was possible to calculate the prevalence of bovine brucellosis for the herds whose owners had participated in the survey as shown in the following discussion. The findings are listed in Table 4.9

The proportion of positive animals from the number of animals tested for bovine brucellosis for both Madikwe and Mankwe magisterial districts was 7.7% (593/7737). The median sero-prevalence of bovine brucellosis in these two magisterial districts was 11%. The prevalence of bovine brucellosis in Madikwe Magisterial District was 14.5% compared to 10.2 % in Mankwe as depicted in Figure 4.5 below.

An estimation and description of the prevalence of bovine brucellosis for the entire bovine brucellosis tested farms follows in the discussion below and findings are listed in Figure Table 4.9 below.

The prevalence of brucellosis in Madikwe was 4.6% compared to 10.7% in Mankwe districts. The inter-herd prevalence in Mankwe was 76% % and in Madikwe was 44%. The median within herd prevalence of bovine brucellosis in Madikwe was zero (IQR 6.7% -0%) whereas for Mankwe it was 3.8. % (IQR 23% - 19.2%). This is summarized in table 4.9:

Table 4.9 The Prevalence of bovine brucellosis in the respective magisterial districts

Variable	**District**	**No. of animals tested**	**No. of animals positive**	**No. of herds tested**	**Herds positive**	Max -Min		**(Within herd) Median**	**Crude sero-prevalence**	
						Max	**Min**			
Prevalence in herd	Mankwe	3882	417	59	45	0.23	0.192	0.101	10.7%	76%
Prevalence in herd	Madikwe	3855	176	50	22	0.067	0	0	4.6%	44%

An estimation of the within herd prevalence of bovine brucellosis per ward (n=15) in the Mabeskraal vicinity follows in the discussion below.

The highest prevalence of bovine brucellosis was in Ward 6 at 31.1% closely followed by ward 8 at 20.9% and ward 4 at 13.9%. The estimation of bovine brucellosis prevalence per ward is displayed in table 4.10 below.

Table 4.10 - Within herd Prevalence of bovine brucellosis per ward in the Mabeskraal vicinity

Ward	Observations	IQR		Median
		75%	25%	
1	14	0.232	0	0.06
2	12	02	0.008	0.062
3	5	0.129	0	0.05
4	3	0.140	0.126	0.139
6	6	0.519	0.199	0.311
8	6	0.484	0.060	0.209
10	11	0.210	0	0.095
11	8	0.12	0	0.021
18	7	0	0	0
19	4	0.464	0	0.178
20	2	0	0	0
25	4	0.273	0	0.045
28	1	0.118	0.118	0.118
29	9	0.136	0.096	0.023
21	9	0	0	0

4.2.9 Identifying risk factors contributing to the spread of brucellosis in the Mabeskraal area.

A summary description of the possible risk factors for brucellosis follows in the discussion below and findings are listed in Table 4.11 below.

Close to 50% (n=46) of study participants indicated they do not vaccinate their cattle against brucellosis, also 72.8% of them stated they do no isolate and test new animals

they introduce on their farms. Seventy-seven percent (n=74) of the study participants indicated they do not remove confirmed positive animals from their herds. Table 4.11 below captures and summarizes the responses of the farmers.

Table 4.11 - List of possible risk factors for brucellosis in Mabeskraal

Characteristic	Yes (%)	No (%)	Total
Have you heard of brucellosis?	57(67.1)	28(32.9)	85
Is brucellosis zoonotic?	28(25.7)	81(74.3)	109
Do you vaccinate against brucellosis?	47(50.4)	46(49.6)	93
Have you heard of brucellosis scheme?	5 (4.9)	97(95.1)	102
Know requirements for admittance to scheme	3(2.9)	99(97.1)	102
Source of animals (bought from)			
Auctions	20 (21.3)		-
Commercial farmers	47 (50.0)	-	-
Other emerging farmers	27 (28.7)	-	-
Criteria for introducing new animals		-	
Isolate and test	28 (27.2)		-
No isolating and testing	75 (72.8)	-	-
What do you do when animals abort on your farm?		-	
Never had disease on my farm	18 (16.5)		-
Report to vet office	59 (54.1)	-	-
Other	32 (29.4)	-	-
Handling of aborted fetuses		-	
Bare hands	34 (34.0)		
With gloves	66 (66.0)		
Disposal of aborted fetuses			
Leave on the farm	3 (3.8)		
Throw in the waste bin	-		-
Take it to state vet office	35 (44.3)	-	-
Dispose and disinfect	30 (38.0)	-	-
Other	11 (13.9)	-	-
Do you clean area where cow aborted?	49 (45.8)	-58 (54.2)	107
What do you use to disinfect?			
Water	1 (1.9)	-	-
Water and soap	37 (69.8)	-	-
Soil	14 (26.4)	-	-
Other	1 (1.9)	-	-

Characteristic	Yes (%)	No (%)	Total
What do you do with the cow that aborted?			
Keep it	74 (77.1)		-
Slaughter and eat	3 (3.1)		
Sell	19 (19.8)		-
Other	16 (19.1)	68 (80.9)	84
Disclose to buyer if you sell positive animal?		-	
Before buying animals, do you inquire if?		-	-
Animal has aborted before	29 (23.2)	-	-
Comes from *Brucella* free herd	22 (17.6)		-
No questions asked, just buy it.	74 (59.2)		

4.2.10 Identifying relationship between risk factors and status of brucellosis in cattle herds in the Mabeskraal area using chi-square analysis.

A discussion of the possible relationships between risk factors and brucellosis follows in the discussion below and findings are listed in Table in Table 4.12 below.

There was a statistically significant relationship between study participants' response to the question of vaccinating their animals and sero-positivity of their animals at 95% confidence as the P≤ 0.05. Also a significant statistical relationship was established between what study participants did once an animal was declared positive and sero-positivity of their animals as the P-value was 0,029 at 95% confidence level. These facts are displayed in table 4.12 below:

Table 4.12 - Risk factors for brucellosis and relationship with status of brucellosis in cattle

Characteristic	N	Pearson's Chi	P-value
Have you heard of brucellosis?	46	0.01	0.698
Is brucellosis zoonotic?	62	0.04	0.671
Vaccinate against brucellosis	59	3.59	0.050
Heard of brucellosis scheme	65	0.13	0.880
Know requirements for admittance to scheme	64	0.14	0.874
Source of animals (Bought from)	49	3.83	0.119
Criteria for introducing new animals	55	1.10	0.999
What do you do when animals abort on your farm?	62	5.7	0.050*
Handling of aborted fetuses	57	0.34	0.562
Disposal of aborted fetus	42	1.45	0.482
Do you clean area where cow aborted?	61	0.67	0.544
What do you use to disinfect?	26	0.77	0.858
Disclose to buyer if you sell positive animal?	45	0.55	0.459
What do you do with the cow that aborted?	53	7.1	0.029*
Before buying animals, do you inquire if?	51	0.18	0.848

P≤0.05 significant *

4.2.11 Socio-economic status of Mabeskraal population

The median value of cows owned per household was R132 000.00 (IQR; R11 000-275 000.00) as depicted in Table 4.13 whilst the median value of goats was R13 900 per household (IQR; 0-22 500).

Table 4.13 – Value of livestock owned by cattle farmers of Mabeskraal and vicinity

	Total owners (n)	Median value (R)	Min-Max value
Bull	71	37 500	37 500-262 000
Oxen	126	27 000	9 000-306 000
Cows	126	132 000	11 000-1 903 000
Heifers	126	66 000	11 000-572 000
Immature Bulls	126	34 000	17 000-0- 221 000
Calves males	126	14 000	7 000-280 000
Calves females	126	8 000	8 000-240 000
Sheep	126	18 000	15 00-96 000

	Total owners (n)	Median value (R)	Min-Max value
Goats	126	13 900	40-2 400
Poultry	126	270	0-22 500

4.2.12 Socio economic classification of residents of Mabeskraal

Twenty-two percent (n=28) households were classified as Lower I SES whilst 32.4 % (n=32) of study participants were identified as belonging to the higher SES as depicted in Table 4.14.

Table 4.14 - Display of SES of Mabeskraal residents

Classification of SES	HH Livestock score	n (%)
Lower I	R102 000 or less	28 (22.2)
Lower II	102 000-252 800	33 (26.2)
Middle	252 801-502 500	33 (26.2)
Higher	502 501 or greater	32 (25.4)

4.2.13 Identifying socio economic factors contributing to the spread of brucellosis in the Mabeskraal area.

SES did not determine whether study participant's animals' were seropositive as the P-value (0.430) was greater than 0.05 at 95% confidence level and this is displayed in table 4.15 below:

4.2.14 Estimating economic losses due to brucellosis in the Mabeskraal area

The median milk production for cows in the Mabeskraal area was 5 liters per day (IQR: 3-11) compared to 3 liters per day (IQR; 2-5) reported by farmers who had Brucellosis in their herd.

Taken at the current price of R4.25 per liter in South Africa, losses in herds reporting abortions were R8.50 per milking animal per day. This represented a loss of 40% in revenue per milking animal.

4.2.15 Estimating economic losses due to cattle theft in the Mabeskraal area

Close to 80% (n=90) of study respondents reported animals having been stolen from their household. The study participants from the Mabeskraal experienced the worst in loss of economic value due to theft in 2014 with a total of 62 animals with an approximate value of R682 000.00 stolen. This is shown in figure 4.16 below:

Table 4.16 - Display of theft losses in Rands terms in the Mabeskraal from 2013-2015

Year	Total No of animals stolen	Total value in Rands
2013	57	627 000.00
2014	62	682 000.00
2015	22	242 000.00

CHAPTER 5
DISCUSSION

5.1 INTRODUCTION

The main objective of this study was to estimate the socio-economic impact of bovine brucellosis in Mabeskraal village and its surrounding villages and areas in the Moses Kotane Local Municipality of the North West Province of South Africa. The study also intended to assess the knowledge, awareness and understanding of the disease, its causative factors and preventative measures among the farmers and the community. In addition, the study intended to estimate the impact of the disease on the livelihoods of the community in and around Mabeskraal.

To be able to conduct this estimation, the following objectives enabled the author to obtain some information that could be used in the analysis:

a) Estimate and describe the prevalence of bovine brucellosis among cattle in the study area
b) Identify the risk factors and socio economic factors contributing to the spread of brucellosis in the study area
c) Estimate economic losses due to bovine brucellosis in cattle and their impact in the study area
d) Determine if there is any association between socio economic status and the spread of the disease
e) Propose a strategy for decreasing the prevalence of the disease considering the risk factors contributing to its spread

The discussion below addresses the main objective and the specific objectives.

5.2 SOCIO CULTURAL AND ECONOMIC CONSIDERATIONS

The composition of families belonging to the interviewed cattle farmers was determined. Close to six hundred people (551) lived in the households of the 126 farmers who were interviewed. Grossly, about five people per household to some extent are dependent on income received from cattle farming in these communities. There are families that have fewer people per household (min 3) and families that have 6 people per household.

The majority of these household dwellers (450) were above 17 years of age and a good number (181) were above 50 years of age. This finding implies that close to 60% (269/450) of household members above 17 years of age and below 50 years of age live in the study area. The fact that more 60% of the household members are between 17 and 50 years old signifies that these members who derive a certain proportion of the livelihoods from livestock, specifically cattle are relatively young to middle aged.

The overall level of education for the interviewed farmers and their families is such that close to 16% (70 out of 450) had tertiary education. Close to 42% (187 out of 450) had at least matriculated. Close to 40% (180 out of 450) had reached secondary education levels. Close to 44% (199 out of 450) had primary education and only 7% (33 out of 450) had no education at all. Looking at these trends, very few members of the households had no education at all but a good number has at least primary education with a very good number with secondary education and matriculation. This may imply that there is a good foundation for educating these communities on animal diseases and particularly on bovine brucellosis and its potential socio-economic impact. If this training and extension is done properly and persistently, these farmers could be made to understand the potential gains that could accrue to them if bovine brucellosis is managed and possibly even eradicated. This is so despite the observations made by Mokantla et al. (2004) that brucellosis is not the only disease of livestock that causes lower reproductive rates in rural communities. According to Mokantla *et al.* (2004), other diseases like trichomonas and factors like plant poisonings do influence these reproductive rates.

Most of the farmers interviewed have had cattle for periods longer than 20 years 31% (37) but there are those owning cattle for less than five years too. The study did not intend to establish if these new entrants are youth or retirees. It is noteworthy that 11% (13) of the

study participants were female; an encouraging observation considering that in this community, cattle farming are very male dominated. This is even more significant considering that the government of South Africa is stressing the importance of women participation in many industries including cattle farming, to help uplift the socio-economic status of women in South Africa (National Development Plan 2030, 2018).

Mookaneng, (2001) and Seimenis, (2012) have alluded to the importance of livestock to communities and traders particularly in the developing world. The fact is emphasized by the responses from the farmers in the study area as they provide their reasons why they keep cattle and other livestock (Table 4.4). The farmers in the Mabeskraal community attach the importance of keeping cattle to income generation, trading of the cattle and cattle commodities and breeding. However, culture and tradition are also very important reasons why the community keeps livestock. Many different reasons for keeping cattle were provided, and these are not mutually exclusive. Cattle are also kept for the production of meat and milk for own consumption.

Table 4.4 and figure 4.1 provides a bird's eye view on the responses provided by the farmers on the importance of keeping cattle. Table 4.5 summarizes the responses and depicts that 78% (39) of the farmers attach significant importance to petty trading when asked specifically on trade. A number of farmers attach importance to cow manure without providing reasons why. Keeping cattle for cultural and ceremonial purposes is also brought up, supporting the observations by Mookaneng, (2001) and McDermott *et al.* (2013).

In addition, Shackleton *et al.* (2009) emphasized the importance of livestock in rural areas within a livelihood analysis framework. More than a quarter (29%) of the farmers regards livestock particularly, cattle farming as a significant contributor to their livelihoods. Indeed, a combination of formal employment, cattle farming, small ruminant farming and poultry production are the most significant combination of activities taking up a significant 19% of 21 different combinations. The category of small ruminants and poultry was not the emphasis of this study, but the fact that these together with cattle farming are surfacing emphasizes the importance of livestock farming to these communities. If production could be improved particularly from the disease prevention perspective, the livelihoods of the farmers may be improved significantly.

In the evaluation of livelihoods contribution of the farmers in the Mabeskraal vicinity community, the second most important combination contributing to livelihoods was that of remittance, small business and cattle, again signifying that cattle are used as a supplement to other activities or that other activities are used to supplement cattle farming.

The fact that livestock farming in general and cattle farming in particular featured prominently as a significant contributor to livelihoods supports the observations by Shackleton *et al* (2001) and Mookaneng (2001) who emphasized the importance of livestock in the social lives of rural communities and Batswana people respectively as a source of food and also for other non- economic issues like acceptance by the community or for status.

Indeed, this fact was also emphasized by Ngeno *et al.* (2011) when he stressed that most farmers in communal areas of the Eastern Cape Province of South Africa keep various livestock species including cattle, goats, sheep and chicken and that cattle are the most valued due to their multiple functions and roles in communal areas.

These trends are observed in the Mabeskraal area where these livestock species seem to be contributing significantly to the livelihoods of these communities. Goats are an increasingly important contributor to livelihoods but are less significant compared to cattle, as also alluded to by Shackleton *et al.* (2005).

The farmers owned a variable number of cattle with the highest number of cattle owned standing at 213.

With the understanding that the farmers of the area do not employ a seasonal breeding approach, the number of calves at foot still seemed low. It was expected that at an approximate calving rate of 80% there should have been at least 1173 calves, or 586 calves at a calving rate of 40%. This may mean that there is a shortfall of 857 calves if the cows were to calve at 80% level and a shortage of 270 calves at a 40% calving rate. From these observations, it may be concluded that the productivity of the cattle is low as the number of calves on foot (316) are well below 586.

There may be many reasons why the calving rates are low. These may vary from inappropriate bull cow ratios, but these were acceptable in this study. Other reasons could

be fertility of the bulls and cows, nutritional factors and last but not least, animal disease issues. There may be other factors too as alluded to by Nowers *et al* (2013) and Mokantla *et al* (2004). The authors had proposed that the wide variation of calving rates in different set ups of commercial and rural communal herds could see a huge improvement from below 35% to above 80% when the animals are provided with better conditions.

5.3 PREVALENCE OF BOVINE BRUCELLOSIS IN THE MABESKRAAL VILLAGE AND ITS SURROUNDINGS

Figure 2.1 above provides a good idea of the reported cases of bovine brucellosis in South Africa. The figure shows high concentrations in the western parts of the North West Province compared to other Provinces. The western part of the North West Province is well known for its production of cattle particularly beef cattle.

The number of farmers from the study area that participated in the both the survey and the brucellosis testing were ten and the number of animals tested from these farmers was 1150. One hundred and fifty seven of these animals turned out positive. The crude sero-prevalence of bovine brucellosis in Madikwe and Mankwe magisterial districts for the herds belonging to these farmers that had participated in the survey (10) was 13.1%. The number of farmers who participated in the survey whose animals were also tested was therefore too small to contribute to a meaningful discussion in this study.

The bigger picture when considering test results for the Moses Kotane Local Municipality gives a better understanding of the bovine brucellosis situation in the study area. A good 7737 cattle were tested over a seven year period and 593 of these animals were positive, giving a crude sero-prevalence of 7.7%. This prevalence is consistent with the 7.4% referred to by Manoto (2016). A comparison of the two district municipalities at macro level with close to similar number of animals tested, 3882 for Mankwe magisterial district and 3855 for Madikwe magisterial district, resulted in a crude sero-prevalence of 10.7 % for Mankwe and 5% for Madikwe, The herd sero-prevalence for Mankwe magisterial district is higher (76%) compared to that of Madikwe magisterial district at 44%. Manoto, (2016) had however found the herd prevalence of the Bojanala District municipality to be 33% and that of Moses Kotane municipality at the much higher levels of 52.9%. As the study area was partially in the Mankwe magisterial district and the Madikwe magisterial district, it is concerning that the area under study had as high herd sero-prevalence for brucellosis as

76%. These findings do not necessarily negate Manoto's findings as a smaller area was used in this study.

Further analysis at magisterial district levels presents an even more interesting picture with the median within herd prevalence level in Mankwe being (10.1%) and an IQR of 23% to 19.2%) compared to the median prevalence in Madikwe at 0% and an IQR of 6.7%-0).

The crude prevalence of bovine brucellosis in each ward was also looked into. The fact that there was such a high prevalence of the disease in ward 6 (31%) ward 8 (20%) and ward 3 (13%) suggests that there may be an association between the wards. Upon scrutiny, indeed, these wards are adjacent to one another, meaning that there may be exchange of animals between these wards or the cattle from the three wards may at one stage share the same grazing or watering resources. Similarly, up to zero prevalence of the disease is seen in wards further away from these three wards like ward 18 and ward 2.

In the study conducted by Manoto, (2016), the crude prevalence of bovine brucellosis in the whole North West Province was found to be 3.2 %. This level of prevalence was compared to that in Kwazulu-Natal Republic of South Africa which was 1.5% and this low rate of prevalence in Kwazulu-Natal was attributed to the efforts of the Kwazulu-Natal Province to intentionally vaccinate heifers against brucellosis. The finding of the high sero-prevalence in the Mabeskraal area of the North West Province of South Africa may be because cattle are not deliberately vaccinated.

5.4 RISK FACTORS AND SOCIO ECONOMIC FACTORS CONTRIBUTING TO THE SPREAD OF BRUCELLOSIS IN THE STUDY AREA

The four broad categories described by Addis, (2015) signifying the contributing or risk factors for the spread of brucellosis are confirmed to be present in the study area. The environment is contaminated by *Brucella* positive cattle as calve and abort and through other routes as already discussed. These cattle serve as reservoirs of the disease as they are unvaccinated and there is absolutely no movement control.

Tesfaye *et al.* (2011) in addition to factors broadly classified by Addis, (2015) above added a significant factor related to the knowledge of the farmers. The authors indicated that lack of knowledge is a significant risk factor.

Table 4.11 covers issues related to knowledge, attitudes and practices of the cattle farmers in the Mabeskraal area and surrounding villages and confirms the observations by Tesfaye *et al.* (2011) and Patel *et al.* (2014). It is concerning that 33% (28) of the farmers had never heard about the disease commonly known as brucellosis. Even more concerning, 74% did not know that the disease is potentially zoonotic. This demonstrated a lack of knowledge of the disease that may lead to the practicing of incorrect cattle farming management practices and hence perpetuating the prevalence of the disease and the continued increase in the prevalence of the disease in the area under study.

There is a risk that some farmers may contract the disease as a sizeable number do not understand the zoonotic potential of the disease. The zoonotic potential of brucellosis was noticeably emphasized by Yumuk *et al.* (2012) and Le Jeune *et al.* (2010). This study did not intend to investigate this possibility of the brucella infection in this community, but the knowledge of the zoonotic potential of the disease together with the basic understanding of the risk factors would hopefully contribute to a change in the attitudes and practices that the community engage in.

Corbel, (2004) and Alusi, (2014) have emphasized the fact that farmers are at a risk of infecting themselves with *Brucella* especially when handling infected and infective material. The number of farmers in the Mabeskraal area that handle aborted foetuses with gloves (66) (66%) is higher than those who handle the products without gloves (34) (34%). The 34% who handle fetuses without gloves are at a higher risk of contracting brucellosis. Makita *et al.* (2011) observed that herds that are constantly meeting and grazing communally run a risk of being infected with *Brucella* and the author agrees with this observation. This becomes even more important if the herds are not even vaccinated against *Brucella*. Close to 50% of the respondents did not vaccinate their cattle for brucellosis. As indicated by Al Majali *et al.* (2009), lack of vaccination under poor biosecurity where herds are mixed, particularly where small stock is mixed with large stock and sometimes with wildlife, is a well-known risk factor

This risk seems to be predominant since these cattle graze on a communal basis, and only fifty percent are vaccinated. There is poor knowledge and understanding of the disease known as brucellosis in this community.

In addition, the cattle farmers in Mabeskraal village and the surrounding area have not heard about the brucellosis scheme nor do the farmers of this community know what the admittance requirements into the scheme are. Although the bovine brucellosis scheme of South Africa is well documented and well legislated, it is probably not well communicated.

The scheme may be well known in the commercial sector of bovine production. There is therefore a need to communicate the objectives and intentions of the scheme to ensure that the scheme is implemented uniformly to benefit all cattle producers in the country.
The prevalence of brucellosis in goats and sheep in this study area has not been determined.

Confirming the argument by Muma *et al*. (2014) indiscriminate buying and selling of animals is a significant risk factor to the spread of brucellosis as positive animals may be bought into the herd. Although about fifty percent (50%) of the farmers buy cattle from commercial farmers, they buy without asking questions about the *Brucella* status of the herds from which they buy. The sellers also fail to disclose to potential buyers about any history of abortions in their animals or their *Brucella* status. In addition, the farmers also purchase cattle from auctions and from other emerging producers without asking questions that are relevant like whether the heifers were vaccinated or not. If indeed the heifers were vaccinated, buyers should also ask questions related to the age at which these heifers were vaccinated for the first time against brucellosis.

The farmers in the Mabeskraal area and vicinity do not have the knowledge that it is significant to quarantine newly introduced animals and test them to ensure that these animals are not bringing in new diseases including brucellosis. In addition, the farmers do not have quarantine or isolation facilities to isolate the newly introduced animals. At least, if there was disclosure of all these facts, the farmers may have an opportunity to vaccinate the newly introduced animals with an appropriate vaccine to ensure that they do not get infected. Seventy five percent (75%) of the farmers do not isolate or test these newly introduced animals. These practices, if not corrected, will continue to contribute to the introduction and distribution of the disease in the area.

Close to sixty percent of the cattle farmers only report abortions to the state if there are massive numbers of abortions, which is rarely the case. In communal areas, cattle do not necessarily calve at the same time because there is no synchronized breeding. The

farming system is extensive and cows may abort at night when nobody is around to see the abortion or notice in time that the cow has aborted.

Cattle that have aborted are kept for future breeding. Seventy seven percent (77%) of the respondents keep these cattle for future breeding. Sixty eight percent (68%) do not disclose the status of brucellosis or that the cattle have at one stage aborted. Cattle with brucellosis most of the times abort only once and may seem to be normal thereafter (Fulasa, 2004). Fulasa however; emphasized that calves born to these cattle may seem normal only to abort later in life and hence contaminate the environment in which they have aborted to perpetuate the disease in future. In addition, future calving from these infected cows will result in future infected calves particularly heifers even if the calves may seem to be normal. The lack of knowledge of these facts help to a large extent to place the herds of Mabeskraal in danger of getting infected and re-infected to increase the burden of disease in the area.

Lack of knowledge on the brucellosis scheme and the admittance requirements to it, coupled with the lack of understanding that cows that have aborted will continue to contaminate the environment at each calving is clearly demonstrated by the responses to the questionnaire by this community. This perpetuates the habit of keeping cows that have aborted. The calves, particularly the female calves that are born to these cows automatically get infected and will multiply the contamination of the environment at maturity.

If a good compensation policy is available or a good system of cow replacement is present, the *Brucella* positive cows should be culled and be replaced with properly vaccinated cattle. The farmers should then be encouraged to be vigilant about new introductions into their herds. Vaccination of heifers should be practiced and constant testing of the herds should be encouraged.

It is very clear from the above that there are too many practices that could be spreading brucellosis in the study area. Lack of knowledge is spearheading the spread of the disease in this area. In addition, lack of vaccination is a serious concern that needs urgent attention. The farmers may be buying the disease from commercial farmers, from auctions and also from the fellow communal farmers. The spreading of the disease in this manner poses a huge risk even to commercial farmers as the disease may find its way into commercial farms if left unattended.

Only thirty eight (38%) of the farmers indicated that they dispose of the aborted and disinfect the premises in which the cows have aborted. This is a good practice if done correctly, but then 62% are not practicing same, leading to massive contamination of the land and the environment in general.

5.5 DETERMINING THE ASSOCIATION BETWEEN THE RISK FACTORS AND STATUS OF BRUCELLOSIS IN CATTLE IN THE MABESKRAAL AREA

Table 4.12 addresses the associations between the risk factors and the occurrence of the disease. As already alluded to above, a significant association, p value of 0.05 exists between lack of vaccination and occurrence of the disease. Our study agrees with the observations made by Al Majali *et al.* (2009).

There is also a significant association between doing nothing on the farm after cattle have aborted, signifying that contaminated pastures play a significant role in the spread the *Brucella* bacterium. This agrees with the observations by de Alencar Mota *et al.* (2016).

Although not demonstrated in this study, wildlife may also play a significant role in spreading the disease by dragging the aborted material and also getting infected and consequently aborting as emphasized by Godfroid *et al.* (2013). There is a significant number of wildlife in the study area.

The importance in the spread of the disease by perpetual keeping of cows that have aborted is also demonstrated in table 4.12 where the p value at 95% confidence level is 0.029. The removal of cattle that are infected from the herds is pivotal in controlling the disease as emphasized by the National Animal Health Forum in South Africa ((2018). It is expected that an appropriate compensation policy will be put in place for this to be done properly (Manoto, 2016) elaborated that there is a lack of a suitable compensation policy to help achieve this objective. To date, all the countries that have successfully achieved this objective have largely succeeded in controlling or even eradicating the disease. Wyatt, (2013) indicated that if this objective of removing infected animals is not achieved, the disease will occur and recur.

5.6 ESTIMATION OF ECONOMIC LOSSES DUE TO BRUCELLOSIS IN CATTLE AND ECONOMIC IMPACT IN THE STUDY AREA

As already indicated by McDermott *et al.* (2013), the economic impact for animal diseases differs from country to country but may be influenced by the livestock dynamics and grazing systems of the country in question. Although we are not able to attribute a low calving percentage to brucellosis in this study, that percentage is too prominent to ignore. The number of calves at foot (316) compared to the total number of adult cattle is also too low to ignore. With the high prevalence of the disease in the area under study, it is clear that brucellosis and other productivity issues are causing massive losses possibly amounting to millions for the cattle farmers in this community, with a conservative estimated calving percentage of 50%, and at an estimated median value of R7000 per calf.

The model developed by McDermott *et al.* (2013) which to a large extent was based on the burden of the disease, systems and epidemiology, sector specific impact on control measures and integrated programs would be a good start to conduct the assessment. The disease in the study area is very prevalent and is constraining production and productivity including calving rates.

The burden of disease between villages or grazing camps in this study area is as high as 76% and is likely to increase if nothing is done urgently to curb the increasing prevalence of the disease. The prevalence at individual owner level is as low as 0% but some kraals have as high a prevalence of 31%. The calving rate is already very low due to a number of factors constraining productivity as mentioned above. Considering that there were 126 farmers that have been interviewed and each of the interviewed farmers is supporting at least three persons, and a predicted shortfall of calves born every year is 857 calves if eighty percent of the cows were to produce a calf every year, it basically means that each of the interviewed farmers and their dependents are losing close to six calves (857/126) every year due to brucellosis and other conditions. These six calves lost is a lost opportunity to improve the lives of the community and improve of the quality of these people‘s lives.

Although the biggest losses of cattle seem to be due to theft, the one most apparent loss is the estimated loss of milk. Close to two liters of milk is lost per lactating cow per day,

adding to a potential loss of opportunity to improve the quality of lives of the Mabeskraal community of cattle farmers and their dependents. The loss of milk may impact greatly on the extent to which young animals will grow. This loss may be in-apparent in financial terms; an estimated loss of R8.50 per lactating cow per day seems to be the case.

In agreement with Jemberu *et al.* (2014), the cattle industry at large is affected by this high prevalence of the disease in the Mabeskraal village and surrounding vicinity in that these cattle may continue to contaminate the environment, exhibiting all the typical clinical signs and may result in spill over to commercial farms located in the area and inadvertently infect the *Brucella* free herds. Brucellosis is a trade sensitive disease and the outbreak may constrain trade in, milk, cheese and other products, resulting in massive losses to the industry. It is therefore important to devise control programs that are specific for areas like Mabeskraal and integrated programs for the industry at large.

Although the study could not prove that socio economic status could lead to the spread of bovine brucellosis in the Mabeskraal vicinity, the fact that these owners are somewhat compelled to use communal grazing makes the practice of good biosecurity very difficult. The people who understand the way the disease spread can also help in the control by ensuring that they do not sell sick or potentially sick animals to the buyers who do not ask relevant questions. The prevalence of brucellosis in the study area therefore supports the significance placed by Otte *et al.* (2004), and Cloete (2018) on farming systems and knowledge, attitudes and practices.

In table 4.11, the behavior of the farmers and the fact that they do not vaccinate their cattle against *Brucella* and the facts that certain practices such as, keeping of cattle that have aborted, not disclosing to potential buyers that cattle offered for sale had aborted before and not cleaning premises on which abortions have occurred have may lead to the spread of the disease.

The livestock sector is severely impacted by brucellosis and the implementation of control measures needs to be strengthened. This remains the case despite a very good legislative framework in South Africa on brucellosis in general. The farmers are not informed of the bovine brucellosis scheme and as a result they don’t participate in the testing scheme.

It is our belief therefore that awareness campaigns are important to start making some impact on the control of the disease. If there is any association between socio economic status and the spread of bovine brucellosis other than communal grazing and mixing of species, a bigger sample may be necessary.

5.7 NEW STRATEGY TO ADDRESS THE BRUCELLA SITUATION IN MABESKRAAL AND ISSUES TO CONSIDER WHEN DEVISING A NEW POLICY FOR THE CONTROL OF BRUCELLOSIS

As already indicated in the discussion above, DAFF is considering a new policy on the control of brucellosis as the department and industry are aware of the economic importance of the disease, the zoonotic potential, the continued increase of its prevalence and the potential trade impact the disease may have. The new policy is necessary even though the current policy is hinged on international standards and is among the best in the author's opinion. Challenges such as lack of appreciation of the importance of biosecurity by cattle farmers grazing their animals on communal farming systems, their lack of knowledge of brucellosis, its existence or the existence of the brucellosis scheme will need to be overcome. In addition, lack of appropriate policies for compensating the farmers that has been identified by Manoto, (2016) and Cloete, (2017) makes it difficult to remove infected cattle for slaughter at appropriate abattoirs. This measure, in addition to the vaccination of heifers at appropriate ages between 4 to 8 months as indicated by Aparicio (2013), Bishop *et al.* (1994) and Carpenter *et al.* (2007), will help reduce infection rates.

The new policy should emphasize the creation of awareness since this seems to be the root cause of the challenge. In addition, a system of test and slaughter with appropriate compensation should be established. The industry has already proposed measures on proposals of establishing a levy system to compensate or buy replacement animals that are properly vaccinated (National Animal Health Forum, 2018). Brucellosis free animals could be used to appropriately re-stock these farms.

The alternative may be to find knowledgeable companies who will be willing to participate in the scheme and to buy infected cattle from the communal farmers, at appropriate prices, take the infected animals for slaughter at approved abattoirs with the intention of helping clean up the herds. It will be difficult for any farmer to agree to this proposal, but it may help, since the government may not afford to compensate all the farmers at the

satisfactory rates. This proposal may also discourage the indiscriminate buying and selling of cattle form existing sellers and buyers in the industry at large (Muma *et al.* 2012).

The infected farms should be rested for an appropriate period, like one month, as already suggested by DAFF (2016). They would then be restocked with thoroughly vaccinated animals. How this could be done is a challenge, but the farmers may be encouraged to temporarily move the cattle testing negative to a clean farm for the recommended period to allow their own grazing land to remain cattle free for that period. The infected cattle would be purchased for slaughter and replaced with tested, vaccinated cattle that will only be allowed to move to the original land after the grazing had been rested for the period of one month. Continuous vaccination of heifer calves with approved vaccines should be encouraged.

The communal farmers should be encouraged to jealously guard their farms and or grazing lands against infiltration by cattle of unknown brucellosis status.

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

The Mabeskraal farming community and vicinity is highly dependent on livestock farming to augment their earnings and maintain up to six people living in their households. Most of the cattle farmers and family members are reasonably educated but very few of them have sufficient knowledge of how to avoid the introduction of brucellosis in their cattle herds and how to prevent the disease from spreading. Their production practices and attitudes need to be improved to have any chance of reducing the spread of the disease in the community cattle herds.

6.2 CONCLUSIONS

The study has confirmed that brucellosis is prevalent in the Mabeskraal village and surrounding vicinity and in some herds, at individual animal level, the prevalence is as high as 31%, and 76% of the villages have at least one cow infected. Although it cannot be confirmed that brucellosis is the only condition contributing to the low calving percentage in the study area, it was noted that the number of calves in the study area over the period of investigation is much lower than desired level with a shortfall of 857 calves if cows were to calve at 80% calving rate.

It was also observed and concluded that half of the interviewed farmers are not aware of the disease known as brucellosis and that close to 97% of the farmers do not know that there is a brucellosis control scheme nor do they know the admission requirements into the scheme. The farmers are also unaware that the disease is potentially zoonotic or that it leads to massive financial losses on their side.

The farmers in the study area are relatively educated and can be taught about major aspects of disease control especially on brucellosis, its epidemiology and economic considerations. It is believed that this will improve on productivity of the herds in the study area and lead to a change in attitude.

The study has proved that the farmers buy cattle indiscriminately from commercial farmers, from the local cattle farmers and at auctions, thereby potentially perpetuating the spread of the disease within and outside their communal grazing lands. This is made worse by the fact that appropriate questions are not being asked particularly on the vaccination status of cows and heifers and on the history of abortions from the farms of origin. The farmers do not keep closed herds or insist on ensuring compliance with stipulations of the Animal Disease Act (35 of 1984) to ensure that the prevalence of the disease is kept down.

The study further concludes that cattle farmers in the Mabeskraal community and surrounding villages do not routinely vaccinate their cattle against brucellosis as stipulated in the Brucellosis Control Manual of South Africa. This may be exacerbated by the lack of knowledge demonstrated in the study.

The study concludes that the cattle farmers in the study area keep cattle that have aborted most likely from brucellosis in their herds and that these cattle play a significant role in the contamination of the environment and grazing, leading to reinfection and continuous infection of naïve animals. This may lead to massive losses and potentially to infection of people, amplifying the challenge from brucellosis and further increasing the risk to their own cattle.

The study concludes that there are economic losses like loss of milk, leading to slow growth of calves and unapparent losses for the farmers that lead to potential loss of opportunity to improve the quality of life of the community of Mabeskraal and the immediate surrounding communities.

In addition, considering that there are approximately three to six people per household living in Mabeskraal village and its surroundings, opportunities of improvement the lives of these families are affected adversely.

At least three risk factors were found to be very serious and highly associated with the spread of the disease. These risk factors are failure to vaccinate heifers with an approved vaccine against brucellosis, failure to remove *Brucella* infected cows from the herds and failure to do anything related to ensuring that the environment is rested wherever the animals may have aborted from brucellosis. The other risk factors identified are also important for the spread and establishment of the disease.

It is concluded that the disease can potentially impact the industry at large since there is indiscriminate selling of the infected or potentially infected cows at the auctions which may lead to spill over into other areas including those farms in which proper biosecurity is practiced.

6.3 RECOMMENDATIONS

The following are the recommendations to reduce the impact of bovine brucellosis:

6.3.1 The new policy that is being developed will have to be inclusive of industry involvement including rural communities and should pay special attention to the rural communal cattle and their brucellosis status as these are posing a significant risk to the national herd.

6.3.2 The knowledge and understanding of the farming communities who do not own land and still need to participate in the cattle industry, grazing their cattle communally, should be augmented.

6.3.3 This enhancement of knowledge could be done through concerted efforts to conduct extension to the farmers in whatever form. Participatory extension may be recommended so that the farmers could experience the benefits of reducing both the incidence and prevalence of brucellosis.

6.3.4 Farmers should be encouraged to buy only *Brucella* free cows into their villages to incorporate into their own herds in order to avoid introducing brucellosis into their cattle herds.

6.3.5 Better controls on selling and buying of animals should be introduced with strict movement controls being put in place.

6.3.6 The community should be taught to understand ways and means that can be used to control and reduce the prevalence and incidence of brucellosis and

other cattle or livestock diseases.

6.3.7 Government should compile and compose vaccination campaigns to encourage vaccination of heifers to reduce future shedding of the *Brucella* bacteria by cows. In accordance with the Brucellosis control scheme, heifers should be vaccinated at the age of 4-8 months. Where appropriate, the state veterinarian could also employ other methods including vaccination with a reduced dose sub-conjunctival. The practice is however very tedious and will need time.

6.3.8 The policy should consider a more appropriate and affordable model for ensuring that infected cows testing positive for the disease are destroyed with appropriate compensation to the owners. Where practical, cattle free zones could be introduced to ensure that grazing become free or relatively free of infection.

6.3.9 Concerted efforts should be made by both the farmers and government to ensure a good state of the fences. This will to a large extent help reduce the movement of cattle from village to village but at the same time from dip tank to dip tank, which will help with the management and control of the brucellosis in the area.

6.3.10 Concerted efforts should be made to ensure that there is sufficient grazing for the animals in the respective dip tanks.

6.3.11 Mixing of different species of animals in the grazing areas is identified as a risk factor. Although resources are limited, it is understood that goats in particular are not competitors with cattle since they browse. An infection of goats would result in infection of cattle.

6.3.12 Continuous research on the disease should continue to take place, particularly in areas of vaccine development, diagnostic methods and economic impact.

6.4. LIMITATIONS OF THE STUDY

The study intended to determine the prevalence of bovine brucellosis in the Mabeskraal village and surrounding villages and determine if the prevalence is perpetuated by any factors like certain practices or other socio cultural factors. At the same time, the study had intended to determine the socio economic impact of the disease on the community. The knowledge practices and attitudes of the farmers were determined by use of a questionnaire distributed by two animal health technicians.

The data obtained from the state veterinarian had at least one hundred and ten farmers in the study area and beyond the study area which was used to compute prevalence. It is important therefore to note that there were too few study participants whose cattle were not bled for brucellosis and that there may be others whose cattle were tested but could not participate in the survey. It was not possible, within the limitations of the study to give detailed 95% confidence intervals or estimate statistical significance over time. The sample size over seven years was very large and the animals were not tested regularly. The data analysed was therefore obtained retrospectively from a mix of routine surveillance and monitoring of outbreaks.

The level of complexity would make confidence intervals and statistical significance invalid unless the study population was subdivided into categories.

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ANNEXURES

Annexure 1 - Questionnaire

BOVINE BRUCELLOSIS SOCIOECONOMIC STUDY

Farmer Questionnaire

Date:	**Name of Interviewer:**

Name of farmer:	**Farm Identification:**								
	GPS coordinates:	**E**	°	‘	“	**S**	°	‘	“
Village:	**District:**								
Diptank:	**Province**								

Please note that the information you provide will not be used for any purpose other than determination of the socio economics for the said disease. I therefore guarantee confidentiality.

Ela tlhoko gore tshedimosetso e o fanang ka yone e ka se dirisiwe botlhaswa le go phasaladiwa ntle le go dirisetwa tshekatsheko ya mathata a tlisiwang ke bolwetsi jwa pholotso mo leruong la gago.

1. General Household Characteristics

1.1 How many people live in your household?_____

Lo ba kae mo malpeng?

1.2 Please provide further information about household members as indicated in the following table.

Ka kopo, re nee tshedimosetso ee mabapi ka maloko a lapa la gago

Household members (start with owner of livestock) NAME	**Gender** ***Bong*** **(C)**	**Age** ***Dinwaga*** **(D)**	**Highest level of education** ***(Maemo a thuto)*** **(E)**
1.			
2.			
3.			

4.			
5.			
6.			
7.			
8.			
9.			
10.			
	Gender (*Bong*) (C) 1=Male *Ntate* 2=Female *Mme*	**Age *(Dingwaga)* (D) 1= below 10 2= 10-13 3= 14-16 4= 17-50 5= Above 50**	**Highest level of education *Maemo a thuto* (E) 1=none 2=primary 3=secondary 4=matriculated 5=tertiary level**

2. Assets

2.1 Current livestock ownership

Leruo le onang le lona ga jaana

Type of livestock Mofuta wa leruo	**Number owned *Ke tse kae***	**Less than 3 years *Ka fat lase ga ngwaga tse tharo***	**3-7 years *Go tlhoga go dingwaga di le 3-7***	**Above 7 years *Go feta dingwaga tse supa***
Bull (*Dipoo*)				
Oxen (*Dipholo*)				
Cattle- cows (*Dikgomo tse digodileng*)				
Cattle –heifers (*Merobana*)				
Immature bulls				

(*Dipoo tse dinnye*)				
Calves male (*Dinamane tse ditonanyana*)				
Calves female (*Dinamane tse tshegadi*)				
Sheep (*Dinku*)				
Goat (*Dipodi*)				
Poultry (*Dikoko*)				
Donkeys (*Ditonki*)				

2.1.1 Are you the owner of the cattle herd? (A ke wena mong wa leruo?)

1= Yes (*Ee*, *gontse jalo*) 2= No (*Nyaa, ga se tsa me*) Other (Please specify) (*Tse dingwe(tlhalosa*)

2.2.2 Where did you get your cattle? (Please Specify) (*O tsaya kae dikgomo tsa gago(tlhalosa)*

1 = Bought (*o di rekile*) 2 = Inherited (*ke boswa*)

3 = Both (*O rekile tse dingwe, tse dingwe ke boswa*) 4 = other (Please specify) (*Tlhalosa tse dingwe*)

2.2.3 How long have you had the herd? (*Go leele go le kae o ruile*)

Code	Years *(Dingwaga)*	Tick (*Tlhopa*)
1	<5yrs	
2	5-10 yrs	
3	11-15 yrs	
4	15-20 yrs	
5	>20	

2.2 Other assets (*Dingwe tsa dilo Tse onang le tsona*)

		Period of ownership in years (Ke sebaka se se kae ona le tsona)		
Domestic assets (*Didiriswa tsa selegae)*				
	Number owned (*Ke tse kae*)	Less than 3 years (*Dingwaga tse di kwa tlase ga tharo*)	3-7 years (*Dingwaga tse di magareng ga tse tharo lesupa)*	Above 7years (*Dinwaga tse di fetang tse supa*)
Cooker (*Setofo*)				
Kitchen cupboard (*Diraka tsa Ntlobojelo*)				
Radio (*Sealemowa)*				
Television (*Lebokoso la ditshwantso)*				
DVD player (*Setshameka di video*)				
Satellite receiver (*Satelite ya TV*)				
Chair (*Setilo*)				

Cell phone (*Mogala wa letheka*)				
Transport (*Transport*)				
Car /Truck (*Koloi kgotsa llori*)				
Motorcycle (*Sekuta*)				
Bicycle (*Peretshitswana)*				
Cart (animal drawn) (*Karaki)*				
Agricultural assets				
Tractor (*Terekere)*				
Hoes (*Petlwana*)				
Ploughs (*Mogoma*)				
Borehole (*Mosima /sediba sa metsi*)				
Sewing machine (*Mochini wa go roka*)				

3. Reasons for keeping cattle (*Mabaka a go rua Dikgomo*)

3.1 Out of 10, how would you rate your household's dependence on cattle for annual income? ____/10

***Lelapa la gago, le ikaegile go le go kae mo leruong la Dikgomo* (*Tlopa nomoro e le nngwe magareng ga nngwe le lesome. NNgwe e kaya gore ga wa ikaega ka dikgomo sepe mme lesome e raya gore o ikaigile gotlhe lele mo leruong la gago*)**

3.2 What are your major reasons for keeping cattle? Please tick and rank the 3 most important ones, where (1) represents the most important. (*Tlhopa mabaka a a dirang gore o rue leruo mo mabakeng a aka fa tlase*)

Objectives	Please tick	Rank
Income (*Letseno*)		
Savings/investment ((*Peeletso*)		
Breeding (Tsadiso ya leruo)		
Meat consumption (*Kuno ya nama*)		
Milk consumption(*Kuno ya masi*)		
Cow manure (*Mosutele*)		
Prestige (*Tlotlo*)		
For cultural events (e.g. Lobola)\,Ditiro tsa mo gae)		
Petty trade (*Thekiso*)		
Tradition ceremonies (*Ditiro tsa setso*)		
Other specify (*Mabaka a mangwe, tlhalosa*)		

3.3 What do you use for draught power if needed (Tick a list below and indicate if owned or rented and how much was the rental if rented)

***O dirisang fa o ya kgonnye,nokeng kana go lema?* (*Tlhopa mo lenaneong le le ka fa tlase*)**

Options	Tick (*Tshwaya*)	1 =Own (*Ke tsa gago*) 2 =Rented *(O a hira*)	If rented, how much were you charged? [R] (*Fa e le gore oa hira , o duela bokae?)*
Tractor(*Trekker*)			
Oxen(*Dipholo*			
Donkey (*Ditonki*)			
Hand hoes (*Petlwana*)			

4. Cattle Management (*Tsamaiso ya dikgomo*)

4.1 Where do you predominantly graze your cattle? Use the codes below (*Dikgomo tsa eno di fula kae*) (*TLhopa mo lenaneong le le ka fa tlase*)

In Summer (*Selemo*)	In winter(*Mariga*)
1 = Own land (*Mafulo a gago*); 2= Communal land (*Mafulo a mo tlhakannwa*); 3= Rented land (*Mafulo a khiro*) 4= Borrowed land (*Lefatshe le le adimilweng*); 5 Other (*Please specify) Mafulo mangwe aa sa tlhalosiwang (Thalosa tswee Tswee*)	

4.2 What type of cattle do you keep? (Please tick) (*O ruile mofuta ofe wa dikgomo?) (Tshwaya mofuta oo mabapi*)

1 = Nguni type (*Kgomo ya setso*) 2= Nguni crosses (*Krosso ya nguni*) 3=Other breed (please specify) (*Tse dingwe (Tlhalosa tswee tswee*)

5. Animal Health management (*Tsamaiso ya boitekanelo ja leruo*)

5.1 Do you ever encounter problems with animal diseases? Yes (*Gontse jalo*)

No (*Nyaa*)

O kile wa lemoga malwetse a leruo mo dikgomong tsa gago

5.2 Please list in order of importance the animal diseases you encounter the most important? 1 is the most important.

***Rulaganya malwetse a okopanang le ona mo leruong lagago go ya ka botlhokwa ba ona. (Fa ore 1, go raya gore bolwetse bo botlhokwa thata, mme 10 e raya gore ga bo bo tlhokwa. Dinomora tse di mo gare ga 1 le 10 di ka dirisiwa le tsona*, i.e. 2,3,4,5,6,7,8,9)**

Disease (*Bolwetse*)	**Rank (*Kemo*)**

5.3 Have you ever heard about brucellosis?

A o kile wa utlwela ka bolwetse ba pholotso?

5.4 Please select the signs associated with brucellosis in the herd

Ke matshwao afe a o ka a bonang mo motlhapeng a a tsaameelanang le bolwetsi jwa pholotso.

Signs	**Tick if respondent identifies the sign *(Tshwaya fa o dumelena)***	**Source(s) of information [*Used codes below table*] *(O bone Thuso go tswa go? Dirisa lenaneo le le ka fatlase)***	**Have you seen these signs in your own herd [tick] *(A okile wa bona matshwao a bolwetse mo motlhapeng wa gago)***	**# of Cows showing signs in last 2 years *(Palo ya dikgomo tse di neg di bontsha bolwetse mo dingwageng dile pedi tse di fetileng)***
Abortion in last 3 months of pregnancy (*Pholotso, mo dikgweding tse tharo tsa bofelo tsa go dusa*)				
Animal not eating (*Go sa fuleng*)				
Silent heats (animal				

not getting pregnant) (*Kgomo ga e duse*)				
1= Extension officer (*Molemisi*); 2= Magazine (*Dibuka*); 3= Radio (*Sealemowa)*; 4=TV (*Lebokoso la ditshwatsho)* 5= Newspaper (*Kuranata*; 6= Internet(mafaratlhatlha) 7= Community members (*Baagisanyi*); 9=Relatives (*Ba losika*); 10 Animal Health Technician (*Ba thusi ka boitekanelo jwa leruo*) 11 Other (specify) (*Mekgwa e mengwe, tlhalosa*)				

5.5 Do you know what causes bovine brucellosis (*A o a itse gore Pholotso e bakwa ke eng*?) Yes (*Ke a itse*) No (*Ga ke itse*)

5.6 If Yes, please indicate (*Fa o itse, tlhalosa*)
1= *Brucella abortus* (*Mogare wa pholotso*) 2= *Brucella melitensis* (*Mogare wa Pholotso ya dipudi*) 3= *Brucella ovis* (*Mogare wa Pholotso ya dinku*)

5.7 Do you know if *Brucella* can be transmitted from animals to humans (*A fa o a itse gore pholotso e ka fetela go tswa leruong go ya bathong?*) Yes (*Kea itse*) No (*Ga ke itse*)

5.8 If the answer is YES, please indicate your knowledge on how the disease can be transmitted to humans (*Fa o itse, supa gore e fetelela jang go tswa mo leruong go ya bathong*)

Means of transmission	Tick if respondent identifies the means of transmission	Source(s) of information [Used codes below table]
By drinking milk from affected animals (Go nwa masi a a tswang mo seruiweng se se tshwaetsegileng)		
Touching the aborted foetus, uterine discharge *Go ama sefolotsane le popelo Thari) morago ga kgomo e fetsa go tsala*)		
Eating meat from affected animal, which has not been properly cooked (*Go ja nama ya kgomo e e tshwaetsegileng esa apeiwa sentle*)		
1= Extension officer (*Molemisi*); 2= Magazine (*Dibuka*); 3= Radio (*Radio*); 4=TV (*TV*); 5= Newspaper (*Kuranata*; 6= Internet (*mafaratlhatlha*) 7= Community members (*Baagisanyi*); 9=Relatives (*Ba losika*); 10 Animal Health Technician (*Ba thusi ka boitekanelo jwa leruo*) **11 Other (specify) (*Mekgwa e mengwe, tlhalosa*)**		

5.9 What is the treatment for brucellosis? [Tick] (*kalafi ya pholotso ke efe*?)

1= Antibiotic (*Melomo e e okobatsang megare*) 2= Anti-inflammatory (*Melemo ee fokotsang go ruruga*)

3= No treatment (*Ga gona kalafi*) 4= Only vaccination (*go soutisa fela*) (*Thibela megare*)

5.10 Do you vaccinate your animals for brucellosis? (A *o soutisa leruo la gago kgatlhanong le bolwetsi jwa pholotso?*)

Yes (*Ee*) No (*Nyaa*)

5.11 If the answer is yes, what do you use? (*Fa o soutisitse ,o dirisitse molemo ofe wa gtshoutiso?*

1= RB51 2= S19 3= Use both (*O di dirisitse dile pedi*) 4= Repeat both (*O di boeleditse di le pedi*)

5.12 Who vaccinates your cattle? (*Ke mang oo o go tlhabelang leruo*?)

1= AHT (*Molemisi wa leruo*) 2= State Vet (*Ngaka ya leruo wa puso*) 3= Private Vet (*Ngaka ya leruo ee ikemetseng*). 4 = Other (specify) (*ba bangwe, Tlaholosa gore bo mang*)

5.13 Where are your cattle vaccinated? (*O tlhabela/ entela lero la gago kae?*)

1= Dip tank (*Ko dipping*) 2= Home (kraals *ko masakeng*) 3= other (please specify) *Kwa gongwe, tlhalosa*

5.14 Are there other diseases that you vaccinate against on your farm? (*A go nale malwetsi a mangwe a o a soutisetsang?*

Yes (*a teng*) No (*Ga ateng) (Nyaa*)

If the answer is Yes, please list them (*Fa go na le malwetse a o a entelang, ke a feng*?) (*a rulaganye ka tlase*)

1 ……

2 ……

3 ……

4 ……

5 ……

6 ……

7 ……

8 ……

9 ……

10 ……

5.15 Have you heard about the Brucellosis Scheme? (*A o kile wa utlwela ka skema sa thibelo ya pholotso*?)

Yes (Ee, *Nkile ka utlwa*) No (*Nyaa, ga ke is eke utlwe*)

5.16 Do you know the requirements for admittance into the Brucellosis Scheme? (*A o na le kitso ya gore go tlhokafala eng gore o amogelwe mo skemeng se*?)

Yes (*Ke a itse*) **No (*Nyaa, ga ke itse*)**

6. Behaviour and attitude

6.1 Where do you buy your cattle? (*oreka kae leruo la gago*?)

1= Auctions(*Ko di fantising*) **2= Commercial farmers (*Ko ba lemi –rui baba ikemetseng*)** **3= Other emerging farmers (*Go tswa ko balemi potlana ba bangwe*)**

4= Other (specify) (*Ko gongwe ko go sa kaiwang) (Tlhalosa*)

6.2 How do you introduce new animals that are purchased into your herd? (*O gorosa jang dikgomo tse diswa mo motlhapeng wa gagao*)

1= Isolate and test (*O a tlhaola o bo o lekola bolwetse*) **2= Test only (*O lekola bolwetse fela*)**

3= No isolation or testing (*Ga o dire epe ya tse*) **4 = Other (specify) (*Tse dingwe, tlhalosa*)**

6.3 Please indicate for the reasons for your response in 6.2 above (*Tlhalosa mabaka a gago gore o dire e nngwe le enngwe ya karabo ya gago ka fa go dimo*)

……

……

6.4 What do you do when there is an abortion in your farm? (*O Dira eng fa enngwe ya dikgomo tsa gago e ka folotsa*)

1= Have never had the disease in my farm (*Ga ke is eke bone pholotso mo leruong la me*)

2= Report to nearest Vet Office (*Ke begelela molemisi o o fa gaufi*)

3= Other (specify) (*Ke dira tse dingwe, tlhalosa*)

6.5 How do you handle the aborted foetus (materials) and the cow? (*Fa kgomo e foloditse,odira jang ka sefolotsane seo?*)

1= Bare hands (*O se tshwara ka diatla tse di sa sirelediwang*)

2= With gloves (*Ose tshwara ka diatla tse disireliditsweng*)

6.6 How do you dispose the aborted foetus/materials (uterus/placenta) (*O dira eng ka sefolotswa seo*)

1= Leave on the farm (*Ose tlogela fela*)

2= Throw in the waste bin (S*elatlhela mo motomong wa maswe*)

3= Take it to state veterinary for test (*Ose isa go ngaka ya leruo ee gaufi*)

4= dispose and use disinfectant *(O a se epela mme o dirise sebolaya ditwatsi*)

5 = Other (specify) (*Mekgwa e mengwe, tlhalosa*)

6.7 Do you clean the area where the cow aborted? (*A o phepafatsa lefelo le sefolotswa se bonweng mo go sona*)

Yes (*Ee*) No (*Nyaa*)

6.8 If answer to 6.7 is Yes, with what? (*Fa go le jalo, o dirisa eng*?)

1= Water only (*Metsi fela*) 2=Water and soap and Jeyes fluid like product (*Metsi le sebolaya ditwatsi jaaka Jeyes fluid*) 3= Soil (*Mmu fela*) 4= Other (specify) (*Tse digwe, tlhalosa*)

6.9 What do you do with a cow that has aborted? (*Odira eng ka kgomo ee foloditseng*?)

1= Keep it (*O a e rua*) 2= Slaughter and eat (O *a e tlhaba,bolaya o be o eja*) 3= Sell it to community members (*A o a e rekisa mo morafeng*?) 4= Other (specify) (*Tse dingwe, tlhalosa*)

6.10 If you sell it, do you disclose to the buyer your purpose of selling? (*A fa o e rekisa, oa bua gore e ne e foloditse*)

Yes (*Ee*) No (*Nyaa*)

6.11 Do you sell it at a reduced fee than you would if it was not infected? (*A o e rekisa ka tlhwatlhwa ee tlase*?)

Yes (*Ee*) No (*Nyaa*)

6.12 When buying cows from other farmers, do you ask if: [tick (*Fao reka dikgomo go tswa go barui ba bangwe, a o botsa*]

Condition	Tick
Has aborted before (*Gore di kile tsa folotsa*?)	
Comes from a brucella free farm (*Gore di tswa motlhapeng o o senang bolwetsi jwa pholotso*	
Nothing, just buy it (*Ga o botse sepe , o reka fela*)	

6.13 After milking your cows, do you: (Fa o fetsa go gama dikgomo tsa gago

Condition	**1= Never** **2= Sometimes** **3= Always**
Drink it raw **(*O nwa maswi a entse fela jalo*)**	
Boil before consuming **(*A o bedisa pele* o a nwa)**	

7. Production parameters

7.1 How often do your cows calve down? (Please tick) (*Dikgomo Tsa gago, a ditsala ngwaga ka ngwaga*?)

1= Every year (*Ngwaga le ngwaga*) **2= Every 2 years (*Morago ga dingwaga tse pedi*)** **3= More than 2 years (*Morago ga dingwaga di feta pedi*)**

7.2 How many litres of milk do you normally collect per cow? (*O bona dilitara tse kae tsa masi go tswa mo dikgomong?*) _____

7.3 From the ones showing have aborted and showing signs of infertility, how many litres of milk do you normally collect? (*Ddikgomo tse di foloditseng di ntsha maswi a le kae*) _____

7.4 Have you experienced cattle theft in your farm (*A o kile wa utswelwa dikgomo*)? Yes (*Ee*) No (*Nyaa*)

7.5 If Yes, how many were stolen in the past 3 years? (*Fa o kile wa utswetswa leruo mo ngwageng tse tharo tse difetileng, ke tse kae*?)

Year	Number (use code below)
2013	
2014	
2015	
1= <5; 2= 6-10; 3=11-15 4 = 16 and above	

8. Marketing

8.1 Where do you sell your animals? (*Orekisa Dikgomo tsa gago kae*)

1= Abattoir (*Slageng/ matlhabelong*) 2= Stock Sale Yards (*Ko fantising*)

3= Community (*Mo motseng*) 4= Other (specify) (*Kwa gongwe, tlhalosa*)

8.2 How often do you sell animals? (*Tlhalosa gore o rekisa dikgomo tsa gago kgafetsa jang*)

1= Monthly (*Kgwedi le kgwedi*) 2= quarterly (*Morago ga kgwedi tse tharo*) 3= once a year (*Gangwe mo ngwageng*) 4= Other (specify) (*Tse dingwe, tlhalosa*)

8.3 How many animals do you normally sell? (*O rekisa dikgomo tse kae ka gale*?)

1= 1-5 2= 6-10 3= Above 10

8.4 Which category of animals do you normally sell? (*Rekisa leruo le le feng mo go a a supilweng ka fat lase*)

Category of animal	Average selling price[R] (*Tlhwatlhwa)*
1= Calves(*Dinamane*)	
2= Cows (*Dikgomo Tse di tshegadi*)	
3= Oxen (*Dipholwana*)	
4= Bulls (*Dipoo*)	

8.5 Who sets the price in the market? (*Ke mang a beyang tlhwatlhwa ya thekiso)*

1= yourself (*Ke wena*) 2= buyer (*ke moreki*) 3= both (*Kelona ka tumelano*)

8.6 Have you experienced a situation where your livestock or livestock products were rejected for not meeting the required standards? (*A o kile wa ganelwa go rekisa leruo la gago ka ntlha ya boleng jwa nama, kgotsa tse dingwe*?)

1= No (*Nyaa*) 2= Sometimes (*Ka dinako tse dingwe*) 3= Often (*Kgafetsa*)

8.7 Do you sell milk from your herd? (*A o rekisa maswi a dikgomo tsa gao*?) Yes (*Ee*) No (*Nyaa*)

8.8 What is the average milk price per litre in your area (*Orekisa maswi a o bokae*) R_____

9. Livelihoods

What are the household's main livelihood activities throughout the year?(*O itshidisa ka eng le ba lapa lagago*) ***(use Livelihood source code, up to 4 activities)***		**Using proportional piling or 'divide the pie' methods, please estimate the relative contribution to the HH livelihood of each activity?**
a. Main	**|____|**	**|__|__| %**
b. Second	**|____|**	**|__|__| %**
c. Third	**|____|**	**|__|__| %**
d. Fourth	**|____|**	**|__|__| %** **Total should be 100%**

Livelihood source codes

1= Remittance (*Madi*)

2= Food crop (*Dijwalo tsa dijo*) production/sales

3= Cash crop production/sales (*Dijwalo tse di tlisang lotseno*)

4 = Vegetable production/sales (*Thekiso yaKuno ya Merogo*)

5= Cattle production/sales(*Thekiso ya)Leruo, dikgomo*)

6= Small ruminant (*Thekiso ya Leruo le le potlana jaaka dipodi*) production/sales

7= Poultry production/sales (*Thekiso ya dikgogo*)

8= Small business (non-agricultural rural based)(*kgwebo potlana ya se legae*)

9= Skilled labour(*Tiro ya diatla*)

10= Formal salary/wages (*o bona moputso kgwedi le kgwedi*)

11 = Casual agricultural labour (*Tiro ya nakoana mo temo thuong*)

12 = Casual non-agricultural labour (*Tiro ya nakwana mme eseng mo temo thuong*)

13= Child social grant (*bona grant ya bana*)

14= Disability grant (*Bona grant ya go sa itekanelang*)

15= Pension (*O bona pension/ madi a bogodi*)

Annexure 2 – Solemn Declaration and Permission to submit

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

Higher Degrees Administration

SOLEMN DECLARATION AND PERMISSION TO SUBMIT

1. Solemn declaration by student

I, Botlhe Michael Modisane

declare herewith that the thesis/dissertation/mini-dissertation/article entitled **(exactly as registered/approved title),** An investigation of the socio-economic impact of bovine brucellosis in Mabeskraal community of Moses Kotane Municipality, North West Province of South Africa

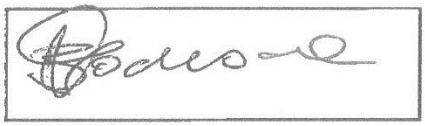
which I herewith submit to the North-West University, Potchefstroom Campus, is in compliance /partial compliance with the requirements set for the degree:

Master of Science in Agriculture (Animal health)

is my own work, has been language-edited in accordance with the requirements and has not already been submitted to any other university.

I understand and accept that the copies that are submitted for examination become the property of the University.

LATE SUBMISSION: If a thesis/dissertation/mini-dissertation/article of a student is submitted after the deadline for submission, the period available for examination is limited. No guarantee can therefore be given that (should the examiners' rports be positive) the degree will be conferred at the next applicable graduation ceremony. It may also imply that the student would have to re-register for the following academic year.

Signature of student  University number 26971313

Signed on this 15th day of November of 20 18

2. Permission to submit and solemn declaration by supervisor/promoter

- The undersigned declares that:

  the student is hereby granted permission to submit his/her mini-dissertation/ dissertation or thesis: Yes ☐ No ☐

- that the student's work has been tested by me for plagiarism (for example by TurnItIn) and a satisfactory report has been obtained: Yes ☐ No ☐

Signature/Supervisor/Promoter **Date**

Annexure 3 – Signed Editing Certificate

Stephen M Njiro

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TO WHOM IT MAY CONCERN

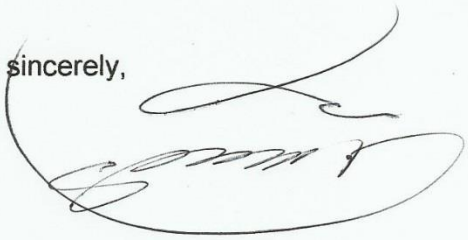
19 November 2018

CERTIFICATE OF LANGUAGE EDITING

I am a qualified English Language Editor and confirm that I have edited the document entitled "An Investigation of the Socio-Economic Impact of Bovine Brucellosis in the Mabeskraal Community of Moses Kotane Municipality, North West Province of South Africa" by Dr. B.M. Modisane.

The process of editing aimed at adding value to the document without altering the essence of its content.

Yours sincerely,



Stephen M Njiro PhD.