KNOWLEDGE, ATTITUDE AND PRACTICES (KAP) OF SMALLHOLDER LIVESTOCK FARMERS AROUND HEARTWATER DISEASE: A CASE OF BUSHBUCKRIDGE, MPUMALANGA PROVINCE, SOUTH AFRICA

BY

TIDIMALO MOKGORO APHANE

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SUPERVISOR: PROF MP SENYOLO

CO-SUPERVISOR: DR P CHAMINUKA (ARC)

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DECLARATION

I declare that the mini dissertation hereby submitted to the University of Limpopo, for the degree of Master of Science in Agriculture (Agricultural Economics) has not previously been submitted by me for the degree at this or any other university; that it is my own work in design and execution, and all material contained therein, has been duly acknowledged.

Mr Aphane TM

Date

DEDICATION

I dedicate this work to the strongest women I know, my mother Mmakgodu and grandmother Ngare. I also dedicate this to my siblings. They always bring sunshine on cloudy days.

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[1] https://leap-agri.com/?page_id=327

ABSTRACT

Heartwater, stemming from *Ehrlichia ruminantium* and transmitted by *Amblyomma* ticks, is a significant infectious threat to ruminants, imposing constraints on animal production. The susceptibility of smallholder livestock farmers to disease outbreaks, particularly heartwater, is heightened by challenges in implementing effective animal health practices. There is relatively little insight and understanding of the Tick-borne disease (TBD), despite it being regarded as one of the deadliest diseases for livestock in places where it is endemic. The research aimed to assess the knowledge, attitude and practices (KAP) of smallholder livestock farmers towards heartwater disease in Bushbuckridge Local Municipality in Mpumalanga Province, South Africa. Specifically, this study profiled the smallholder livestock farmers, analysed their KAP towards heartwater disease and finally, analysed factors influencing their KAP in the study area.

This study sampled 180 smallholder livestock farmers through the multistage sampling technique. Primary cross-sectional data, which was collected using structured questionnaires were used in this study. Descriptive statistics, KAP survey framework, which used Likert scale and the Multinomial Logistic Regression (MLR) model were used to address the study objectives.

The key findings revealed a majority of male farmers with an average age of 59, often possessing only primary education. A general lack of knowledge about heartwater disease influenced farmers' attitudes and practices. The MLR model identified eight influential variables, including gender, income sources, access to animal handling facilities, and annual expenditure, impacting the KAP of smallholder livestock farmers. The study recommended prioritizing government efforts to disseminate information on heartwater, addressing farmers' knowledge gaps. Moreover, subsidies for expensive animal health medication and vaccines were proposed to alleviate financial challenges faced by the majority of smallholder farmers.

Keywords: Heartwater disease; Knowledge, attitude and practices; Multinomial Logistic Regression; Smallholder livestock farmers.

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CHAPTER 1: INTRODUCTION

1.1. Background

Livestock production, the worlds' major land use sector, is crucial for sustainable development (Abu Hatab *et al.,* 2019). This sector is a cornerstone of economies worldwide, contributing 40 percent to agricultural output in developed nations and 20 percent in developing ones. Globally, it sustains the livelihoods of at least 1.3 billion people [Food and Agriculture Organization (FAO), 2018]. Recognizing its significance is crucial for fostering balance in agricultural practices and ensuring the well-being of diverse communities across the world.

Many resource-poor farmers in Africa, Asia, and Latin America rely heavily on animals as a source of their livelihoods (Donadeu *et al.,* 2019). Livestock production is one of the most significant agricultural activities in South Africa, as it is in many other developing nations, and it has historically played an integral part in sustaining the livelihoods of rural people (Mdlulwa *et al.,* 2021). Livestock serves a range of purposes, including the provision of important food products, draught power, and for social ceremonies (Chipasha *et al*., 2017). Livestock also provides employment and income for most of the smallholder farmers living in the rural areas (Kerario *et al.,* 2018).

South Africa, and Africa at large shows exciting potential for animal agriculture due to a diverse climate (Njisane *et al.,* 2020; Nkadimeng *et al.,* 2022). However, due to the developing nature of the continent, farmers face the constraint of disease outbreaks (Nkadimeng *et al.,* 2022). For this reason, production potential has not been fully realised (Donadeu *et al.,* 2019). Animal diseases are found to be a complex challenge, particularly in traditional livestock production systems (Abu Hatab *et al.,* 2019). Outbreaks within herds can have devastating impacts on the production of food as well as the prices, especially impacting resource-poor farmers (Abu Hatab *et al., 2019*). Tick-borne diseases (TBDs) are often ranked higher than the other diseases (Laisser *et al., 2015*).

TBDs in livestock may significantly increase farmers' burden in terms of applying preventive measures for their livestock and financial hardship owing to loss of animals (Johansson *et al.,* 2020). One of the most economically significant livestock diseases in Southern Africa is heartwater (Molepo *et al.,* 2022). It is historically one of the most important TBDs in the following countries; South Africa (Molepo *et al.,* 2022), Zimbabwe (Sungirai *et al.,* 2016), Tanzania (Kerario *et al.,* 2018), Ethiopia (Duguma, 2020), and Botswana (Ramotadima *et al.,* 2021), amongst others.

Heartwater, caused by *Ehrlichia ruminantium,* is an infectious and noncontagious disease of ruminants transmitted by *Amblyomma* ticks that poses a constraint to animal production (Younan *et al.,* 2021). The disease infects cattle, sheep, goats, and some wild ruminants, and it is a financially significant disease with high mortality rates in populations that are prone to it (Molepo *et al.,* 2022). It is endemic to the north-eastern regions of South Africa, from the north-east of North West Province, to Limpopo and north-eastern parts of Mpumalanga, and through the KwaZulu-Natal and Eastern Cape Provinces' coastal regions (Bath and Leask, 2020). This TBD has an enormous impact on the livestock industry in South Africa (Bath and Leask, 2020). Losses can come in different forms; this includes the death of animals (direct costs) and medication cost (indirect costs) (Oladele *et al.,* 2013). The entire economic burden of heartwater disease on the South African livestock industry is projected to be R1 266 million per year, with the direct costs contributing 66.47%, and indirect costs contributing 33.57% to the total cost of heartwater (van den Heever *et al.,* 2022), showing the damaging effects of this TDB.

1.2. Problem statement

Smallholder livestock farmers' inability to implement animal health practices well makes them very vulnerable to disease outbreaks (Hernández-Jover, 2019). The impact of heartwater is expressed by the number of livestock mortalities the disease causes in livestock, which can reach 90% in some herds (Deetman, 2014), and it is made worse by livestock farmers' high expenditure that has to be incurred to control the ticks and treat the disease (van den Heever *et al*., 2023). Allsop (2015) reported that the organism that causes heartwater disease has high genetic variability, which makes it highly difficult for vaccine manufacturers to develop an effective vaccine for livestock defence against heartwater disease.

Many livestock farmers perceive ticks and TBDs as the most dominant restrictive problem their cattle face (Yawa *et al*., 2020). This problem shows that knowledge regarding the causes and effects of ticks and TBDs such as heartwater is required in the quest to discovering effective inexpensive control measures. Maziya *et al*. (2019) suggest that smallholder livestock farmers generally lack information on suitable livestock vaccines, which is partly due to inadequate training by extension workers on the primary animal healthcare (PAHC) practices. A lack of education about sanitation and knowledge regarding health issues have been frequently discussed as a cause for animal disease related issues, presenting a potential leverage point to make the situation better (Abu Hatab *et al.,* 2019). Furthermore, scientists that are involved in the development of vaccines and medicines to address the challenges of livestock diseases often do not have adequate information on the socio-economic drivers of adoption and other primary animal health care decisions made by farmers.

The right knowledge, good practices by farmers and positive attitudes to livestock vaccinations may reduce the impact of diseases and increase smallholder livestock productivity. Inadequate knowledge of the disease, the presence of multiple high-risk farm practices, and inappropriate perceptions and bad practices require education for improvement (Olaogun *et al.,* 2023). Bath and Leask (2020) stated that limited data exist on the real economic impact of this disease and that the epidemiological dynamics of heartwater in South Africa according to accessible literature are not clear. Melaku *et al*. (2014) also noted that there is relatively little insight and understanding of the TBD, despite it being regarded as one of the deadliest diseases for livestock in a number of countries on the African continent. In South Africa, studies have been conducted on the knowledge, attitude, and practices of farmers on other diseases (Habiyaremye *et al*., 2017) and on tick resistance and TBDs (Yawa *et al*., 2020), but none have focussed solely on smallholder livestock farmers KAP towards heartwater disease. Therefore, this study aimed to assess smallholder livestock farmers' knowledge, attitudes, and practices (KAP) towards heartwater disease and their means of controlling or treating the disease.

1.3. Rationale

Livestock plays an important economic, social, and cultural role for households because it contributes significantly to household income and improvement of the wellbeing of people (Bettencourt *et al*., 2015). However, livestock production is still vulnerable to various animal diseases such as heartwater, thus, threatening the productivity of smallholder farmers while potentially threatening their food security (Mdlulwa *et al*., 2021).

Deetman (2014) reported that heartwater is endemic in and around parts of the Bushbuckridge area. It is still one of the major constraints to livestock production in areas where it is endemic, which are dominated by ticks of the *genus Amblyomma* (Tshikhudo *et al*., 2010). The Bushbuckridge area is close to various game farms, like the Kruger National Park. The presence of wildlife, especially some antelope species, is seen as a major factor in the increased effect of heartwater disease because these species can carry heartwater ticks (Bath and Leask, 2020). There is still no safe and effective vaccine globally for the protection against heartwater disease (Faburay, 2017; Tjale *et al.,* 2018), which consequently contributes to the devastating impact of the disease.

A study by Kerario *et al*. (2018) found heartwater as being one of the most important diseases of cattle in Tanzania. The documentation of heartwater disease in Kenya like most other African countries, is negligible because heartwater disease is not notifiable in most countries, and therefore, it is overshadowed by other important TBDs (Wanjohi *et al*., 2021). Furthermore, farmers in endemic areas are often reluctant or financially constrained when it comes to obtaining precise diagnoses for heartwater, hindering the accurate assessment of its economic consequences (Allsop, 2015). To address the economic challenges posed by heartwater, farmers need to acquire comprehensive knowledge about the disease, adopt preventive attitudes, and implement practices that enhance livestock production while minimizing the risk of outbreaks in their herds.

KAP analyses are crucial for identifying gaps in information among various public groups and landscapes, assisting to document current practices that may increase the risk of infections in livestock (Kiffner *et al.,* 2019), while also evaluating a country's vulnerability to diseases. For instance, in order to prevent uncontrollable disease spread, farmers need to know the dangers involved and imperative precautions have to be adopted (Tiongco *et al.,* 2011). Furthermore, KAP analyses are also important for generating information that can be used to inform policy making (Kairu-Wanyoike *et al*., 2014). Therefore, this study attempted to assess the KAP of smallholder livestock farmers towards heartwater disease. The study was part of a bigger project titled “MuVAH: Multivalent inactivated vaccine against heartwater in Africa”, providing integration of socio-economic analyses to inform development of heartwater disease vaccines and related drivers of adoption for the envisaged innovation.

1.4. Aim of the study

The study aimed to assess smallholder livestock farmers’ knowledge, attitudes, and practices (KAP) towards heartwater disease in Bushbuckridge Local Municipality.

1.5. Objectives of the study

i. To profile the smallholder livestock farmers in the study area.
ii. To analyse smallholder livestock farmers’ knowledge, attitude, and practices towards heartwater disease in the study area.
iii. To analyse the socio-demographic factors influencing the knowledge, attitude, and practices of smallholder livestock farmers towards heartwater disease in the study area.

1.6. Hypotheses

i. Socio-demographic factors of livestock farmers in Bushbuckridge Local Municipality do not influence their knowledge, attitude, and practices towards heartwater disease.
ii. There is no relationship between the knowledge, attitude, and practices of livestock farmers towards heartwater disease in Bushbuckridge Local Municipality.

1.7. Organisation of the study

The structure of the study is as follows: In Chapter 1, the introduction provided an overview of the study, outlined the identified problem, and justified the need for conducting the research. The chapter also presented the research aims, objectives, and hypotheses guiding the study. Chapter 2 delved into a review of literature covering similar and relevant empirical studies related to KAP, exploring factors influencing KAP. Chapter 3 focused on the research methodology, detailing the study area and outlining various analytical procedures employed to achieve the study's objectives. Chapter 4 encompasses the results and discussions, aligning them with the specified objectives. Finally, Chapter 5 includes a summary, conclusions drawn from the results, and recommendations based on the findings.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

This chapter covers the review of literature in relation to the farmers' KAP towards heartwater disease. It starts with defining the key concepts that will provide easy understanding of what the key words were used in the study and assist in operationalising them in the context of the current study. Next, the chapter presents previous studies that were conducted both locally and internationally. This also provided deeper insights into studies previously conducted, methods employed and ultimately provided an opportunity for identifying gaps, drawing conclusions, and making recommendations based on those studies.

2.2. Definition of key concepts

Heartwater (Cowdriosis) is a tick-borne disease caused by *Ehrlichia ruminantium*, an obligatory intracellular bacterium of the order *Rickettsiales*, transmitted by several ticks of the genus *Amblyomma* (Deetman, 2014; Stachurski *et al.,* 2019).

Indigenous knowledge (IK) is institutionalised local information that is passed down from generation to generation, typically through word of mouth. It is the result of experience gained over many years (Makate, 2020). It is local expertise that is specific to a particular culture or community (Akullo *et al*., 2007).

Ethnoveterinary medicine (EVM) is a branch of science that focuses on people's knowledge of livestock diseases and their control, practices employed, and solutions for animal disease treatment and prevention. It also includes management strategies and religious aspects associated with animal health care and production. (González and Vallejo, 2021).

Smallholder livestock farmers in this study are defined as those owning less than 100 cattle, including small stock (sheep and goats) (Mdlulwa *et al*., 2021). They are generally found in poor areas characterized by communal farming systems (Sungirai *et al*., 2016), and have relatively lower income levels (Adehan *et al*., 2018).

2.3. Review of previous studies

This subsection goes through relevant and related literature, looking at different aspects from the socioeconomic impact of diseases and farmers' demographics, to their KAP as well as the factors which influence the KAP of farmers

2.3.1. Socio-economic impact of livestock diseases

In Africa, livestock disease epidemics jeopardise improved animal and human health, higher productivity, and long-term agricultural livelihoods (Masemola *et al.*, 2019). In the absence of animal diseases, livestock farmers can boost livestock productivity, hence improving earnings made from livestock farming (van den Heever *et al.*, 2022). Many kinds of livestock diseases are considered economically important, like Foot and Mouth Disease (FMD) (Knight-Jones *et al.*, 2017), Brucellosis Disease (Pal *et al.*, 2017), Rift-Valley Fever, and Lumpy Skin Disease (Masemola *et al.*, 2019), and Heartwater Disease (Bath and Leask, 2020). The economic losses from these diseases disproportionately impact smallholder resource-poor farmers who depend on livestock production for financial and nutritional security (Knight-Jones *et al.*, 2017; Masiga *et al.*, 2022). Disease outbreaks can also cause local livestock markets to close, as well as affect the cross-border movement of other commodities such as maize due to import bans (Knight-Jones *et al.*, 2017).

The true cost of these livestock diseases on farmers is recorded as direct and indirect costs (Mdlulwa, 2015). Direct costs are costs from mortalities, while indirect costs are associated with the costs of treatment and control of diseases farmers incur, including medication, acaricides for dipping, vaccinations, and labour (van den Heever *et al.*, 2022). Livestock vaccines are a cost-effective method of controlling disease (van den Heever *et al.*, 2022). Although they are a cost-effective method, Donadeu *et al.* (2019) wrote that vaccines are not easily accessible to the average farmer because they are either not available for purchase at local markets or they are not as affordable as acaricides.

For TBDs such as heartwater, acaricides are mainly used to control ticks (Kerario *et al*., 2018). Yet, the continuous usage of acaricides is often too expensive for smallholder cattle farmers (Nanteza *et al*., 2023). This is because smallholder farmers have low-income levels (around R2775 per month on average), which hinders them from purchasing livestock vaccines and acaricides adequately as they have to distribute the money across their household needs (Masemola *et al*., 2021).

Kerario *et al*. (2018) reported that farmers resorted to dipping their livestock fortnightly in a quest to reduce the costs of acaricides. This was in line with the results by van den Heever *et al*. (2022), who reported that cattle farmers mainly apply acaricides around 24 times a year, which is equivalent to twice a month. Of the different acaricide application methods available to farmers, the plunge dipping acaricide application method has been found to be the most cost-effective for cattle and sheep (van den Heever *et al*., 2023). This was, however, not the case for goats, where the pour-on approach was the most economically viable method. Pour-on acaricide strategies were the least cost-effective for cattle and sheep, whereas spray methods were the least cost-effective for goats (van den Heever *et al*., 2023).

2.3.2. Farmers' demographics

The literature available on the different demographic characteristics of farmers is extensive, and various authors have reached different conclusions in their respective studies. Idamokoro *et al.* (2019) found that there is an unbalanced gender interest in goat farming, with males mainly tending to the goats in their households. One cause for the imbalanced interest in goat farming could be the amount of time and effort required in caring for goats; as a result, most women find it difficult to devote to it, and consequently, males handle the goats often. Similarly, Tyasi *et al.* (2022) found that men were the majority of goat keepers, which is to be anticipated given South African rural people's traditional and cultural customary rules, which consider the man to be the head of the household and likely to make decisions on issues concerning livestock. Sheriff *et al.* (2020) also found that the majority (67.5%) of farmers who reared goats, especially indigenous breeds, were men, which influences their knowledge on goat keeping.

In terms of cattle, men owned more compared to women while also dominating the livestock industry in communal areas as they had more cattle than women (Katiyatiya *et al.*, 2014). These findings concur with those by Tada *et al.* (2013), who found that males are generally the owners of cattle, proving that the majority of cattle owners are male. Even in female-headed homes, men in the extended family are usually engaged in decisions to sell cattle. Some females have indicated that their in-laws are often consulted over livestock issues, even though they do not live in the household (Gwiriri *et al.*, 2019).

Moreover, it was reported that according to certain cultures, women cannot enter a kraal because it is a sacred space and they will contaminate the environment, ultimately causing the cows to not reproduce or abort (Muyambo *et al.*, 2017). However, not everyone agreed with the significance of that taboo in contemporary South Africa. There was a consensus among women that some of these beliefs and customs made no sense in this day and age as they were the very reason that women are seen as incompetent in taking care of livestock (Gumede *et al.*, 2018). However, contrary to these views about men being the primary handlers of livestock, a study in Tajikistan found that in many households, females were mainly responsible for the management of the cows (Lindahl *et al.*, 2019). This was in line with the findings by Andaleeb *et al.* (2017), who concluded that women were involved in almost all activities of livestock farming.

Even with regards to sheep farming, a majority of sheep keepers are males, showing that sheep farming is more popular among males than females (Nkonki-Mandleni *et al.*, 2019). The gender distribution of livestock ownership between men and women determines the sort of livestock kept by the community. Males are more likely to own cattle, sheep, goats, and horses, whilst females are more likely to own pigs and poultry (Tyasi *et al.*, 2022). These findings are in line with those by Kugedera *et al.* (2021), who found that there were more male compared to fewer female farmers who were owners of the livestock. This could be due to the fact that females are still expected to cook and conduct housework, whereas males are expected to handle activities that require a lot of energy, such as some farm operations like herd maintenance (Moyo, 2010), hence women do not take care of livestock regularly.

Household size is an important determinant of family labour available to the farmer. The primary motivation for engaging in livestock production for most people is for income generation (Osman *et al*., 2018). Family labour is mostly used for animal management and herding, which is done by the males in the household (Mthi *et al*., 2017). Within smallholder or rural farming communities, most farmers depend on family labour, therefore, the household size is often used as a proxy for labour availability (Mapiye *et al*., 2018).

The size of a household is a major element in ensuring labour availability for livestock farming practices (Nkonki-Mandleni *et al*., 2019). It has been said that successful livestock keeping for optimal profit requires labour provision from various members within the household (Omotoso *et al*., 2018). The number of people in the household can provide much needed labour in livestock management practices (Martey *et al.,* 2013). Therefore, the availability of family labour allows the household head to have time for achieving other tasks, both on- and off-farm. This suggests that if there are more people within the household, they are likely to share responsibilities and provide labour for some of the farming activities (Nkonki-Mandleni *et al*., 2019). Interestingly, Singh *et al.* (2019) found that livestock farmers from larger households had less knowledge than those from smaller households, which could be because larger households have fewer resources, resulting in a lower degree of schooling in such families.

The general trend with age distributions of farmers in rural communities in South Africa is that most of them are elderly people (Mapiye *et al*., 2018). Most of the smallholder livestock farmers are over 60 years of age (Oladele *et al.,* 2013). Younger people migrating from rural to urban areas in search of better life opportunities contribute to the higher proportion of rural farmers being the elderly in the age group of over 60 years old. This is also exacerbated by the poor interest in farming by the younger population, who might have opted for other jobs as a means of attaining their livelihoods. Additionally, Tada *et al.* (2012) observed that younger people tend to relocate to urban areas in pursuit of their tertiary aspirations and try to secure more lucrative jobs, thereby abandoning the idea of farming altogether. Such distributions in age could inhibit the widespread adoption and application of new agricultural technology and practices (Mapiye *et al*., 2018). This is because younger farmers are more likely to adopt technological innovations than their older counterparts (Dhraief *et al.,* 2018).

Since most livestock farmers are older people, they are usually unemployed and have their major source of income in the form of social grants or pensions from the government (Oladele *et al.,* 2013). Apart from crops and livestock, many farmers supplement their household income by non-farming activities such as wages, remittances, pensions, and small businesses (Mapiye 2018). Notably, it was found that receiving social grants was found to restrict farmers in their ability to spend money on animal health care (Habiyaremye *et al*., 2017). These observations were supported by Mdlulwa *et al*. (2021), who revealed that farmers who have other sources of income such as salaries were able to spend more on animal health care and management.

Low income is a burden for many smallholder livestock farmers, especially in the communal areas. Myeni *et al.* (2019) found that 98% of farmers had never received credit for production, proving that resource-poor farmers have relatively little access to credit due to their low income, poor literacy levels and old age. Access to credit or funding continues to be an obstacle for most smallholder farmers in South Africa (Bahta and Myeki, 2021). Having access to funding allows farmers to overcome the financial problems related to the production and adoption of improved practices (Sithole *et al.,* 2014). As a result, access to credit enables farmers to get sufficient capital to overcome the financial restrictions that prevent them from adopting contemporary livestock production and management practices (Myeni *et al.,* 2019).

Metawi *et al.* (2019) reported that there is generally a high level of illiteracy among smallholder livestock farmers. This was supported by Rufai *et al*. (2021) who said that the level of education among the farmers in Nigeria was generally low. The low level of literacy among farmers remains a significant concern (Nwafor *et al.,* 2020). For instance, when livestock farmers have poor education levels, the consequence is usually improper tick control, leading to infestations and diseases (Yawa *et al*., 2020). These findings were supported by Mdungela *et al*. (2017), who found that the incorrect application of acaricides is closely linked to farmers' poor literacy levels as most of them cannot correctly read and comprehend the dosage instructions, leading to an increase in the tick population and the occurrence of acaricide resistance (Yawa *et al*., 2020).

However, the aforementioned results contrast with the report of Sungirai *et al*. (2016), who found that around 90% of the farmers involved in livestock farming in Zimbabwe had secondary education level, while Gammada (2020) also found that most farmers were in possession of secondary education. These results are supported by Lazarus *et al.* (2017) who indicated that most farmers were literate and therefore, more likely to adopt innovations. This generally implies that education makes farmers adopters of technological innovations (Dhraief *et al.,* 2018), thus, improving their chances of dealing with livestock diseases well. This is supported by Thinda *et al.* (2020) who reported that educated farmers usually have a better understanding of farming challenges.

Smallholder livestock herd sizes usually range from 1 to 94, with many of the households having an average of around nine animals (Chaminuka *et al.,* 2014). In Tunisia and Zambia, herd sizes of around eight animals were common (Dhraief *et al*., 2018; Namonje-Kapembwa *et al.,* 2022). Ndlela *et al.* (2022) found an association between indigenous knowledge use and ownership of livestock. Indigenous knowledge was mainly used in smaller herd sizes and less in larger herds. This concurs with Dhraief *et al*. (2018) who reported that farmers with large herd sizes are more likely to adopt contemporary technologies in farming.

2.3.3. Knowledge, Attitude and Practices of farmers

Knowledge

According to Adehan *et al*. (2018), farmers were aware of management practices, such as control of internal and external parasites, vaccination, and the importance of nutrition and general management of livestock. However, some of their methods are no longer effective, and there is also a significant knowledge gap. This could be because farmers heavily relied on other farmers for information, in which case the information may be incorrect, unreliable, or outdated (Ntuli and Fourie, 2021). Most smallholder livestock farmers rely on experiential knowledge and their fellow farmers as their primary source of information about ticks and TBDs (Mutavi *et al*., 2021).

Laisser *et al*. (2015) also noted that most livestock farmers correctly mentioned the signs of the common TBDs. Furthermore, the majority of the farmers knew about heartwater disease as it was cited as one of the most important TBDs affecting farmers (Habiyaremye *et al*., 2017). Farmers in Tarime District knew that the disease is characterized by *"kizunguzungu",* which means circling in their local language (Chenyambuga *et al*. 2010). It was also noted that farmers were not using modern nor EVM to treat heartwater disease, but they were reportedly burning the ticks off (Duguma, 2020).

Farmers in Ethiopia also possessed good knowledge of common TBDs and were able to describe some of the diseases by their vernacular name, clinical signs and parts of the body affected (Duguma, 2020). Unfortunately, no local name was mentioned for heartwater disease, but farmers were able to describe it by its clinical signs. Reduced appetite, circling or high stepping gait, white foam from mouth, and tears from eyes, bloody diarrhoea, and moving tongue in and out were mentioned as the symptoms of heartwater disease (Duguma, 2020).

The aforementioned symptoms were also mentioned in Tanzania in a study by Kerario *et al*. (2018), where heartwater disease was described by farmers as "*Moyo kujaa maji*" in Swahili. It was reported to be characterized by reduced appetite, moving in circles or difficulty standing, fever, emaciation, and diarrhoea. In that area, heartwater disease causing ticks were found to be common during the wet season (November to May). This was in line with Katiyatiya *et al*. (2014), who found that most of livestock farmers were able to mention the signs related to the common TBDs. Farmers were also very aware of the dangers of TBDs. Death and undesired meat quality were said to be the consequences of ticks in livestock (Kerario *et al*., 2018).

In Zimbabwe, ticks were also associated with several effects on livestock. The most common were heartwater disease (*Cowdriosis*) followed by mastitis, gall sickness (*Anaplasmosis*), tick bite wounds, red water (*Babesiosis*) and poor body condition (Sungirai *et al*., 2016). Clinical and post-mortem signs, which are synonymous with TBDs such as red urine (babesiosis), circling movements of cattle (*Cowdriosis*) (Mthi *et al*., 2020), hard dung (*Anaplasmosis*), hair loss (sweating sickness) and swollen lumps on the neck (*Theileriosis*) were seen as being caused by ticks. In general, farmers had the ability to point that TBDs are a problem in the region while also naming heartwater disease as one of the most important TBDs and in some cases describing the symptoms (Sungirai *et al*., 2016).

Khunoana *et al.* (2019) reported that individuals with knowledge about EVM were predominantly elderly people with ages ranging from 40 to 83 years. This was in line with the findings by Sanhokwe *et al.* (2016) who revealed that there was low knowledge about EVM, and it is mostly confined to older people. The contradiction is found in a study by Chenyambuga *et al*. (2010), who found that farmers had good knowledge on traditional herbs, which they used for the treatment of heartwater disease and other TBDs.

Often farmers are aware that some plants are safe to use and cannot cause harm to the person handling the plant. Other plants, however, need to be handled with care, implying that necessary precautions should be considered when using the plant. Farmers noted that some plants can be harmful to the eyes and skin (Mkwanazi *et al*. 2021). Sanhokwe *et al*. (2016) found that most farmers prefer to use leaves when treating livestock. The observation that leaves are mostly preferred by farmers resonates with that of Kioko *et al*. (2015) who reported that farmers preferred to use leaves instead of barks and roots. In contrast to these findings, the roots were most commonly used parts in the study by Moichwanetse *et al*. (2020), followed by the leaves and the whole plant, and the bark was the least used part.

Attitudes

According to Yawa *et al*. (2020), there was a consensus among the farmers that the current acaricides used are ineffective to the extent that they cannot effectively control ticks from their livestock, leading to a reoccurrence. Vaccines, on the other hand, have proven to be the most viable option for diseases prevention (Maziya *et al*., 2019). Farmers, however, view vaccines as too expensive and not readily available in rural areas. Rural livestock farmers often travel long distances to get vaccines.

The aforementioned views contradict with the findings of Habiyaremye *et al*. (2017), where farmers acknowledged that vaccines are readily available for use but mentioned the challenge with their affordability. Most smallholder farmers are above 60 years of age with a state old-age grant as their main source of livelihood (Mdlulwa *et al*., 2021). Hence, farmers usually have a strong opinion that vaccines are costly, and that these high costs for livestock vaccines should be paid by the Government (Mdlulwa *et al*., 2021). As a result, vaccines are more likely to be adopted by relatively well-off households who have alternative sources of income like off-farm employment (Karanja-Lumumba *et al.,* 2015). Nevertheless, most farmers were aware of the importance of vaccines on livestock, despite feeling that they are too expensive for them (Maziya *et al*., 2019). This concurs with Pham-Duc *et al*. (2019) who reported that farmers preferred technical interventions such as vaccination or obtaining antibiotics when preventing disease outbreaks.

Practices

Indigenous methods of controlling ticks include the use of (1) ethno-veterinary remedies and (2) non-plant materials. Non-plant methods used to control ticks include measures such as manually picking ticks by hand early in the morning before livestock goes to the fields for grazing (Mkwanazi *et al.,* 2021). However, this could be relatively tedious and time-consuming, requiring too much labour availability to carry out the activity.

Despite significant progress in the development of livestock vaccinations and treatment, the implementation of good management practices is still the most effective strategy to avoid and control many infectious diseases in livestock herds (Ritter *et al.,* 2017). There are various tick control methods used by livestock farmers. Adehan *et al*. (2018) found that certain farmers use acaricides, but they also employ older methods such as manual tick removal and the use of homemade mixtures, indicating that they interchange between older and newer tick control methods. Manual tick removal from livestock is a very old method among farmers and is challenging to perform on disobedient animals. It is also uncomfortable for the animals and time-consuming.

It is worth noting that some farmers have used other traditional tick management methods. In Zimbabwe, the most widely used traditional method of managing tick infestations is the use of black soot mixed with chilies, known as *chin'ai* in the local Shona Language (Sungirai *et al*., 2016). This substance is mixed in water and then brushed on the body of the animal using a broom or tree branch with fine leaves. The effectiveness of this method has not been proven scientifically, but farmers claim that it is helpful (Sungirai *et al*., 2016).

Due to the widespread presence of ticks and TBDs in communal areas, farmers resort to the use of a pour-on dipping technique twice a month during high tick infestation seasons and once a month during low tick infestation seasons (Yawa *et al.,* 2020).

Katiyakiya *et al.* (2014) found that farmers facing the challenge of ticks in their herds use either acaricides or EVM to control ticks, while some use both acaricides and EVM to control ticks. The usage of acaricide chemicals is also the most practiced measure used to control ticks in Botswana (Ramotadima *et al*., 2021). This contrasts with reports by Moyo and Masika (2009) in South Africa and Sungirai *et al*. (2016) in Zimbabwe, who reported that most resource-poor farmers also seek alternative methods to manage ticks, such as engine oil, Jeyes fluid, paraffin, chickens, and manual removal due to the high cost of acaricides. The engine oil and Jeyes fluid are brushed and sprayed on the tick-infested livestock, while chickens remove ticks when they are pecking on the tick-infested livestock with their beaks (Moyo and Masika, 2009). Chemical tick control may not be sustainable in the long run, and alternative control strategies must be implemented for a comprehensive tick control program (Cloete *et al*., 2021). Tick control methods are expensive and may affect livestock health. The major drawback of using these chemical acaricides is that ticks are now becoming resistant (Jain *et al.,* 2020). Alternatively, crushed leaves, seeds, and roots of *Euclea undulata,* Protea, *Grewia occidentalis*, and *Aloe maculata* were used and administered orally to treat heartwater disease by certain farmers. According to the farmers, aloe is used for treating heartwater disease in cattle. Seeds of the Protea were used to treat heartwater disease. Oral administration was found to be the only method of remedy administration (Mthi *et al.,* 2020).

However, there have been concerns over the efficacy, safety (toxicity), quality (phytochemicals), and dosage regimens of these plants, and standardized procedures are needed for their evaluation as medication for livestock (Mthi *et al.,* 2020). As indigenous ethnoveterinary medicines are commonly used, their efficacy should be thoroughly researched. The widespread use of indigenous ethnoveterinary treatments emphasizes the importance of promoting this as a livestock healthcare practice (Kioko *et al*., 2015).

Gammada (2020) reported that heartwater disease, caused by seasonal tick infestation, can be alleviated by spraying. Wherever farmers fail to follow the dipping regime recommended by the government, spraying can be used as an alternative. Farmers who cannot maintain the dipping tanks utilize different tick control methods, with hand spraying by a knapsack being the most commonly employed method

(Vudriko *et al*., 2018). As a result, spraying is the commonly utilized acaricide application method in various locations (Kasaija *et al.,* 2021; Mutavi *et al*., 2021).

Tick resistance in herds can be reduced through integrated control techniques that include a variety of measures such as acaricide use, ethnoveterinary practices, and vaccinations (Githaka *et al*., 2022). This was previously stated by Moichwanetse *et al.* (2020) when they wrote that farmers often interface ethnoveterinary knowledge and contemporary methods to treat their livestock. The two different practices are, in fact, complementary to each other, as some farmers have used them before when they had money (Ndlela *et al*., 2022).

2.3.4. Factors influencing KAP

Age of the farmers has been found to influence the knowledge and practices used by farmers in animal health and management. Knowledge of medicinal plant use is mostly limited to older people in the communities; hence, older farmers were the ones using IK more than all age groups (Chitura *et al*., 2018). This is also because younger farmers are more likely to adopt innovations, while the older farmers rely more on traditional methods (Dhraief *et al*., 2018). The conclusion that age is an important indicator of knowledge gives circumstantial evidence that knowledge about certain diseases may be influenced by historical disease outbreaks. Therefore, a farmer's age may merely indicate greater accumulated knowledge over their lifespan (Kiffner *et al*., 2019).

The gender of a farmer has also been found to influence knowledge, with males often having greater knowledge about a specific livestock disease (Traore *et al*., 2020; Tesfaye and Abate, 2023). Women's limited of knowledge of veterinary medicinal herbs could be attributed to the fact that even if they own cattle, the care and maintenance of their herds is left to either their spouse or a male relative who looks after their health and pastures (Traore *et al*., 2020). According to most cultures, males are often responsible for the well-being of the livestock; and for this reason, females lacked knowledge about livestock management and about using EVM (Khunoana *et al*., 2019). The responsibilities given to males positively influenced their usage of IK, with male farmers likely to use IK more than females (Mkwanazi *et al*., 2020). However, there was an interesting contradiction to these findings whereby Chitura *et al*. (2018)

claimed that traditional EVM was utilised more by female farmers, despite male farmers making up the majority.

Households receiving government grants were found to be using IK more (Mkwanazi *et al*., 2020), showing that there is a significant association between IK use and income. Indigenous farming practices are more popular among the resource constrained small-holder farmers because of their inability to purchase acaricides (Shiba, 2018). Farmers who had other sources of income such as salaries, remittances and businesses were able to control disease breakouts by buying vaccines and acaricides (Mdlulwa *et al*., 2021). The reason why certain farmers are not using acaricides is the lack of purchasing power (Adehan *et al*., 2018), hence, they sometimes resort to using their indigenous knowledge. Also, household size influences how income is spent because larger households spend more on food and other household needs instead of livestock healthcare (Sithole *et al.*, 2014).

Education is a key factor for improving the adoption rate of innovative technologies that can positively affect the future improvement of livestock production (Duguma, 2020). The use of indigenous knowledge, however, is relevant to rural communities that have high illiteracy levels (Yawa *et al*., 2020). Where farmers cannot access information owing to illiteracy, indigenous agricultural knowledge usually aids them in coping with livestock management practices (Muyambo *et al*., 2017). Mkwanazi *et al*. (2020) concluded that the farmers who were in possession of tertiary level of education were less likely to use IK to control ticks due to their knowledge of modern methods. Knowledge of farmers on acaricide resistance is generally influenced by the level of education a farmer possesses, but the use of EVM was commonly associated with farming experience, showing that age can influence knowledge about EVM (Yawa *et al*., 2020).

Overall, the influence of literacy to farmers' responses could be explained by the fact that education level, which is used as a proxy of human capital (Lubungu 2016), improves the comprehension of farmers by providing them with access to fresh and relevant information, as well as their ability to interpret that information in order to overcome obstacles (Nigussie *et al*., 2017). Therefore, educated farmers are less likely to be affected by livestock challenges compared to their less educated peers

(Mapiye *et al*., 2018). This is proven by Sambo *et al*. (2014), who found that farmers who have secondary education and above generally had better practices for managing livestock diseases. This is because more educated farmers discard certain methods and usually seek better animal health practices (Lazarus *et al*., 2017). It was also noted that farmers with higher levels of education have better knowledge and positive attitude compared to those with lower education (Pham-Duc *et al*., 2019). Interestingly, Mwanga *et al.* (2019) reported that farmers' education level was not associated with adoption of new methods. This could be because of informal exchanges of information among farmers as well as experience obtained through actual practice, which can, in some instances provide crucial information, more than formal education would. This was supported by Hundal *et al*. (2016), who revealed that education and age of a farmer did not affect their knowledge level and awareness of the prevalent diseases. Interestingly, a study in Turkey by Özlü *et al.* (2020) found that high level of education amongst farmers does not necessarily result in them having better livestock practices, even though they might have better knowledge than their less educated counterparts.

Access to animal handling facilities (AHFs) has been reported as having a positive influence on livestock farmers' choice to practice any form of animal health care practice (Mdlulwa *et al*., 2021). AHFs are important for the management of animal health as resource poor farmers can make use of these facilities when treating and vaccinating their livestock, making it easier to work on the animals. The most popular AHFs available to farmers are the dipping tanks, neck clamps, and loading ramps.

2.4 Conceptual Framework

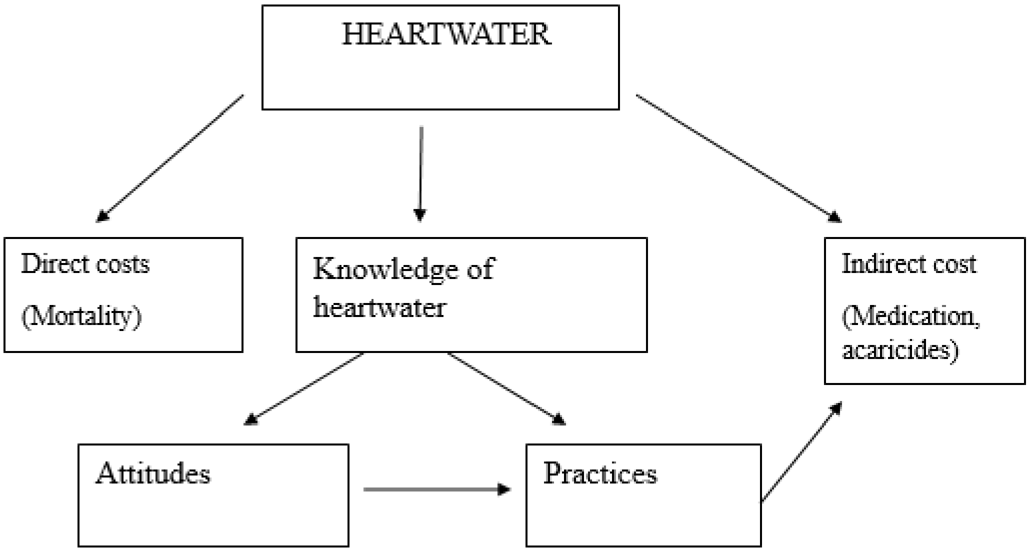

Figure 2.5: Conceptual framework

Source: Author's compilation

Figure 2.5 outlines a comprehensive framework for understanding heartwater, focusing on the KAP of farmers. Within the context of heartwater, both direct and indirect costs play a significant role, as seen in existing literature. The interconnectedness of these factors is depicted through the links in the diagram, illustrating the intricate relationships between different elements. Notably, a farmer's knowledge about heartwater emerges as a key determinant influencing the quality of their practices. The more informed a farmer is about the disease, the more effective and informed their approach to managing it is likely to be. This knowledge, also, directly shapes the attitudes farmers hold regarding heartwater.

Moreover, the diagram highlights the presence of indirect costs associated with heartwater, specifically the expenses related to medication and acaricides. These costs, while potentially burdensome for all farmers, pose a particular challenge for small-scale farmers. This observation underscores a crucial link between farmers' practices and the economic implications they face. In essence, the figure provides a nuanced portrayal of the multifaceted dynamics within the realm of heartwater, emphasizing the interplay between knowledge, attitudes, practices, and the economic considerations associated with disease management.

2.5 Chapter Summary

This section delved into a comprehensive review of empirical studies relevant to the current research. It commenced by reviewing essential concepts, namely heartwater disease and indigenous knowledge, and subsequently examined prior investigations conducted on both a local and international scale. The studies were conducted in numerous African countries (South Africa, Zimbabwe, Tanzania, Ethiopia, etc.) which are affected by various TBDs including heartwater disease. The reviewed studies provided critical information regarding farmers' socioeconomic characteristics that are likely to influence farmers KAP. It also looked at the influence those characteristics have on the knowledge, attitude, and practices of farmers around heartwater disease. Several of the studies reported that livestock farmers' age, gender, their education level, access to AHFs, etc. have an influence on farmers' KAP around heartwater disease. It was also noted from some of the studies that farmers often interface/combine indigenous and ethnoveterinary knowledge with modern methods to protect their livestock against ticks and also to treat TBDs. This shows that the two different practices are in fact complementary to each other.

CHAPTER 3: METHODOLOGY

3.1 Study area

This KAP study was conducted in the Mpumalanga Province, which is characterised by summer rainfalls. The study area (24° 49‘60‖ S and 31° 4‘0‖ E) is situated in the South African lowveld vegetation, on the border between the Mpumalanga and Limpopo Provinces. The Kruger National Park borders the Bushbuckridge Local Municipality on the east, while the Limpopo Province borders the northern parts of the Municipality (see Figure 3.1). Agriculture is one of the two leading sectors in the province, constituting 60% of the total land area in Mpumalanga (Khwidzhili and Worth, 2020), with 76 307 households practicing livestock farming (Community Survey, 2016).

The current KAP study took place in the Bushbuckridge Local Municipality (BLM), which is a Category B municipality located within the Ehlanzeni District in the northern parts of the Mpumalanga Province. It is the biggest among the four municipalities that formulate the district, accounting for over a third of its land space (Local Government Handbook, 2019). The area is predominantly rural, and it is characterised by smallholder farming activities (Chepape *et al*., 2014). Many tick species, including *Amblyomma* ticks, which transmit heartwater disease, thrive in the area (Van der Steen, 2014), hence it was befitting to conduct the current study to provide insights on the knowledge, attitude and practices regarding heartwater disease amongst livestock farmers in the area.

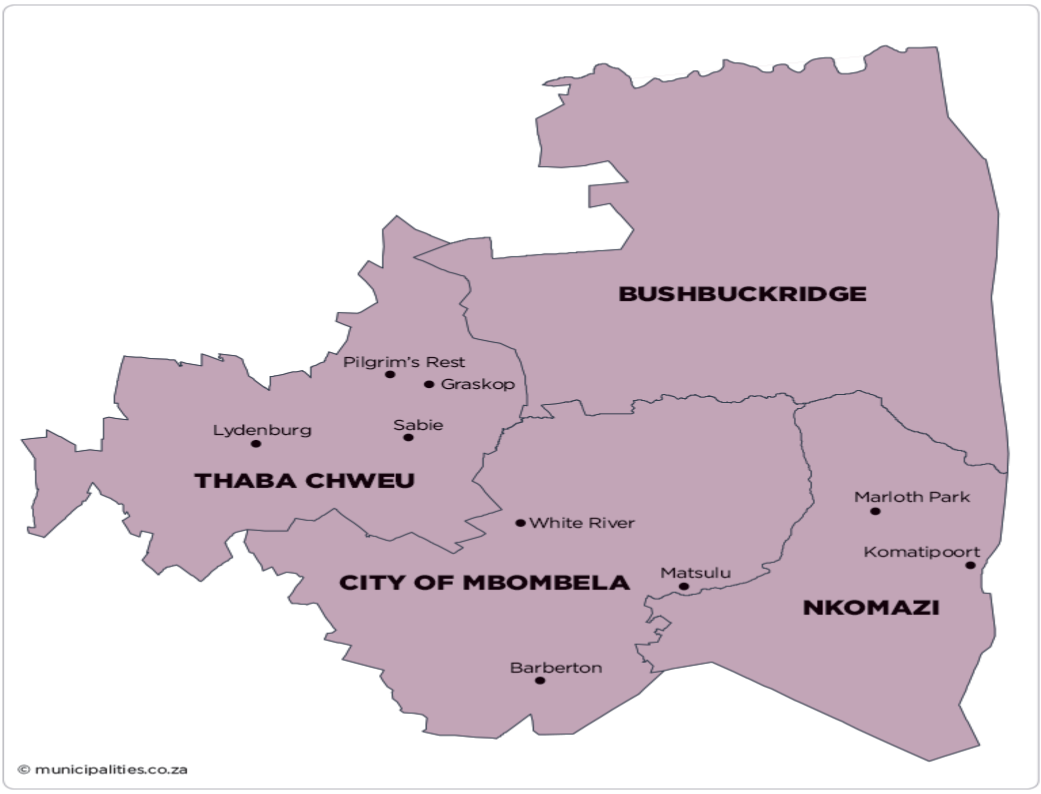

Figure 3.1: Map of Mpumalanga showing Bushbuckridge local municipality

Source: Municipalities South Africa (2019).

3.2. Sampling procedure

The study used a quantitative research approach, with the inclusion of primary cross-sectional data that was obtained by structured questionnaires based on the objectives of the study. The questionnaire, which consisted of open-ended and closed questions, was used to collect the required data on the KAP of smallholder farmers towards heartwater disease. Data gathered in the survey included, but not limited to, the following: demographic information, household characteristics, sources of income in the households, type of livestock kept, livestock activities and access to health facilities, insight of other tick-borne diseases and perceptions on possible livestock vaccination.

Due to the large area size of the BLM, the study employed a multi-stage sampling method. The multi-stage sampling technique was considered best for this study because it is useful when dealing with a large population (Sharma, 2017) while it is also known to increase precision of results (Acharya *et al*., 2013). In the first stage, a purposive sampling approach was conducted to select the study area. The second stage involved stratified sampling. This sampling method allowed the smallholder livestock farmers to be put in to separate strata based on the type of livestock they own (e.g., cattle owning and goat owning farmers). The third stage involved the selection of farmers through the simple random sampling technique. According to the records of Animal Health Technicians (AHTs), 909 farmers engaged in livestock farming were identified from the surveyed regions. To align with Kabir's (2015) guidance, a sample of 180 smallholder livestock farmers, constituting 20% of the population, was randomly selected for the study.

Since the research took place during the COVID-19 periods, throughout the interviews, both the researcher and trained enumerators for the study adhered to COVID-19 health protocols, as gazetted by the South African Government. This includes, but not limited to, wearing masks all the time, and keeping safe distances during the interviews in order to minimize the risk and to ensure the safety of both researchers and the respondents. The permission to conduct this study was sought from the Turfloop Research Ethics Committee, which provided a certificate of approval (see Appendix 1 for reference). In line with the ethics of conducting research, respondents' privacy, anonymity was adhered to in line with the Protection Of Personal Information (POPI) act. Furthermore, respondents' right of consent was respected fully.

3.3. Analytical techniques

3.3.1. Descriptive statistics

Descriptive statistics method was used to identify and describe farmers' socio-economic characteristics. This was based on the summary counts of the questionnaire structure and the use of means, percentages, and frequencies. The descriptive statistics also provided key insights into the farmers' KAP. To obtain the descriptive results, the data was gathered and encoded on a spreadsheet using Microsoft Excel before being uploaded to the Statistical Package for the Social Sciences (SPSS) version 25 software. The SPSS was then used to analyse the data, thereafter, giving results in the form of tables and figures.

3.3.2. KAP survey framework

In order to address the second objective of this study a KAP survey was used. A KAP survey is a quantitative type of method, which consists of clearly defined questions compiled in standardised questionnaires that gave access to quantitative and qualitative data about the KAP of the subjects.

Subsequently, in this current study, the KAP survey framework was used to investigate farmers' behaviour concerning heartwater disease, where knowledge (K) was what the farmers know about heartwater disease, attitude (A) referred to their feelings of and perceptions about the disease, and practices (P) were what the farmers are doing about the disease. The KAP questions have managed to reveal not only characteristic traits in knowledge, attitudes, and various practices, but also the thoughts that each farmer has regarding the disease. Table 1 below contains the guidelines that were followed in analysing the KAP of farmers.

Table 1: The KAP theoretical framework; description, attributes, and unit of measures

Component	Definition	Attributes	Unit of Measure	Sources
Knowledge	Farmers' understanding of heartwater disease and its possible effects	- Farmers' knowledge about heartwater disease, knowledge about the symptoms of heartwater - Farmers' knowledge about the dangers of heartwater on livestock - Indigenous Knowledge about ethnoveterinary medication used for heartwater	**Five-point Likert scale** Scaling range: Strongly Agree, Agree Neutral, Disagree and Strongly Disagree	**Koo *et al.* (2015).** **Kabir (2015).**
Attitudes	Attitude refers to the feeling towards the methods used for the control and management of heartwater as well as any preconceived ideas that farmers possess about the disease	- Farmers' assertiveness about their current control measures for heartwater disease - Farmers' attitudes towards other indigenous and modern practises of controlling heartwater disease - Farmers' assertiveness about the potential of vaccines as a means of controlling heartwater disease in livestock	**Five-point Likert scale** Scaling range: Strongly Agree, Agree Neutral, Disagree and Strongly Disagree Farmers who agree to the statements were regarded as having a positive attitude and those who do not agree were regarded as having a negative attitude.	**Meijer *et al.,* 2015.** **Koo *et al*. (2015).**
Practices	Practices refers to what farmers are currently doing as informed and influenced by their knowledge and attitudes related to heartwater	- The indigenous methods used by livestock farmers to manage heartwater. - Modern practices that the farmers use to manage heartwater. - The chemical acaricides used by the farmers to control ticks	**Binary response** Scaling: 2 if the farmer preferred conventional methods, 1 for indigenous methods.	**Kabir (2015).**

For measuring knowledge and attitude of the respondents a 5-point Likert scale was used. The 5-point scale: strongly agree, agree, neutral, disagree and strongly disagree with assigned score 5, 4, 3, 2 and 1, respectively. The scores for knowledge and attitude of farmers were transformed into percentage scores by dividing the scores obtained by the respondents with the possible maximum scores and multiplied by 100, following the methods used by Koo *et al.* (2015). Based on the sum scores, level of knowledge was classified into low-level knowledge (less than 60%; 0-42 scores), medium-level knowledge (from 60% up to 80%; 43-56 scores) and high-level knowledge (greater than 80%; 56-70 scores). Meanwhile, the scores for farmers' attitude were classified into negative attitude (less than 60%; 0-36 scores), neutral attitude (from 60% up to 80%; 37-48 scores) and positive attitude (greater than 80%; 47-60 scores).

For scaling the practices, 1 point was given for using an indigenous method to control heartwater disease, while 2 points were given for each contemporary practice used, with a possible total score of 9. Based on the sum scores, usage of indigenous practices was noted if a particular farmer scored 33% or less (3 points and under), modern practices were from 33% to 66% (4-6 points out of 9), and lastly, a combination of these methods was observed when farmers scored over 66% (7-9 points).

3.3.3. Multinomial logistic regression model

The Multinomial Logistic Regression (MLR) model serves the purpose of forecasting the categorical placement or the likelihood of category membership on an outcome variable. This prediction relies on multiple independent variables, as outlined by Starkweather and Moske (2011). The model also has the ability to handle both categorical and continuous variables (Liang *et al.*, 2020). In this study, it was used to analyse the factors, which influenced the KAP of farmers. According to Greene (2002), MLR model specification is as follows:

$$\text{Prob}\ (y_i = j\ |x_i) = P_{ij} = \frac{exp(\beta'_j x_i)}{1+\sum_{k=1}^{j} exp(\beta'_k x_i)}$$

Where; j = 0, 2, 3 … j: β = 0

j represents the categories of the dependent variable and j' is the reference category.

y_i is the dependent variable.

x is a vector of all the explanatory variables of the i^{th} observations. The specific MLR model for the study is expressed as:

$$log \frac{P_r\ (Y = j)}{P_r\ (Y = j')} = \alpha + \beta_1 GND + \beta_2 MS + \beta_3 AGE + \beta_4 HHS + \beta_5 LE + \beta_6 NA + \beta_7 IL + \beta_8 FE + \beta_9 AES + \beta_{10} AC + \beta_{11} KHW + \beta_{12} DLS$$

Given that knowledge, attitude, and practices are three variables representing different aspects, this study ran a Chi-square test of independence between the dependent variables to test for any significant relations. After obtaining evidence of a relationship between the dependent variables, the MLR model was used to analyse the data. First, knowledge was categorised as low, moderate, and high level of knowledge. Moderate level of knowledge was used to represent the reference groups. Second, attitude was categorised as negative, neutral, and positive attitude. Third and lastly, practices were categorised as indigenous, modern and both indigenous and modern practices.

Table 2: Variables considered in the study for MLR model

Dependent Variables	**Measurement**	**Expected sign**
Knowledge (K)	Low, moderate, or high	
Attitude (A)	Negative, neutral, or positive	
Practices (P)	Indigenous, modern or both	
Independent Variables		
1. Gender (GND)	Dummy	Positive
2. Marital status (MS)	Dummy	Negative
3. Age (A)	Years	Positive
4. Household size (HHS)	Number	Negative
5. Primary occupation (PO)	Categorical	Negative
6. Level of education (LE)	Years	Positive
7. Number of animals (NA)	Number	Positive
8. Source of income (SOI)	Rands	Negative
9. Farming experience (FE)	Years	Positive
10. Access to animal handling facilities (AAHF)	Dummy	Positive
11. Access to extension (ATE)	Dummy	Positive
12. Annual expenditure (AEX)	Rands	Negative
12.Vaccinate against heartwater (VAH)	Dummy	Positive
13. Dipping livestock (DL)	Dummy	Positive

Source: Author’s Compilation (2022)

4. RESULTS AND DISCUSSIONS

4.1 Farmers' demographics

This section discusses the demographic features of the household head, which include gender, age, and level of education.

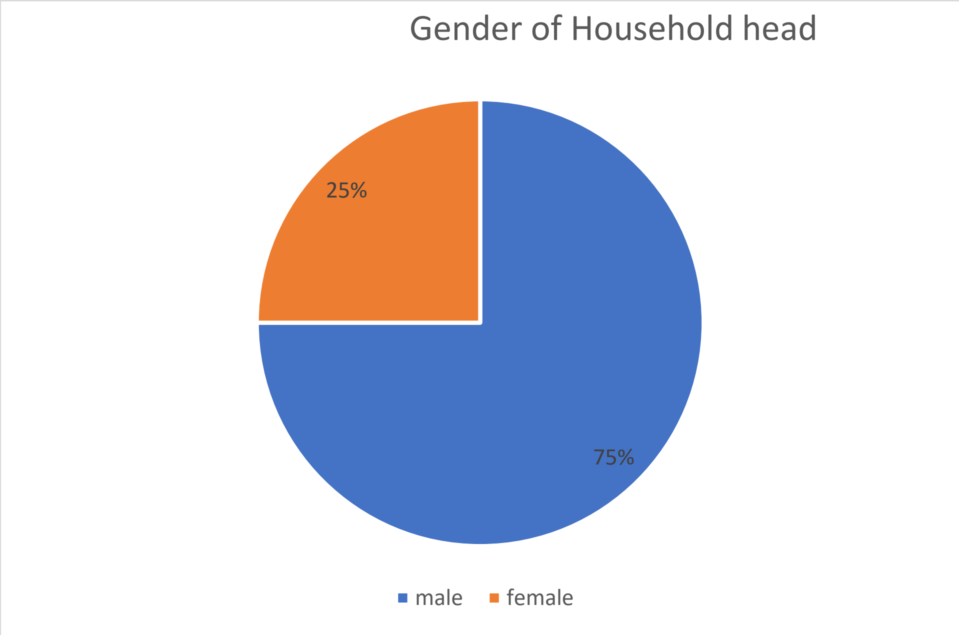

Figure 4.1.1: Gender of household head

Source: Field survey data (2022)

Gender

The results in Figure 4.1.1 show that male headed households constitute three quarters (75%) of those involved in livestock rearing, way more than the female headed households (25%). These results follow the general trend in many parts of South Africa as Yawa *et al*. (2020) reported that the majority (84%) of livestock farmers were males. Tyasi *et al*. (2022) added that this is frequently expected because of the traditional and cultural customary beliefs of African rural people who believe that the man is the head of the household and so has the ultimate say in livestock-related issues. It is also hard for women to care for livestock because they are sometimes prohibited from entering into the livestock kraals (Muyambo *et al*., 2017). Similar findings were reported in Zimbabwe (Sungirai *et al.* 2016) where males outnumber females in livestock farming in communal areas.

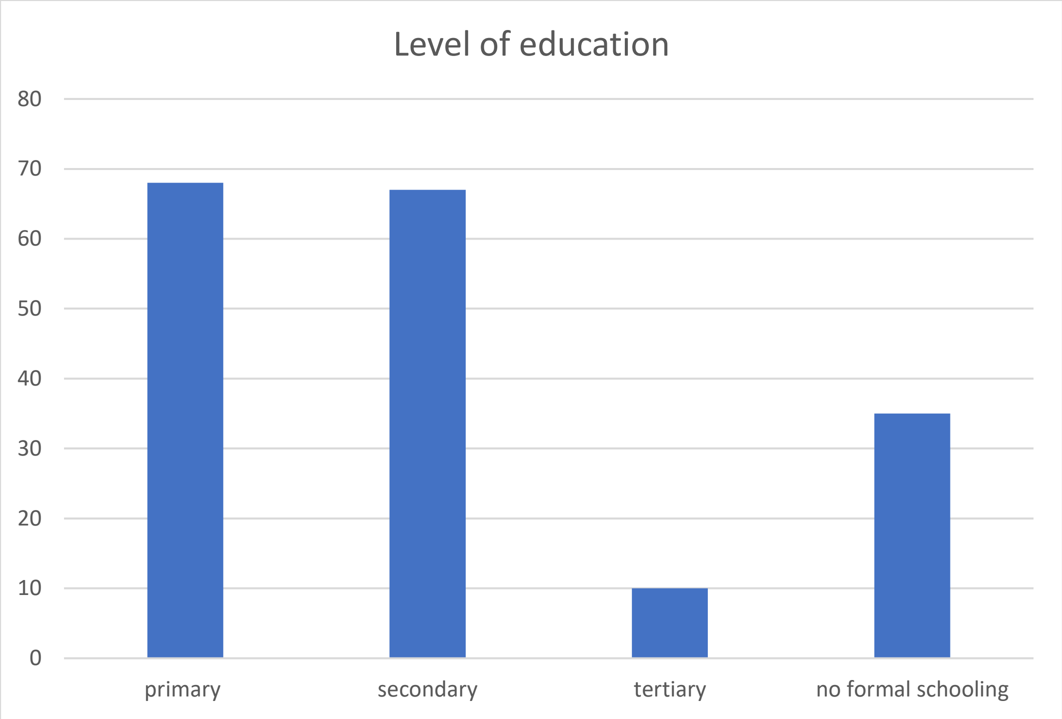

Figure 4.1.2: Education level of respondents

Source: Field survey data (2022)

Results in Figure 4.1.2 show that primary education was the highest (38%) ranked level of education obtained by the farmers in the study area, followed by secondary education with 37%. This suggests that farmers in the study area were fairly literate and are likely to be able to read and write to some degree. These results are in line with the results obtained by Habiyaremye *et al.,* (2017) as they reported that two-thirds (66%) of the livestock farmers in their study were in possession of a form of formal education. The relatively low level of education attained by farmers is most likely due to limited chances for higher learning in rural locations where most smallholder farmers are based (Olaogun *et al.,* 2023). In addition to this, Moutos *et al.* (2022) found that the higher education levels of farmers are associated with better knowledge about diseases and related practices.

Table 3: Farmers' age and farming experience

Respondent's age					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Age	180	20	98	58.61	14.118
Valid N (listwise)	180				
Farming experience					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Experience	180	1	51	18.19	12.292
Valid N (listwise)	180				

Source: Field survey data (2022)

Age

According to Table 3, the average age of the respondents in this study was 59 years. These results follow the general trend of older members of the community being the main livestock farmers in rural South Africa, which was observed by Tada *et al*. (2012) and Oladele *et al*. (2013). The survey results reveal that fewer young or middle-aged individuals own livestock or have full-time jobs in livestock production. Only 11% of farmers were under 40 years old, 15% were aged 40-49, 23% were 50-59, and the majority, 51%, were 60 years old and above. These results can be likened to those of Mdungela *et al*. (2017) who reported that young individuals tend to leave rural areas due to the expensive living conditions and limited job opportunities. This migration results in an increase in the number of older livestock farmers in rural areas, as they continue relying on farming for their livelihoods. However, a study conducted in India by Hundal *et al*. (2016), found that most of the farmers handling livestock were younger people, most of which, were below the age of 40 years old.

The presence of older farmers in livestock farming has influenced the overall experience of farmers. In the study area, farmers, on average, have been engaged in livestock farming for 18 years. This duration is not surprising, considering the age demographics observed in the communities. Ngoshe *et al.* (2022) found that older farmers are usually more knowledgeable about livestock diseases and have better practices in terms of disease prevention and management compared to their younger and less experienced counterparts. However, Sylvain *et al.* (2021) found different results as they reported that it is possible for farmers to have considerable experience but lack knowledge of ticks and TBDs, thus leading to a shortage of effective tick control measures, showing that experience does not always equate to better knowledge.

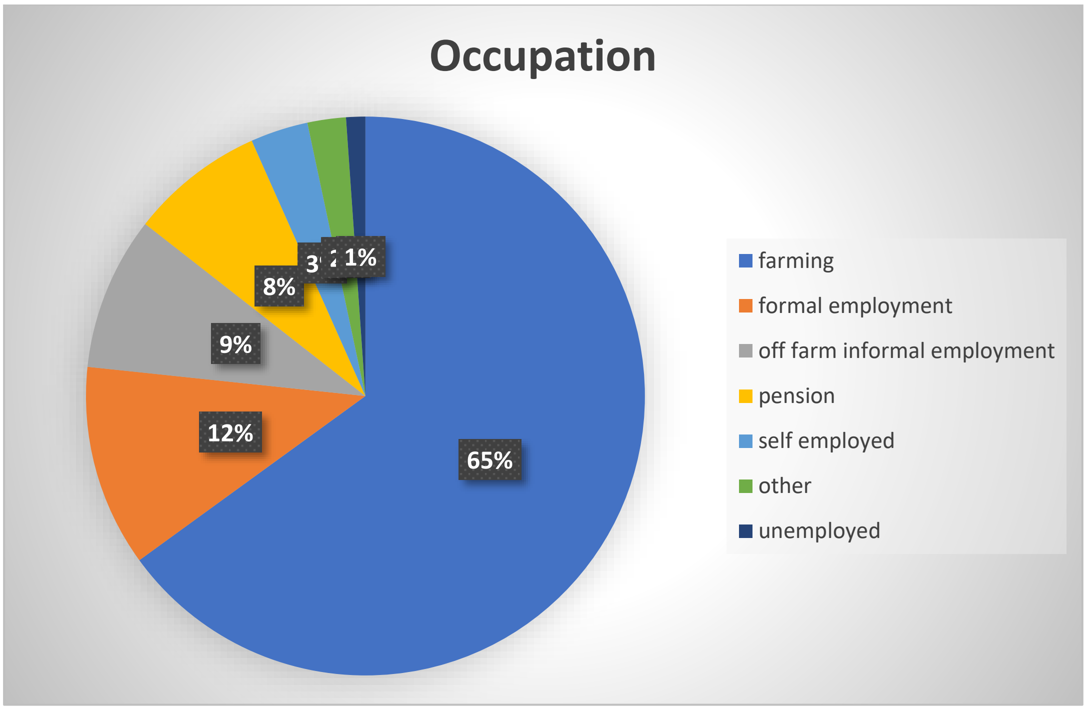

Figure 4.1.3: Respondents' occupation

Source: Field survey data (2022)

Primary occupation

As for the occupational statuses of the livestock farmers, the results reported in Figure 4.1.3 indicate that 65% of the farmers devoted their full-time to rearing livestock, which was dominated largely by males. This concurs with the findings of Zannou *et al.* (2021), who found that livestock farming was the main occupation for most farmers. The fact that more men compared to women were engaged in full-time livestock production may be a result of the gendered nature of livestock keeping and the patriarchal role-distribution among African families in rural areas, where males as heads of households are in charge of looking after and caring for the livestock, while women may be more involved in tasks in and around the household.

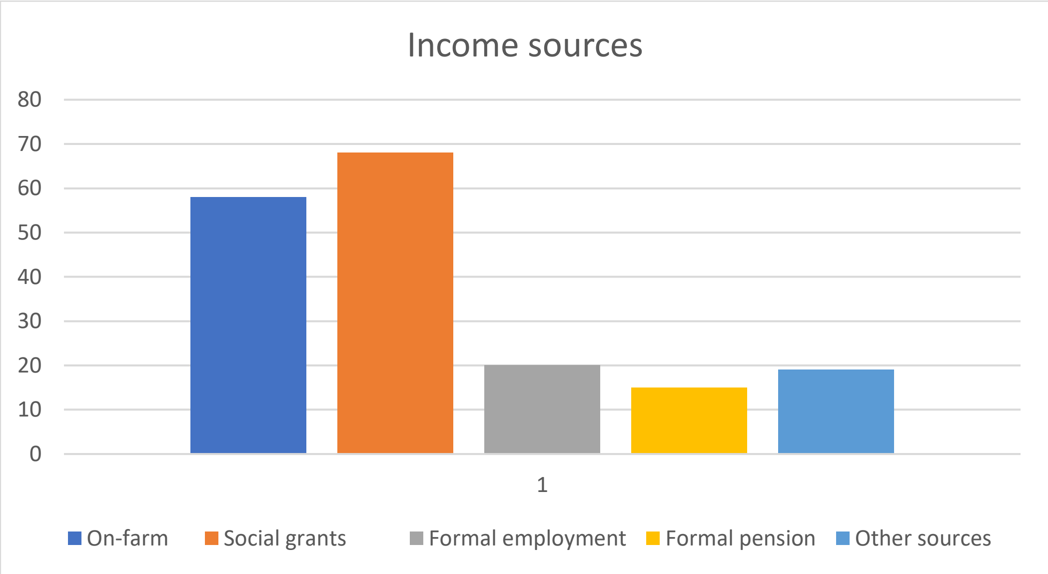

Figure 4.1.4: Respondents income sources

Source: Field survey data (2022)

Income sources

Figure 4.1.4 shows that 68 of the 180 surveyed farmers (38%) in the study area relied on social grants as their main source of income. This is because older individuals, often unemployed and recipients of social grants, typically make up the majority in the livestock farming sector. This is in line with the results by Oladele *et al*. (2013), where they wrote that older farmers rely mainly on the social grants from the government or pensions from their past employers. However, there were sizeable variations across the surveyed households because some heads rely on social grants only, while others have formal employment. There was also a significant number of farmers who had combinations of these sources of income. As they were predominantly elderly people, they received social grants and also had income from their livestock farming practices.

Table 4: Household size

Household size					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Household size	180	1	18	5.59	2.904
Valid N (listwise)	180				

Source: Field survey data (2022)

The average household size in this study was found to be around 6 people per household (see Table 4). This high number is due to the fact that certain households had over 6 members, with one having as much as 18 members. Household size is a significant component in determining labour availability for livestock management practices (Nkonki-Mandleni *et al*., 2019). This implies that as the number of individuals within a household increases, the probability of their engagement in labour associated with livestock handling activities also rises.

Table 5: Livestock ownership

Livestock Owned	**Average**	**Min**	**Max**	**Std Dev.**
Cattle	14	1	97	14.23
Goats	10	1	89	12.16

Source: Field survey data (2022)

Table 5 shows that the farmers interviewed in this study all fit the criteria of being regarded as smallholder farmers as their herd sizes were 1-97 and 1-89 for cattle and goats, respectively. The average flock size for goats was 10, which is in line with the results by Masika and Mafu (2004), who also reported an average herd size of 10. For the cattle, a mean of 14 animals per herd was found, which concurs with the results by Mohamed-Brahmi *et al*., (2022), who reported similar findings on average cattle herd sizes. Farmers with a larger herd size are generally more likely to have better knowledge, as reported by Panchbhai *et al.* (2017), who found that livestock herd sizes had a highly significant relationship with the knowledge level of farmers in terms of improved farming practices.

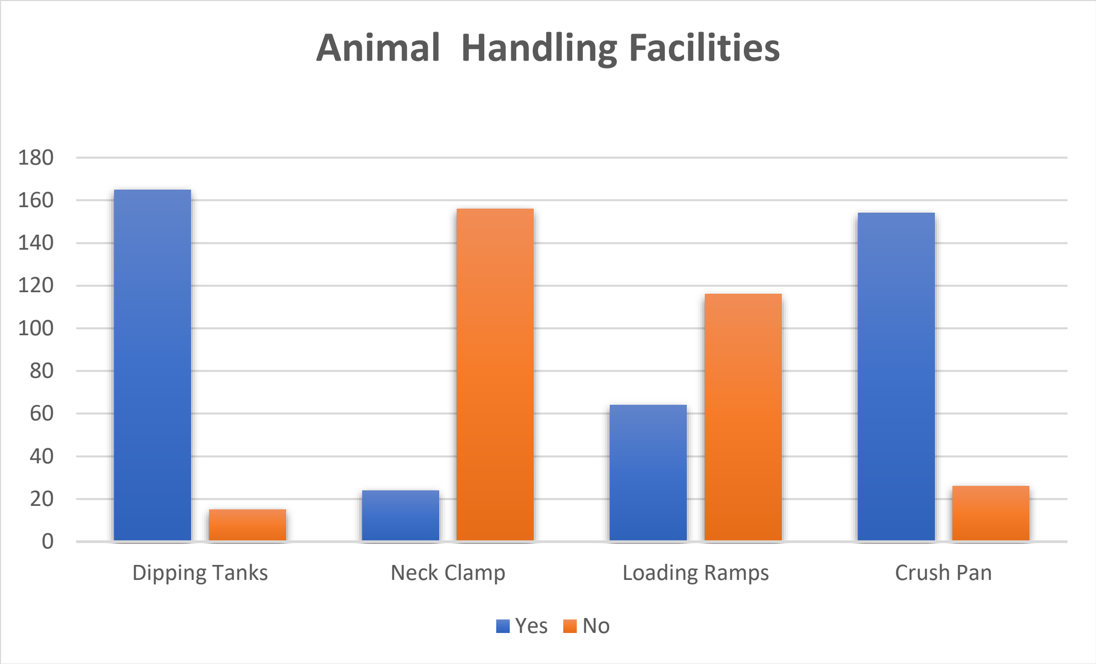

Figure 4.1.5: Respondents' access to animal handling facilities

Source: Field survey data (2022)

According to the results presented in Figure 4.1.5, most farmers (93%), from the surveyed areas in Mpumalanga Province had access to animal handling facilities (AHFs). Dipping tanks and crush pans were the most accessible facilities to farmers as 92% and 86% of the farmers reported that they had access to these, respectively. These results are in line with findings by Mdlulwa *et al.* (2021), who found that a majority of the smallholder livestock farmers in Mpumalanga Province have access to a form of animal handling facility. AHFs are important for the management of animal health as resource-poor farmers can make use of them when treating and vaccinating their livestock, allowing for the easy handling of animals.

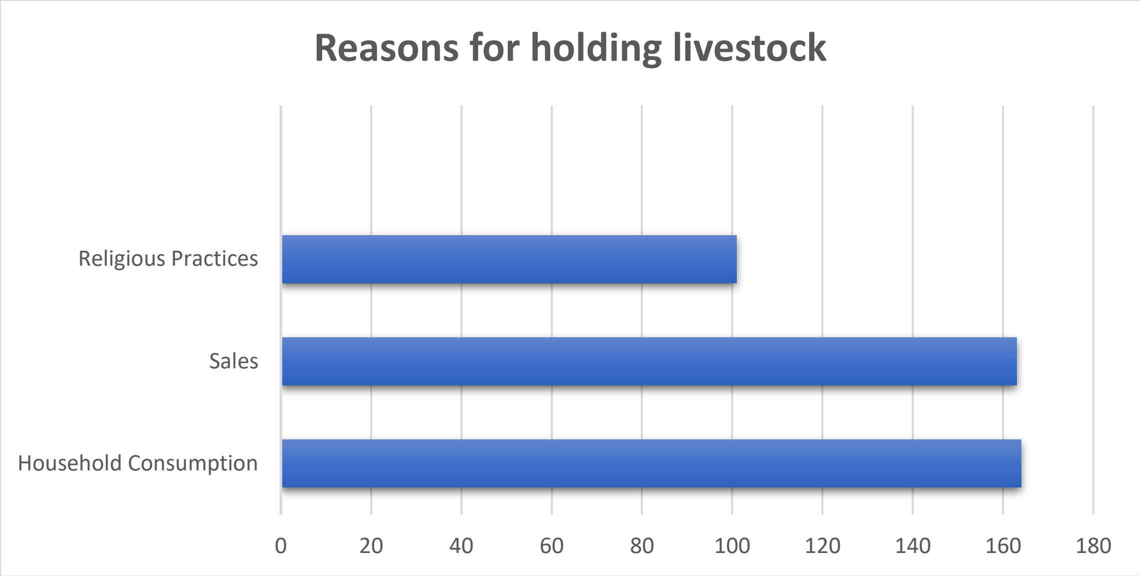

Figure 4.1.6: Respondents' reason for holding livestock

Source: Field survey data (2022)

According to the results presented in Figure 4.1.6, three main reasons farmers in the study area kept livestock were for their own consumption within the household, followed by selling livestock for income generation, and then for religious/social practices. Livestock is used for a variety of functions such as the provision for food security, (Donadeu *et al.,* 2019; Chipasha *et al.,* 2017), social and cultural values such as ancestral rituals, *lobola* (bridal) payment (Chakale *et al*., 2021), as well as for income generation for most of the smallholder farmers living in the rural areas (Kerario *et al.,* 2018).

4.2 KNOWLEDGE, ATTITUDE AND PRACTICES

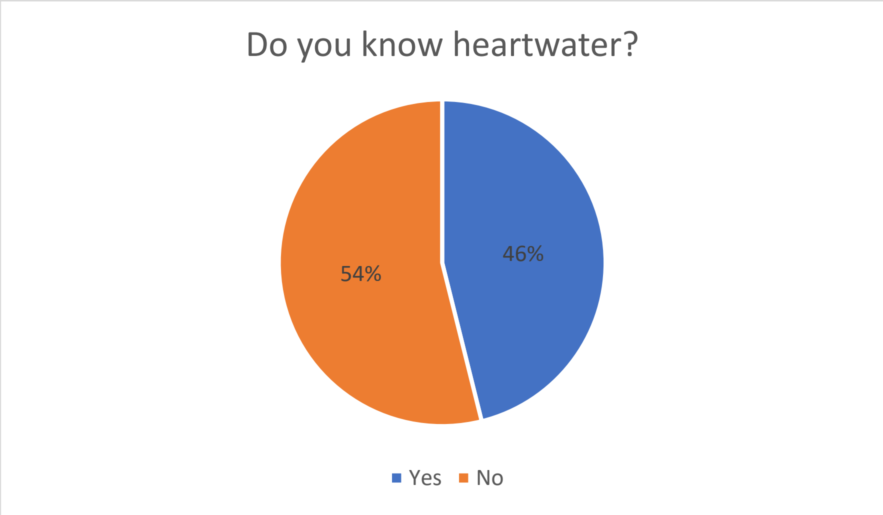

Figure 4.2.1: Respondents' knowledge on Heartwater disease

Source: Field survey data (2022)

Knowledge on Heartwater Disease

The interviewed livestock farmers in the study area were asked if they were knowledgeable about the heartwater disease, and 54% of them denied knowing the disease (See Figure 4.2.1). This shows that in the study area, a majority of the farmers do not know this livestock disease. Further questioning followed in the form of a 5-point Likert scale to determine the actual level of knowledge of the farmers.

Table 6: Likert scale results on Respondents knowledge of Heartwater disease

Knowledge Of Heartwater Disease	**Strongly Disagree and Disagree %**	**Neutral %**	**Agree and Strongly Agree**
I am knowledgeable about heartwater	51	11	38
Heartwater is an important disease in livestock	27	50	23
Do you know symptoms of heartwater	46	15	39
Heard about heartwater from media	81	10	9
Heard about heartwater from farmers	55	10	35
Heard about heartwater from Animal Health Technician	49	14	37
Heartwater kills livestock	8	53	39
Heartwater is caused by ticks	12	58	30
Heartwater affects wildlife	6	66	28
Heartwater is seasonal	10	56	34
I use vaccines to control heartwater	36	33	31
Vaccines work best in preventing heartwater	7	61	32
Acaricides work well in controlling heartwater	7	67	26
Traditional remedies work in controlling heartwater	22	66	12

Source: Field survey data (2022)

In Table 6, we looked at farmers' opinions using the Likert scale. It turns out that 51% of the farmers we interviewed did not know much about heartwater disease. This matches up with other questions we asked, where half of the farmers did not really know much or were not aware about how important heartwater disease is for their animals. Basically, most farmers did not agree that they knew the symptoms of this disease very well, showing that there is limited awareness about it.

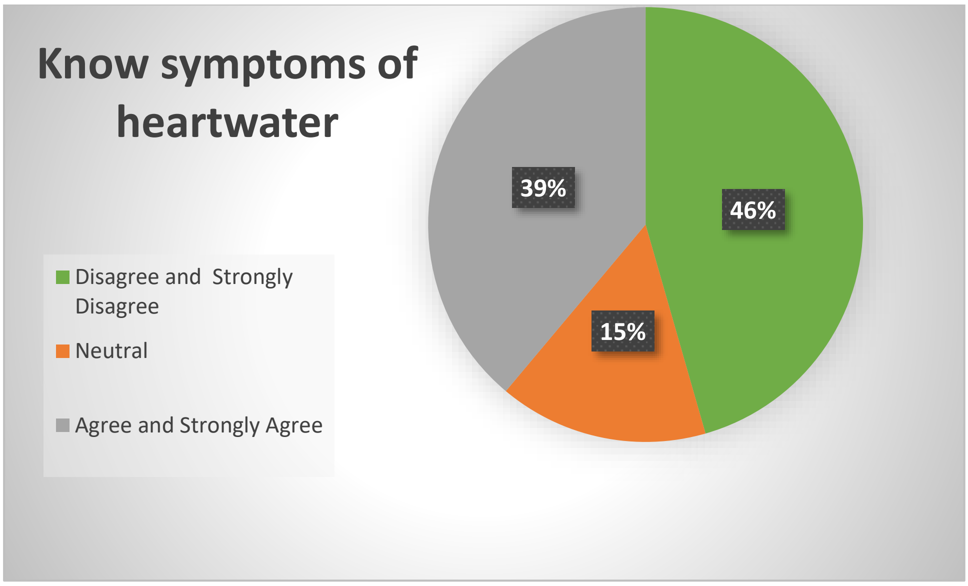

Figure 4.2.2: Respondents' knowledge on symptoms of heartwater disease

Source: Field survey data (2022)

Knowledge on Symptoms of Heartwater Disease

According to Figure 4.2.2, only 39% of the farmers in the study area agreed that they knew symptoms of heartwater disease, while a majority (46%) of the farmers indicated they did not know symptoms of the heartwater disease. This is in line with the findings by Zannou *et al.* (2021), who reported that farmers in Burkina Faso have very limited knowledge with regards to TBDs. Interestingly, a study in Ethiopia by Duguma (2020) found contradicting results, which indicated that farmers knew about heartwater, and they were also able to mention its symptoms very well. Furthermore, Duguma (2020) findings were supported by Katiyatiya *et al*. (2014)'s findings who also found that a majority of livestock farmers were able to describe the clinical signs associated with the common TBDs that they faced. Most of the farmers in the study area had noticeably better knowledge about other livestock diseases relative to heartwater disease. Foot and mouth disease was the most common disease mentioned by the farmers, followed by Lumpy skin disease. Heartwater disease came in third place, followed by Blackquarter and Anthrax (see Table 7). Some of the farmers were even able to state their symptoms as well as the indigenous names of these diseases (The indigenous name of Lumpy skin disease was not mentioned).

Table 7: Indigenous and common names of livestock diseases (from most to least commonly mentioned)

Common name	**Indigenous name**
Food and mouth disease	*Nzom-zom*
Blackquarter	*Mukhonwana*
Heartwater	*Xihlokwahlokwane*
Anthrax	*Rivengo*

Table 8: Levels of knowledge

Possible score	**Observed scores**	**Levels of Knowledge**	**Number**	**Percentage**	**Mean**	**Std deviation**
14-70	27-61	Low	98	54	40.94	8.138
		Medium	75	42		
		High	7	4		

Source: Field survey data (2022)

The farmers' knowledge on heartwater disease was generally poor as a majority (54%) of them obtained unsatisfactory scores (refer to Table 8). Meanwhile, 42% of the farmers had medium level of knowledge and only 4% of the interviewed farmers showed high level of knowledge towards heartwater. The low level of knowledge was supported by the mean of the scores, as the average of 40.94 fell below the 42 score, which was the cut-off point for low level of knowledge.

Table 9: Likert scale results (Attitude)

Attitude Of Farmers	**Strongly Disagree and Disagree %**	**Neutral %**	**Agree and Strongly Agree %**
I have interest in learning about the disease	3	1	96
My present knowledge of heartwater is enough	73	20	7
I feel that the methods I use currently are the best	43	43	14
I feel that acaricides are expensive	3	24	73
Government should provide acaricides	1	3	96
Vaccines are expensive	3	17	80
I am willing to spend money on heartwater vaccines	21	20	59
Vaccines cause harm/negative effects to animals	50	36	14
Vaccines work as medicine	37	42	21
I would stick with the current methods to control heartwater	47	38	15
Without the assistance of AHT, I would not be able to deal with heartwater	28	32	40
I believe that wildlife causes heartwater	11	69	20

Source: Field survey data (2022)

According to results in Table 9, 76% of the farmers revealed that they had interest in learning more about the disease, its causes, and symptoms, as well as possible remedies as they felt their present knowledge regarding the disease is not enough. Notably, 73% of the farmers felt that acaricides and vaccines were too expensive for their liking and affordability, and that the government should be tasked with providing them with the acaricides and vaccines. This indicates a prevalent unfavourable sentiment regarding the substantial expenses associated with managing the disease (acaricides, vaccines, etc.), potentially constraining their utilization. In connection to this, 58% of farmers stated their willingness to invest significant funds in obtaining vaccines to protect their source of livelihood.

These results are in line with those by Maziya *et al*. (2019), who reported that most farmers were aware of the importance of vaccines on livestock, despite feeling that they are too expensive for them. Additionally, Williams *et al*. (2022) also found that the high cost of vaccines were ranked amongst the top factors that influenced the decisions of farmers on vaccinating their animals. The negative attitude farmers had on vaccinations and their high cost was supported by the findings of Monje *et al*. (2020), who found that the level of knowledge (which was low in this study), has an influence on the attitude of farmers.

Table 10: Respondents level of attitude

Possible score	**Observed scores**	**Categories of attitude**	**Number**	**Percentage**	**Mean**	**Std deviation**
12-60	21-56	Low	16	9	42.24	4.974
		Medium	141	78		
		High	23	13		

Source: Field survey data (2022)

The attitude of the farmers was generally neutral as 141 farmers (78%) obtained scores of 60-79 from the survey (Table 10). Thirteen of the farmers had a positive attitude, while 9% were recorded as having a negative attitude overall. The mean of the attitude scores was found to be 42.24, indicating that most of the farmers indeed showed a neutral attitude to the questions about heartwater (141 farmers’ scores were above 36 but less than 48). The results on knowledge revealed that farmers have limited knowledge about heartwater disease, which could be the reason for their neutral attitude. This is because good knowledge is often linked to a positive attitude (Kainga *et al*., 2020).

Table 11: Respondents cultural practices on Heartwater disease management

Type Of Practise Used	No %	Yes %
I use Ethno-veterinary medicine to control ticks and heartwater	91	9
I use acaricides to control ticks	38	62
I perform manual tick removal on livestock	89	11
I use chemicals to control ticks (Paraffin, Jeyes Fluid, etc.)	70	30
I vaccinate livestock against heartwater	67	33
I use a plunge dip for the livestock	20	80

Source: Field survey data (2022)

Due to the abundance of ticks and TBDs in communal areas during the wet summer months relative to cold and dry months, most of the farmers (62%) resorted to using pour-on dipping system at biweekly treatment intervals during the wet seasons and monthly during the dry seasons (as seen in Table 11). This was in line with the results by Yawa *et al*. (2020), who reported that farmers tend to apply acaricides more during seasons where tick infestation is high. Controlling ticks in livestock reduces the occurrence of heartwater and other TBDs.

It was observed that modern practices of dealing with ticks were used more than the traditional methods. For example, only 9% of the farmers reported the use of traditional herbs to treat heartwater within their herds, on the one hand. This concurs with the findings by Yawa *et al.* (2020), who found that most farmers do not possess knowledge on the usage of traditional plants to control ticks. Acaricides were used by 62% of the farmers, with dipping being the most common form of applying the chemicals, on the other hand. The acaricides were preferred due to their convenience and accessibility.

The usage of acaricides by the resource-poor farmers observed in this study is supported by van den Heever *et al*. (2023), who found that plunge dipping is a cost-effective method of controlling ticks in livestock herds, particularly for cattle

4.3. Factors influencing knowledge, attitude, and practices

Table 12: Chi-square test results-Knowledge and attitude

Chi-Square Tests			
	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	11.798[a]	4	.019
Likelihood Ratio	13.412	4	.009
Linear-by-Linear Association	7.024	1	.008
N of Valid Cases	180		

According to the Chi-square test outcomes shown in Table 12, there is sufficient evidence (p-value<0.05) indicating a connection between farmers' knowledge and attitude levels. This suggests a lack of independence between the dependent variables. This means that there is a significant relationship between the knowledge and attitude levels of farmers.

Table 13: Chi-Square test results- Knowledge and practices

Chi-Square Tests			
	Value	**Df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	17.371[a]	4	.002
Likelihood Ratio	17.407	4	.002
Linear-by-Linear Association	8.088	1	.004
N of Valid Cases	180		

The results in Table 13 show that there was strong evidence of an association between the knowledge of heartwater that farmers have and the practices they use for controlling the disease in their livestock. P-value<0.05 shows that there was no independence between the farmers' level of knowledge and the type of practices they used. These results are in line with those by Zhang *et al*. (2020), who reported that knowledge can influence an individual's attitude and practices towards a particular disease. Kainga *et al*. (2020)'s study revealed that there are possible links between low knowledge and negative attitudes, as well as between low knowledge and poor management practices. This suggests that elevating farmers' knowledge could potentially result in better attitudes and practices.

Table 14: Model fitting information and Pseudo R-Square

Model Fitting Information				
	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept only	330.635			
Final	244.121	86.513	26	<,001
Pseudo R-Square				
Cox and Snell	.382			
Nagelkerke	.454			
McFadden	.262			

Based on the model fitting information results in Table 14, the Chi-square value of 86.513 and the p-value<0.001 show that the model fits the data significantly. These show that the independent variables that were used in the model collectively contribute significantly towards determining factors, which influence livestock farmers' KAP. The generally used R-Square measure is the Nagelkerke (0.454), which shows that 45% of the variations in the dependent variables was explained by the used predictor variables. It is, however, important to note that although the Multinomial logistic regression computes Pseudo R-Square measures, such as Nagelkerke's R-Square, these do not really reveal much about the accuracy or errors associated with the model (Baloi and Chaminuka, 2017). Furthermore, values from 0.2 to 0.4 for the McFadden R-Square are seen as highly satisfactory, which is what was observed in the results of this study (Petrucci, 2009).

Table 15: Multinomial Logistic regression results

Knowledge Levels		B	Std. Error	Wald	Df	Sig.	Exp(B)
Low-level Knowledge	Intercept	5.160	2.055	6.304	1	.012	
	Age	.001	.018	.002	1	.969	1.001
	Gender	.159	.507	.099	1	.753	1.173
	HHS	-.068	.075	.821	1	.365	.934
	LE	-.374	.302	1.536	1	.215	.688
	PO	-.327	.142	5.302	1	.021**	.721
	SOI	.471	.218	4.663	1	.031**	1.601
	FE	-.007	.018	.135	1	.713	.994
	AAHF	-1.600	.927	2.982	1	.084***	.202
	ATE	-.418	.885	.223	1	.637	.658
	MOA	-.262	.412	.404	1	.525	.770
	DL	-1.482	.496	8.910	1	.003*	.227
	VAH	-2.402	.476	25.492	1	<,001*	.091
	AEX	.000	.000	.324	1	.569	1.000
High-level Knowledge	Intercept	-1.477	2.918	.256	1	.613	
	Age	.017	.029	.356	1	.551	1.017
	Gender	1.825	.957	3.638	1	.056***	6.204
	HHS	.094	.096	.948	1	.330	1.098
	LE	-.713	.454	2.468	1	.116	.490
	PO	-.538	.306	3.087	1	.079***	.584
	SOI	.609	.394	2.392	1	.122	1.839
	FE	.041	.028	2.184	1	.139	1.042

	AAHF	-1.742	1.114	2.447	1	.118	.175
	ATE	-2.175	1.200	3.287	1	.070***	.114
	MOA	.810	.677	1.429	1	.232	2.247
	DL	-.150	.716	.044	1	.834	.860
	VAH	.516	.732	.496	1	.481	1.675
	AEX	.000	.000	4.910	1	.027**	1.000

Moderate level of knowledge was used as the reference category

*, ** and *** are used to denote 1%, 5% and 10% level of significance, respectively

The next subsections include the interpretations of the variables that were found to be significant in the MLR model. The following variables were regressed against the dependent variable: Age, Gender, Dipping Livestock (DL), Access to animal handling facilities (AAHF*),* Vaccinating against heartwater (VAH), Member of association (MOA), Access to extensionist (ATE), Annual expenditure (AEX), Household size (HHS), Level of education (LE), Primary occupation (PO), Farming experience (FE) and Source of Income (SOI). Of the 13 variables regressed, only 8 variables were found to be significant (Table 15), and they will be discussed in the next subsections.

Access to animal handling facilities (AAHF) – This variable exhibited statistical significance at the 10% level, indicating that having access to animal handling facilities decreases the probability of possessing a lower level of knowledge by 0.0202 odds. These results align with the observations of Mdlulwa *et al.* (2021), who found that AHF positively impacts livestock farmers' capacity to implement animal health care practices. These facilities streamline livestock handling, aiding in disease and parasite control, particularly with regards to ticks (Mampane, 2019). This means that AAHF makes it easier for farmers' to handle livestock, improving their ability to deal with ticks and TBDs like heartwater disease.

Dipping livestock (DL) – this variable was found to be negative and significant at the 1% level of significance. This implies that, holding other factors constant, a one unit increase in the frequency of dipping livestock reduces the probability of having low level of knowledge in heartwater disease by .0227 odds. This is due to the fact that farmers who know the dangers posed by ticks on their livestock usually resort to controlling the ticks, commonly through dipping the cattle (Yawa *et al*., 2020).

Vaccinating against heartwater (VAH) – this variable was found to be significant at 1% with a negative coefficient. This implies that using vaccines on livestock reduces the probability of a farmer having low level of knowledge by 0.091 odds. Using vaccines is a sign that farmers know and understand the dangers involved in livestock diseases, thus, resorting to a strategy for controlling the disease. This is supported by the results of Williams *et al.* (2022), who found that farmers' decisions to vaccinate their livestock was mostly influenced by the knowledge they possess regarding the diseases. This implies that farmers who have more knowledge about livestock diseases are more likely to vaccinate their livestock. This is in line with the results of study conducted in

Ghana by Nuvey *et al.* (2023), who found that using vaccines is negatively associated with limited knowledge, meaning that farmers who have limited knowledge are less likely to vaccinate their livestock against diseases. This shows that improving knowledge of farmers can thus, contribute to creating increasing demands for, and uptake of, vaccines, and with prospects to significantly decrease livestock mortality rates (Lindahl *et al., 2019*).

Primary occupation (PO) – this variable was significant at 5% and 10% in the first contrast and second contrast, respectively. The results in the first contrast show that a unit increase in the primary occupation of a farmer, which is like having multiple occupations, reduces the likelihood of having low level of knowledge by 0.721 odds. This could be explained by the fact that being unemployed and depending on social grants only restricts farmers in their ability to spend money on animal health care and makes it harder for them to have better knowledge in animal diseases (Habiyaremye *et al*., 2017).

In the second contrast, a unit increase in the primary occupation of a farmer, reduces the likelihood of having high level of knowledge by 0.584 odds. This means that when farmers have other employment apart from farming, they tend to move away from livestock farming possibly because they do not have enough time on their hands and they also have access to an alternative basic household income (Taruvinga *et al.,* 2022), and thus, their reduced knowledge levels. This was in line with the findings of Dossa *et al*. (2008), who found that having employment outside of farming can negatively affect the decision to go into livestock farming.

Gender – the variable of gender is statistically significant at 10% level of significance. This implies that a unit increase in the number of male smallholder livestock farmers increases the odds of having high level of knowledge in heartwater disease by 6.204 odds. This means that, holding other factors constant, male farmers were 6.204 more times likelier to have better knowledge than their female counterparts. This is in line with the results by Traore *et al*. (2020), who reported that males generally have better knowledge when it comes to livestock disease as compared to female farmers. However, contradicting results were reported by Alessandra *et al*. (2017), who found that men and women in Tanzania have similar levels of knowledge about animal diseases as they performed complementary activities in livestock farming and animal health.

Annual expenditure (AEX) – this variable was positive and significant at the 5% level of significance. Therefore, a unit increase in the annual expenditure farmers make towards their livestock, increase the odds of those farmers having better knowledge about livestock diseases by 1.0 unit. This means that farmers who spend more towards livestock management on average, are likely to possess better knowledge about livestock diseases. This concurs with the results by Mdlulwa *et al*. (2021), who reported that farmers who are able to spend more on animal health care and management do so because they are aware of the health risks.

Access to extension services (ATE) – this variable was negative and significant at 10%. This means that holding other factors constant, a one unit increase in farmers' access to extension services and animal health technicians does not automatically improve farmers' knowledge levels. This is because extension services are not always beneficial for livestock farmers on their own, and the success of these services also depends on other factors, like access to credit (Ndoro *et al.,* 2014). However, having access to extension services can be of benefit to farmers as they can improve farmers' knowledge of preventing and controlling diseases (Akintunde and Adeoti 2014). This was supported by Ipara *et al.* (2021), who found that access to extension services increases farmers' knowledge on disease detection while also improving management practices by allowing farmers to access information on various issues related to diseases, contrary to the findings of this study. Phares *et al.* (2020) reported that increased access to extension services is linked to farmers administering antibiotics to animals, while Mukamana *et al.* (2022) further revealed that the ability of certain farmers to use livestock vaccines is constrained by a limited access to livestock extension services, showing that extension services are important in knowledge dissemination and disease prevention.

Source of income (SOI) – this variable was significant at 5% in the first category of the analysis. These results show that a unit increase in a farmers' sources of income reduces the likelihood of having low level of knowledge by 1.601 odds. Taruvinga *et al.* (2022) found an association between income and livestock farming. This could be due to the fact that farmers with multiple sources of income have the ability to practice primary animal health care among their livestock while still having money for other household needs. Another reason why farmers with multiple sources of income have an advantage is because one income alone is insufficient to cover all expenses. Households that get a combination of farm and off-farm income, as well as social grants, are less inclined to adopting risky or unsafe practices in livestock management (Cele and Mudhara, 2022). This is because an increase in a farmers' income has been found to be associated with an increase in the level of positive knowledge, attitude, and practices (Özlü *et al.,* 2020). This is in line with the findings of Nyangau *et al.* (2021), who found that having higher incomes is linked to better knowledge levels about certain diseases.

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of the study, which includes the study aims and objectives, methods employed to carry out the current study, including the justification of the study area and sampling methods used to select respondents as well as the analytical techniques used for data analysis. Next, key findings of the study are presented as well. Moreover, recommendations based on the study findings are also presented in this chapter. In the next subsections, the summary of the results, the conclusions drawn from the analyses and the recommendations based on the study findings are presented.

5.2 Summary

This subsection goes through the important sections and parts that were included in the study. The main aim of this study was to assess smallholder livestock farmers' KAP towards heartwater disease in Bushbuckridge Local Municipality, South Africa. The specific objectives set for this study were; i. to profile the smallholder livestock farmers in the study area; ii. to analyse smallholder livestock farmers' KAP towards heartwater disease in the study area; iii. to analyse the factors influencing the KAP of smallholder livestock farmers towards heartwater disease in the study area. The study was conducted in the Bushbuckridge Local Municipality in the Enhlanzeni District of Mpumalanga Province, South Africa. The study area was chosen due to a high prevalence A*mblyomma* ticks of among the livestock and also because heartwater disease is endemic in the area. A multistage sampling technique was employed, which consisted of the stratified sampling in the first stage and the simple random sampling in the second stage, and 180 farmers were sampled to take part in the study.

To address the first objective, descriptive statistics were used, which included means, frequencies, and tables in order to profile the sociodemographic characteristics of livestock farmers. The second objective was addressed through the KAP survey framework, where the use of Likert scales and percentage indices helped to get an understanding of farmers' KAP in the Bushbuckridge Local Municipality. For the third objective, the MLR model was employed to determine the factors which influence the KAP of smallholder livestock farmers.

The results of the first objective showed that there were more male farmers compared to females, with the average age being 59 years old. Since most farmers were older people, they mainly depended on social grants. Thirty-eight percent of the farmers had obtained primary education at best, with another 37% being in possession of secondary education. This had an effect on their employment status, as the results indicated that 65% of the farmers devoted their full-time to rearing livestock.

The second objective, through the usage of Likert scales, revealed that most farmers in the study had a low level of knowledge regarding heartwater. They also had, on average, a neutral attitude towards the disease. Ninety-one percent of the farmers revealed that they do not use ethnoveterinary medication on their livestock. Sixty-two percent of the farmers in the study were using acaricides while 67% of the interviewed farmers revealed that they use vaccinations against heartwater.

For the third objective, Pearson's Chi-square test of independence was used to check for relations between knowledge, attitude and practices that farmers use. There was enough evidence to conclude that there was a relationship between knowledge and attitude, as well as between knowledge and the practices of the farmers. Furthermore, the MLR revealed that eight factors, which significantly influenced farmers' KAP were gender, primary occupation, access to extension services, access to AHFs, dipping livestock, annual expenditure, source of income and vaccinating against heartwater.

5.3 Conclusions

The study looked to address two hypotheses. The first posited that socio-demographic factors among livestock farmers in Bushbuckridge Local Municipality do not influence their knowledge, attitude, and practices towards heartwater disease. This hypothesis was rejected based on clear evidence from the MLR, indicating that socio-demographic factors, such as the gender of farmers, had an impact on their KAP towards heartwater disease. The second hypothesis stated that there is no relationship between the KAP of farmers towards heartwater. This hypothesis was also rejected because Pearson's Chi-square test of independence revealed evidence of a relationship between the knowledge and attitude of farmers, as well as between the knowledge and practices

5.4 Recommendations

From the results, 73% of the farmers interviewed felt that acaricides and vaccines were unaffordable. Therefore, another recommendation is that the Government through the Department of Agriculture, Land Reform and Rural Development (DALRRD) should draft relevant policies that will work towards subsidising farmers when purchasing animal health care products like vaccines, which farmers felt were a bit expensive for them given their lack of purchasing power.

Seventy five percent of the farmers interviewed were males, and the MLR results revealed that male livestock farmers are likelier to have better knowledge of heartwater disease than their female counterparts. Thus, it is recommended that the Government should level the playing field providing training to women and implementing relevant education programmes to ensure that the number of females involved in livestock farming increases significantly, thus breaking stereotypes prohibiting women from rearing livestock.

The study found that there is low level of knowledge in the study area with regards to heartwater, and that extensionists and animal health technicians do not necessarily improve farmers' knowledge. Based on this finding, it is recommended that the Government through DALRRD in collaboration with the Department of Science and Innovation (DSI) should have a comprehensive programme that makes access to extensionists and animal health technicians easier for farmers, while also equipping these extensionists with relevant skills to ensure successful dissemination of knowledge, through relevant Research and Development (R&D). Dissemination of better information through trained extensionists will equip farmers with the required knowledge to deal with the disease and ultimately protect their livelihood source.

And lastly, the development and roll out of livestock vaccines should be informed by socio-economic analysis, farmer preferences and drivers of innovation adoption. This can only be possible through multi, inter and trans disciplinary scientific approaches to tackling societal challenges such as that posed by livestock diseases.

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APPENDIX 1

Ethical clearance certificate

University of Limpopo
Department of Research Administration and Development
Private Bag X1106, Sovenga, 0727, South Africa
Tel: (015) 268 3935, Fax: (015) 268 2306, Email: anastasia.ngobe@ul.ac.za

TURFLOOP RESEARCH ETHICS COMMITTEE

ETHICS CLEARANCE CERTIFICATE

MEETING: **27 June 2022**

PROJECT NUMBER: **TREC/286/2022: PG**

PROJECT:

Title:	Knowledge, Attitude And Practices Of Smallholder Livestock Farmers Around Heartwater Disease: A Case Of Bushbuckridge, Mpumalanga Province, South Africa
Researcher:	TM Aphane
Supervisor:	Prof MP Senyolo
Co-Supervisor/s:	Dr P Chaminuka
School:	Agricultural and Environmental Sciences
Degree:	Master of Science in Agriculture (Agricultural Economics)

PROF D MAPOSA
CHAIRPERSON: TURFLOOP RESEARCH ETHICS COMMITTEE

The Turfloop Research Ethics Committee (TREC) is registered with the National Health Research Ethics Council, Registration Number: **REC-0310111-031**

Note:

i) **This Ethics Clearance Certificate will be valid for one (1) year, as from the abovementioned date. Application for annual renewal (or annual review) need to be received by TREC one month before lapse of this period.**

ii) **Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee, together with the Application for Amendment form.**

iii) **PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES.**

Finding solutions for Africa

Faculty approval letter.

University of Limpopo
Faculty of Science and Agriculture

07/04/2022

NAME OF STUDENT:	Aphane TM
STUDENT NUMBER:	201634748
DEPARTMENT:	Agricultural Economics and Animal Production
SCHOOL:	Agricultural and Environmental Sciences
QUALIFICATION:	MSA02

Dear Mr Aphane

FACULTY APPROVAL OF PROPOSAL (PROPOSAL NO. 49 OF 2022)

I have pleasure in informing you that your **masters** proposal served at the Faculty Higher Degrees Committee meeting on **09 December 2021** and your title was approved as follows:

"**Knowledge, attitude and practices of smallholder livestock farmers around heartwater disease: A case of Bushbuckridge, Mpumalanga Province, South Africa.**"

Note the following: The study

Ethical Clearance	**Tick One**
Requires no ethical clearance Proceed with the study	
Requires ethical clearance (Human) (TREC) (apply online) Proceed with the study only after receipt of ethical clearance certificate	√
Requires ethical clearance (Animal) (AREC) Proceed with the study only after receipt of ethical clearance certificate	

Yours faithfully

Prof P Masoko
Research Professor: Faculty of Science and Agriculture

CC: Prof MP Senyolo
Prof JJ Hlongwane
Prof TP Mafeo

APPENDIX 2

Questionnaire ID:

Dear respondent, my name is Tidimalo Mokgoro Aphane, an MSc. Agricultural Economics student in the Department of Agricultural Economics and Animal production, School of Agricultural and Environmental Sciences, Faculty of Science and Agriculture, at the University of Limpopo.

My MSc work includes research and for this reason, I am conducting a research titled: KNOWLEDGE, ATTITUDE AND PRACTICES OF SMALLHOLDER LIVESTOCK FARMERS AROUND HEARTWATER DISEASE: A CASE OF BUSHBUCKRIDGE, MPUMALANGA PROVINCE, SOUTH AFRICA.

This study is part of a project led by the Agricultural Research Council in collaboration with the Universities of Limpopo, Fort Hare and Pretoria.

Thus, I would like to ask for a few minutes of your time to discuss this. Since I understand that you are very busy, our discussion will take approximately 20- 30 minutes of your time.

Should you have any questions or concerns about your participation in the study, please contact:

1. **Prof MP Senyolo, Associate Professor: Agricultural Economics – University of Limpopo, Tel: 015 268 4628**

E-mail: mmapatla.senyolo@ul.ac.za

2. **Dr P Chaminuka, Senior Economist – Agricultural Research Council,**

Tel: 012 427 9834. E-mail: ChaminukaP@arc.agric.za

HOUSEHOLD SURVEY QUESTIONNAIRE

TO BE FILLED IN BEFORE THE INTERVIEW COMMENCES

Name of Enumerator:…………………………………….

Village of household: …………………………………………

Date of Interview:……………………………………………

Full name of respondent ………………………………………………………………….

Gender of respondent: **Male/Female**……………………………………………

Is the respondent the head of the household **Yes/ No ……**if no, please indicate relationship to Household head ***……………………………….***

SECTION A: FARMERS' DEMOGRAPHICS

<table>
<tr><td>A1</td><td>A2</td><td>A3</td><td>A4</td></tr>
<tr><td>Age of household head (or year of birth)</td><td>Gender

1 = Male
0 = Female
2 = Other/Prefer not to mention</td><td>Number of people in the household[1]</td><td>What is your highest level of education?
1 = No formal education
2 = Primary education
3 = Secondary education
4 = Tertiary education</td></tr>
<tr><td>A5</td><td>A6</td><td>A7</td><td></td></tr>
<tr><td>Primary occupation
1 = Farming
2 = Off farm informal employment
3 = Formal employment
4 = Self-employment/Business
5 = Other (specify)____________________</td><td>Sources of income (you can tick more than 1 if applicable)
1 = On-farm
2 = Formal pension
3 = Social grants
4 = Formal employment
5 = Other (specify)
____________________</td><td><table><tr><td>Source code</td><td>Amount/month</td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr></table></td><td></td></tr>
</table>

SECTION B: FARMING/ LIVESTOCK KEEPING ACTIVITIES AND FACILITIES

B1. Livestock owned	**How many**
Cattle	
Sheep	
Goats	
Other (specify)	

B2. Farming experience- for how long have you been keeping livestock?	

	Yes	No
B3. Member of farmers association	O	O

B4. Three reasons for keeping/ owning	**Rank according to importance**

Household consumption O Sale of animals O Wealth status O Sale of animal by-products O Religious/traditional practices O		
Other (specify)		

B**5. Do you have access to animal handling facilities?**	Yes No O O

B5.1. If yes, which handling facilities	
Crush pan	O
Dipping tank	O
Neck clamp	O
Loading ramp	O
Other (specify)	

B6. When your animal is sick, who do you contact first?	
State veterinarian	O
AHT (Animal Health Technician)	O
CAHW (Community Animal Healthcare Worker)	O
Co-op	O
Other famers	O
Other (specify)	

	Yes	No
B7. Do you have access to agricultural extension services?	O	O

B7.1. If yes, how often?	
Weekly	O
Monthly	O

Quarterly Once in a year	O O
Other (specify)	

B8. Do you usually sell your livestock?	Yes O	No O
B8.1. If yes, how often?		
Cattle	**Sheep**	**Goats**
Weekly O	Weekly O	Weekly O
Monthly O	Monthly O	Monthly O
Quarterly O	Quarterly O	Quarterly O
Once in a year O	Once in a year O	Once in a year O
Other (specify)	Other (specify)	Other (specify)

B9. Reason for selling livestock	
Household needs Emergency Profit making	O O O
Other (specify)	

B10. Do you spend money on the health and care of your animals?		
Animal feed, licks & salt	Yes O	No O
Vaccines	Yes O	No O
Medicine	Yes O	No O
De-worming	Yes O	No O

Tick control	Yes O	No O
Other (specify)		
Annual estimated expenditure	R	

B11. What are the 5 most prevalent diseases / disease symptoms affecting your livestock? Please indicate the livestock affected			
Name of disease	Cattle	Sheep	Goat

SECTION C: KNOWLEDGE ON HEARTWATER DISEASE

		Yes	No
C1	Do you know about heartwater disease?		
C2	Did you hear about heartwater from the media?		

C3	Do you know the symptoms of heartwater?		
C4	Did you hear about heartwater from other farmers?		
C5	Did you hear about heartwater from a farmers' association?		
C6	Do you know which livestock can get infected with the disease?		
C7	Can heartwater kill livestock?		
C8	Do you use indigenous herbs to control ticks?		
C9	Do you use indigenous herbs to treat heartwater?		
C10	Do you know if vaccination can be used to prevent this disease?		
C11	Do you know what kind of treatments are available for this disease?		
C12	Do you know that heartwater is caused by ticks?		
C13	Do you know the type of ticks that cause heartwater?		
C14	Do you know if this disease can affect livestock or wildlife?		
C15	Do you know the season of the year when heartwater is most common?		

SECTION D: ATTITUDE		Negative		Neutral	Positive	
		SD	**D**	**Neutral**	**A**	**SA**
		1	**2**	**3**	**4**	**5**
D1	Heartwater is an important disease in livestock production					
D2	I have interest in learning more about the disease					
D3	Acaricides work well in controlling heartwater					
D4	Ethno-veterinary medication works well in controlling heartwater					
D5	Vaccines work best in preventing heartwater					
D6	I feel that my present knowledge regarding heartwater is enough.					
D7	I feel that the methods I use currently to control heartwater are the best.					
D8	Being a member of an association made me aware of heartwater disease.					
D9	I feel that acaricides are expensive					
D10	The government should provide us with acaricides					
D11	Without the assistance from extension agent, I would not be able to deal with heartwater.					
D12	Being in the rural areas make access to acaricides extremely hard					
D13	I do not know enough about vaccines for heartwater					
D14	I feel that vaccines are too expensive					
D15	Vaccines cause harm/death/negative effects to animals					

D16	There is no one to administer the vaccines					
D17	There is no need for me to try out other heartwater control measures					
D18	I would stick with the current method to control heartwater even if I had a choice to use other control measures					

SECTION E: PRACTICES

Practices	**Yes**	**No**
E.1 Do you control tick infestation on your livestock?		
E.2 Do you use ethnoveterinary medicine/ indigenous herbs to control ticks? (If yes, which plants?)		

How do you apply the indigenous medicine to control ticks?		
How often do you apply it?		
E.3 Do you use acaricides to control ticks (If yes, which acaricide?)		
What do you use to apply the acaricides?		
When was the last time you applied acaricides?		
How often do you apply acaricides on your livestock?		
E.4 Do you practice manual tick removal?		
E.5 Do you use any chemicals to control ticks? (If yes, which chemicals? Jeyes fluid, engine oil or paraffin? Other, specify)		
E.6 Do you vaccinate your livestock against heartwater? If yes, how often do you vaccinate? ___________________		
E.7 Do you dip your livestock? How often do you dip your livestock?		
E.8 Do you use a pour-on dip?		

E.9 Do you use a plunge dip?		
E.10 Do you isolate any new / sick animals?		

End of questionnaire- thank you for your time