Farmer knowledge and behavior towards the prevention, control and eradication of bovine theileriosis in Zimbabwe: Principal-agent problem and animal health management

2024

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ジンバブエにおける牛タイレリア症の予防・抑制・撲滅に向けた農家の知識と行動：プリンシパル・エージェント問題と家畜衛生管理

令和 6 年

（2024）

帯広畜産大学大学院畜産学研究科
畜産科学専攻博士後期課程

ノクワラ　シェルトン　ムニャラジ

Contents

List of Abbreviations

AGRITEX	Agricultural, Technical and Extension
AHMC	Animal health management centers
CAHWs	Community Animal health workers
CFA	Confirmatory Factor Analysis
CLAFA	Crop, Livestock and Fisheries Assessment Report
DVS	Department of Veterinary Services
ECF	East Coast Fever
FAO	Food Agriculture Organization
FTLR	Fast track Land resettlement program
IV	Instrumental Variable
KAB	Knowledge, Attitude and Behavior
MLAFWCRD	Ministry of Lands, Agriculture, Fisheries, Water, Climate and Rural Development
MLR	Multivariate Logistic Regression
SDG	Sustainable Development Goals
SEM	Structural Equation Modelling
TDB	Tick Borne Disease
UNICEF	United Nations International Children's Emergency Fund
VEWs	Veterinary Extension workers
WOAH	World Organization for Animal Health
ZimStat	Zimbabwe Statistical office
5-5-4	14-day cattle dipping cycle once every 5 days then after 4 days

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Chapter 1 Introduction

1.1 Background and challenges

Agriculture production forms a large and important part in any country and more so in developing countries as it addresses issue to do with food security both at national and household level. Global statistics show that agriculture is the backbone of many economies and its contribution is unparalleled, however the scale of output may differ per country and economy but its importance is undoubted (Worldbank 2023). The contribution of agriculture ranges from reducing poverty, to securing household income, making agriculture a vital sector of an economy that has the capacity to fulfil at least some of the SDG goals like poverty alleviation SDG goal 1 (Worldbank 2023 and FAO 2023).

Livestock production is an integral part of agriculture which is widely practiced both for commercial and subsistence purposes and a very important part of the agriculture economy in developing countries (FAO 1995). Livestock production contribution goes beyond the production of food to including capital accumulation, fuel, fertilizer, skins and fibre (FAO 1995) and livestock has social and cultural importance serving millions of farmers across the world (FAO 1993). FAO researches have helped to document the importance of livestock globally, thus publications ranging from livestock production a world perspective, role of ruminants in livestock in food security, livestock and pasture improvement and strategies for sustainable animal agriculture in developing countries (FAO 1982, 1992, 1993), to livestock solutions for climate change and unlocking the potential of sustainable livestock production (FAO 2017, 2023). This shows the increasing importance in research and approach to livestock development to the global economies and developing countries.

Sub-Saharan Africa livestock production is threatened by animal disease kill thousands of cattle dead and leave the burden of disease lingering over the livestock sector of a country for decades (Nuvey et al 2022). Livestock diseases can be categorized as endemic and epidemic (UN, 2014). According to UN 2014 "Epidemics are defined as occurrence of a certain disease in a population above expected level. These increases in disease can be termed outbreaks or plagues. The most serious epidemic diseases are caused by rapidly transmitting pathogens that produce acute and serious disease in large numbers of hosts." The definition provided proves that many of these diseases pose big threats to the general livestock productivity and thus governments and non-government organizations invest a lot in activities aimed at prevention, control and intervention towards a certain disease or diseases.

Tick borne diseases (TBD) are one of the greatest hinderance to the development of cattle and general livestock industry in sub-tropical and tropical countries in this world (De waal, 2000). In tropical and subtropical regions, the real cost of tickborne disease including piroplasmoses the root cause of theileriosis, is extremely difficult to estimate (De waal 2000). However, there are direct loses due to the disease that can be recorded which include poor performance, poor growth, poor milk production and mortality of infected animals which ultimately have an indirect effect to the high costs involved in treating he affected animals (De waal, 2000). The mortality rates in theileriosis vary from 0-50% in endemic stable conditions while in endemic unstable condition the mortality is high as far as 80-100% (Staak, 1981; Moll et al, 1984; Julla, 1985; Berkvens et al, 1989; Lawrence, 1991).

East Coast Fever (ECF) is a cattle disease that is caused by the parasite Theileria parva and is transmitted by the tick Rhipicephalus appendiculatus (Norval et al 1992; Mukhebi, Perry and Kruska, 1992). The disease is also named theileriosis following the extensive works on Sir Arnold Theiler on Piroplasma parvum in 1904 that resulted in researchers naming it after him in honor of his researches (De waal 2000; Du Toit and Jackson, 2011, Ahmed, 2016). Theileriosis is a tickborne disease caused by the tick vector Theileria parva (Lawrence and Waniwa, 2019). The signs for theileriosis are salivating, teary eyes, cloudy eyes, swollen lymph nodes and immunosuppression and the diagnosis involves use of clinical tests. As commonly known in Zimbabwe, January Disease, it is claimed to be causing about 60% of the cattle deaths in the seasons from 2017-2022 and with an 80-90% fatality (DVS, 2022).

Control of theileriosis is done by dipping cattle in a plunge dip full of acaricides or use a spray race in a 14-day cycle in dry season and 5-day cycle in rainy season because ticks breed more under wet conditions known as the 5-5-4 dipping cycle. In Zimbabwe there is no approved vaccine at the moment however vaccine trials are at advanced stages. Farmer knowledge of theileriosis i.e. identification of signs and symptoms and proper dipping methods and 5-5-4 timing determine success in eradicating and controlling theileriosis. Zimbabwe situation can be described as an unstable endemic condition as there has been disruption in the service delivery and the dipping system resulting in spread of the disease uncontrollably and uncontainable affecting and killing thousands of cattle.

The economic costs of treating theileriosis directly incurred by the farmer has been estimated to be between US$10 to US$20 per animal per treatment (Young et al 1988; Mutugi et al 1988). These costs are then added to the annual acaricide costs that a farmer incurs which is estimated to be between US$2 to US$8.50 per animal (Young et al 1992; Lawrence and McCosker, 1981). The costs for treating affected cattle in

Zimbabwe come up to US$60 for a single treatment pack for a head of three cattle, while on the other hand there is a government program where farmers pay only US$2 per cow per year so as to participate in the weekly dipping program (Cattle site 2018). These costs are huge in a nation where the farmer poverty levels are high and thus dependence of cattle dipping and herd tick control is the solution for the poor farmers.

In the past few years tick borne diseases especially theileriosis have ranked the highest in both the smallholder farmers and the commercial large-scale farmers in Zimbabwe leaving more than negative and adverse effects on the livestock industry (FAO, 2023). Despite the efforts put by the government through DVS to reduce the prevalence of tickborne diseases, there has been an increase and a projected increase in cattle deaths and expenses surrounding control of theileriosis. This increase is theileriosis cases has attracted various programs aimed at the control of the disease and researches to understand the disease in Zimbabwe has been increasing. There has been strain in veterinary services due to farmer increase as a result of land reform and this resulted in imbalance in the flow of information the farmers receive resulting in information asymmetry induced by the principal in this case DVS, thus making the diseases surveillance and control methods proposed and put in place not so effective.

Farmer knowledge is regarded as an important aspect in disease control and communication between farmer and veterinary is critical to motivate the farmers implement disease prevention, control and eradication strategies (Bard et al., 2022). Studies in Zimbabwe have focused more on identifying tick species leaving a gap on the farmer characteristics and veterinary communication. The gap in veterinary extension and farmer contact which has been rarely touched in research can give clues as to why there has been an increase in theileriosis cases and cattle deaths despite DVS efforts to reduce the prevalence of the disease. A closer examination on farmers characteristics and the factors that influence and impact the relationship between farmer and veterinary can provide suggestions into how disease management strategies and information can be used to influence knowledge and behavior of farmers in diseases management. Therefore, the general objective of this thesis is to show the current status of theileriosis in Zimbabwe and the level of knowledge with farmers and how the principal-agent model can be used to reduce information asymmetry in livestock production among rural farmers in Zimbabwe.

1.2 Literature review

This literature review is aimed at discussing key issues in the research that define concepts used and creating understanding of economic thinking and models suggested. The literature review will discuss the following: principal-agent problem, information asymmetry, socio-economic determinants of disease knowledge and knowledge, attitudes and behaviors for disease control.

1.2.1 Principal-Agent Problem

One important area of research in the economics of information is its consideration for incentives, contracts and behavior. In many countries both developing and developed, the governments and farmers in particular the livestock farmers and industry, there is collaboration in livestock disease prevention and control (Hennessy and Wolf, 2018). The role of the government is to control boarders, establish eradication and surveillance programs and negotiate trade agreements, while farmers` responsibility is to their own cattle herd health management and they have to report all disease in a bid to have eradication programs. In some countries the government put in place compensation which can be in different forms, sometimes it's in monetary value and sometimes it's in technical assistance in cleaning the residue and disinfecting affected areas, and this is usually in the situation when there are contagious diseases especially those that can be transmitted to humans or were there are trade implications (Hennessy and Wolf, 2018). The relationship between the farmer and government can be considered as a principal and agent relationship with contract terms though much of the terms are not written down but by the sole fact that the government offers free public and or / subsidized services to the smallholder farmer the relationship holds. The farmer (agent) will focus on own herd management to prevent, control and report the disease while the government (principal) commit to securing the boarders and providing within country surveillance and control of disease.

The model of the principal-agent is more concerned with a structure in which the contractual relationship ensures the agent is motivated to act in the best interests of the principal. In the case of livestock production, the government through the department of veterinary is the principal whose goal is on prevention, control and eradication of disease and doing this on behalf of the common good, while the farmers keeping livestock are the agents (Hessenney and Wolf, 2018). In this research the smallholder farmers are the agents and special emphasis is to show the connectivity between the principal (DVS) and the famers and how DVS uses information to influence farmer behavior and any hidden actions to be used in the best interest of controlling, preventing and eradicating the disease. The assumption in this research is that DVS (principal`s) objective it to reduce prevalence of the disease in the short run and totally eradicate the disease in the long run. The key issue in livestock production on the principal-agent relationship is the efforts put on biosecurity and reporting, and if there exist imperfect monitoring or imperfect information about the actions of the other and the risks associated the result will be constrain in participation. This imperfection will result in either moral hazard or adverse selection in the livestock production industry leading to information asymmetry.

Moral hazard is a situation in the market when one side cannot observe the actions of the other (Varian, 2002). Other researcher calls it hidden action problem and it arises when an institution or individual in a transaction acts but does nor bear full consequences or hide the consequences of their actions without the other party knowing it (Butter et al, 2010). Moral hazard in livestock production can arise when the livestock production affects directly a farm`s biosecurity management. In this case the government would be preferring that the farmer take precaution to prevent and control the disease, however, there are limitations on the farmer side which include lack of information, combined with limitation in resources and time (Hennessy and Wolf, 2018). The constrains the smallholder farmer may face in putting in place either on farm biosecurity or to acquire information can be dealt with by the principal in this case department of veterinary as the effects of one farm not putting enough biosecurity in the wake of a contagious may have more adverse effects on the public. Thus, the government sometimes introduces subsidies and incentives to ensure total participation of farmers for a common good.

Adverse selection is the failing of a market due to information asymmetries between the buyers and the sellers, in which case selection of 'bad' products of customers is more likely to happen rather that 'good' ones (Akerlof, 1970). Examples of second-hand cars refers to as lemons in the works of Akerlof show that buyers of cars face the 'lemons problems' because the buyers typically do not have expertise to know a lemon 'bad-car' or a peach 'good car' (Akerlof 1970). In livestock production, it has to do with reporting disease to the veterinary once signs of a disease are identified. In this case the agent (farmer) may not report the disease because the costs associated with the reporting may be more that the farmer can manage (Hessenny and Wolf, 2018). Reporting a disease will affect the farm income and other costs associated with running the farm of selling the cattle, farmers may end up not reporting and, in some cases, dispose the cow to an unknowing party. In a situation where the reporting results in mandatory depopulation, farmers with lower fixed costs will not be forthcoming as those with huge fixed costs i.e., commercial farmers can report while smallholder farmers will not report or may underreport (Wolf, 2006).

1.2.2 Concept of Information Asymmetry Theory

Information Asymmetry is a key issue in livestock production as put forward by Akerlof, the idea of artificial information asymmetry is a major issue even in agriculture. The basic concept of information asymmetry can be summarized as put forward in the works of (Afzal, 2015).

- Proximity: Physical and Intellectual closeness. Person to person physical proximity may lead to intellectual proximity and vice versa. T-Change: Whenever change occurs naturally or artificially, it creates imperfection in the information held by humans for some time, creating necessity to acquire further information.
- Causal Complexities: cause has effect and the other way around, thus any imperfection in understanding on what causes what. An understanding of whether the cause is single, multiple or a combination one distal or proximal cause(s).
- Disturbance: its occurrence is when a new event happens that produces new information and renders the current information distribution obsolete and creates desire for new information.

Information asymmetry comes in two types which are based on either human deliberate action or non-deliberate actions: inherent information asymmetry and artificial information asymmetry.

- Inherent Information Asymmetry: Commonly sub-divided into two categories, which are natural-inherent information asymmetry and artificial-inherent information asymmetry.
    - ✧ Natural-Inherent Information Asymmetry: this is information asymmetry in the universe which are independent from human interference. This is important to humanity as they necessitate the need for humans to deepen understanding of certain things by exploration, deeper thinking and acquire knowledge to make sense of the world. This is because of two things which are unavoidable: constant change and causalities.
    - ✧ Artificial-Inherent Information Asymmetry: this arises without deliberate effort for example, when another party has informational advantage because of position, experience or education.
- Artificial Information Asymmetry: Arises due to deliberate human effort such as in politics, hospitals, markets etc. This is made possible when information is made hard to access for individuals on the receiving end or difficult to clearly understand

the matter of interest.

1.2.3 Information Asymmetry and Veterinary extension

This research applies the theory of artificial information asymmetry a concept showing that veterinary can be applied in terms of proximity but falls short in providing adequate information on disease control to the farmers. Thus, in this case the agency problem is realized in that DVS the principal is in the proximity with the agent but the agent may not be receiving enough information on disease control thus affecting the action of the agent in order to eliminate, prevent and control tick borne disease. More literature on information asymmetry is in the fields of economics, health and psychology and the researchers give different perspectives on how this theory is applicable to the different situations (Major 2019; Spread, 2015; Scheneider, 2005). The main theme of these researchers in information asymmetry is to show how the principal hold more information than the agent.

In Economics, the concept of information asymmetry was birthed by Akerlof and in the theory of lemons one wants to sell a car and another wants to buy, but, the problem will be on the quality and condition of the car. In health sector this has to do with information given to the patient as pertains to the condition of the disease and other related issues. In agriculture and mainly in livestock production some researchers have focused on usage of drugs and selling a diseased cow or animal. In this context of the current study the information critical to this research is on control of disease and prevention which is a function of the veterinary services as they contact the farmer.

The works of Adakwa, (2022) in the paper "Relevance of Akerloff's theory of information asymmetry for the prevention of zoonotic infectious diseases in Sub-Saharan Africa: Perspective of Library and Information Services Provision". This was based on a systematic review of literature on information asymmetry and prevention of zoonotic diseases, with a special focus on the applicability, relevance and practicality of Akerloffs theory and its use in zoonotic disease area. The research reviewed the theory's use in economic and medicine, paying attention to how library information has played a part in giving information to the public on the issues of zoonotic diseases. In the researches understanding, artificial information asymmetry was found to be the lead in contributing to the situation where humans exposed to animals were receiving less information or no information on the prevention and spread of zoonotic diseases.

Though there has been increase in researches and journals on human and animal interaction and the impact on zoonotic disease, the research concluded that the unavailability of information with the people interacting with animals resulted in increase in zoonosis cases. The research recommends that libraries should play an important role in creating awareness and providing space, outreach programs, relevant information, and engaging the civil society. These recommendations are important and can be easily implemented when the level of literacy and access to education is possible.

In Sub-Saharan Africa there are issues to do with access to basic education, which is mainly in issue in rural areas, thus making the recommendation of using libraries not realistic or applicable. The reports issued by UNICEF in (2020) showed that in Zimbabwe the education rate is low especially in rural area where completion of secondary school is as low as 38%, thus it affects the capacity for libraries to be used as an avenue to bridge the information gap. With all this in hand the recommendations of this paper can be considered on the grounds of solving the artificial information question but the implementing agent being the one that is in close proximity with the farmer and in this case the veterinary services has to work closely with the individual farmers and the community at large in order to increase knowledge of disease prevention, treatment and control.

Hennessy and Wolf, (2015) did put a good research titled "Asymmetric information, externalities, and Incentives in Animal Disease prevention and control". The research was aimed at showing how problems with information and other externalities affect farm biosecurity in the light of incentives. The study used the principal-agent framework to study management of livestock diseases in the presence of potential adverse selection and moral hazard. Adverse selection may apply to disease reporting while moral hazard may apply to decisions on biosecurity. The research was established to outline if there are weak links in a disease absent region, and what risk would pose threat to disease entry.

They concluded that there are three central points towards the implication of disease management and these are: regulators need to be empathetic with famers, disease management must recognize implications of decentralized productions in order to be effective and coordinated on centralized disease management and lastly biosecurity risks and actions taken to control risks coming in any form. Since this research is done in the context of the principal-agent problem, it shows that there is much to be done by the principal in order to raise awareness and help the farmer improve on-farm biosecurity.

This research being applied to the veterinary extension and disease prevention in developing countries, creates an understanding that the veterinary extension office must take responsibility to increase farmer knowledge which has the capacity to influence behavior towards disease control. The veterinary extension can do more to improve farmer access to rightful knowledge about a disease and how the farmers must act in order to control the spread of the disease in their herd and community. The gap created by this research is on the execution of the communication and motivation given to the farmer in order to participate in disease control and prevention. This means that farmers can be motivated by the understanding of the purpose of keeping the cattle and the benefits they get other than from the incentives and subsidies form the government which may not exist of maybe unrealistic.

The principal-agent theory is also used in a study by (Yu et al, 2018), in their study titled: "The principal-agent leasing model of company + farmers under two division modes". This study was based on agriculture contracting companies running contract farming with many farmers and how the relationship is equated to principal-agent. The leasing in this case has two parties, one which is risk-neutral the company and the other which is risk -averse the farmer. The farmer seeks to fulfill the promise of producing crops in the way the company has requested so as to achieve the intended quality and quantity in yield. This research analyses data and suggest that there are two division modes and these have no influence on determination of the optimal level of effort and incentive coefficient on each party. The main idea in this paper was to analyze the two strategies used in contract farming of concentration and decentralization.

The researchers conclude that in the two modes that exist yield benefit when the total income of the company and that of the farmer is equal. The paper identified that the that in these two modes farmers prefer a decentralized mode while the companies prefer a centralized mode. This research only focusses on crop production and the relationship between farmer and the contracting company on the side of preferred mode of production and its profitability. While this is less applicable in the context of the farmer and veterinary extension services analyzed in this research, the principle at hand can be adopted that the mode of conduct between the two is critical. The farmers prefer a decentralized mode which creates room for information flow while the company is focused on the centralized model which has its challenges on contact with the farmer. The gap created by this research is on the implementation side, though the researchers identify the different needs of the two groups in question but they did not propose a possible solution for the two groups in the contract. Thus, in this research the aim is to find a communication solution when the principal is risk-neutral and the agent risk-averse.

1.2.4 Socio-economic factors and farmer knowledge

Agriculture development and learning is impacted and affected by various things both those that a farmer has direct contact and control over and these that are external to the farmer. Socio-economic factors are a combination of the social and economic indicators of the well-being of an individual (Mattsson, Fors and Kareholt, 2017). They can be and have been operationalized in a variety of ways however, it is commonly agreed that education, employment, social class and income are the main indicators of socio-economic status (Mattsson, Fors and Kareholt, 2017). There has been research on the impact of socio-economic factors to agriculture productivity and the findings and conclusion in general show that socio-economic factors do impact agriculture productivity in a huge way (Dash et al, 2022). This literature review will focus on the socio-economic indicators that impact and affect agriculture productivity and how livestock production is affected by which indicators.

Socio-economic factors and aspects affect the farm and farmer in basically two ways, which are, specific farm and farmer conditions and the forces that interacts within a farm of community (FAO, 2015). These two indicators show that socio economic have both individual implication to productivity as well as community effects which impact the total productivity of the farm and region.

Education is one of the indicators of socio-economic and in this regards it denotes the level of education attained by the individual or by the farmer (Vadivel et al, 2023). This means that if an individual has one more level of education above the average the assumption is they are more likely to have better agriculture productivity that the farmer with less education. This is on the basis that the more or higher the education the better the knowledge. However, education being an indicator of socio-economic status can also be impacted by other indicators like income, because families with low income quickly sends their kids into employment than for them to increase their education (Vadivel et al, 2023; Finau, 2021).

The other indicator of the socio-economic status is employment. Employment is the capacity for an individual to be engaged by an organization to work either fulltime or part-time. A study done between 1973 and 1993 show that employment plays an important role as an indicator in socio-economic status of an individual or family (Bartley and Owen, 1996). The study also shows that the type of employment can determine the type of social class an individual will be associated with, therefore the individuals who do manual works have a different social class than those who work in the offices (Bartley and Owen 1996). Employment play a role in determining the social class and also employment can influence other indicators such as the family income.

Income is one of the key indicators that is used to determine the socio-economic status of an individual. While it determines the status, it is also a factor that is impacted by other factors like education or employment and in agriculture the participation in a given market can be a factor that impact the level of household income (Mattsson, Fors and Kareholt, 2017). How much one earns can determine the standard of living they will have and economic bodies like World bank measure poverty using the cost spent by an individual in a day on their meals. Income can be made from employment or agriculture activities such as selling crops or livestock.

Socio-economic indicates vary from one social group and region and their impact differ from one region to the other. There are other indicators like age, family size and other indicators that are external from the farmer like geographic region and availability of amenities and social public systems and structures. There is much in literature about socio-economic factors and their impact on the individual in health, education and other related industries. Researches focusing on agriculture have been limited, however in the introduction of behavioral economics there has been more interest to have a fusion of epidemiology and the socio-economic factors that impact the numbers of disease prevalence and control of certain and specific diseases. Therefore, this research finds a gap in that there is limited research in Zimbabwe on the socio-economic factors that are critical in the control of theileriosis in Zimbabwe.

1.2.5 Knowledge, Attitudes and Behaviors on Tickborne disease control

Researches on tick-borne diseases knowledge, attitudes and behaviors have been increasing over the past decades. This has helped to create a deeper understanding into the farmers and the ones directly affected by the diseases. Researches have been done in various livestock production systems. Spanning from the developing countries to the developed countries and the also research on tick effect on animal health and human health.

Knowledge, attitude and behaviors (KAB) are models created to evaluate how change in behavior can be induced through the use of information and attitudes. The development of KAB studies originated in the 1950's as researchers wanted to stablish the effect of learning objectives on teaching and learning (Bloom et al 1956). The framework is usually used in medical research seeking to establich how behaviors can be influenced by knowledge and attitudes of patients (Liu et al, 2016). The KAB framework was is an abridged version of the Knowledge Attitudes and Practice (KAP) model. The framework is mainly used to show the interrelatedness of knowledge attitudes and behavior and is essential in creating understanding and formulating strategies. This research will look into its application and use in agriculture and livestock production.

Agriculture knowledge is a key part of agriculture development and researches done in the past link try the role of knowledge in influencing the attitudes of farmers and the behavior practice with a certain objective. Much studies on KAP or KAB show that there is a good or average level of knowledge among famers (Yassin, Mourad and Safi, 2022; Gholami and Papzan, 2021). While on the other hand a study on KAP in agriculture technologies showed that the farmers did nor adopt the new technologies because of inadequate information resulting in milling knowledge about the smart agriculture technologies at hand (Chuang, Wang and Liou, 2020). The gap existing that most KAP studies do not focus on in the information gap which had a huge impact on increasing knowledge and attitudes.

Farmer attitudes are a critical part in the acceptance of knowledge and can influence behavior. In a study on farm succession, the farmers showed positive attitudes towards the practice and even encouraged their children to prepare for farm work as the farmers aged (Aquino et al, 2021). Farmers in Ethiopia had undesirable attitudes towards the anti-microbial use and anti-microbial resistance (Tufa et al, 2023). The findings on the research on usage of pesticides showed a different outcome as farmers had proper attitude towards the usage of personal protective equipment (Rostami et al, 2019). Researchers conclude that if the knowledge is limited, it is unavoidable for the attitudes of the farmers to be low, this a key in improving attitude is the increase in knowledge.

Farmer behavior is one important factor is achieving specific goals in livestock production and agriculture productivity. Farmer behavior was directly linked to the level of knowledge the farmers had and the when the farmers had limited knowledge the behavior practice was generally low (Shahidullah, Islam and Rahman, 2023; Tufa et al, 2023; Rostami et al, 2019). It can be argued that without information, knowledge will remain low and thus, limited knowledge and poor attitudes and unfair behavior practice. The information gap in the studies identified in this research, is the basis for which this research is being conducted as he researcher aims to close the information asymmetry gap that results in limited knowledge and potentially market failure. The aim of the KAB study is to evaluate how access to veterinary information will influence theileriosis knowledge and improve the dipping behavior.

1.2.6 Tickborne disease control researches and research gaps in Africa

There have been various studies in tick-borne disease in sub-Saharan and their effect on cattle productivity. The countries that have been mainly affected by tick-borne diseases especially EFC or theileriosis are Tanzania, Kenya, Uganda, Rwanda, Zambia, South Africa, Zimbabwe and Botswana among the other countries. Studies have been done to analyze the relationship between farmers and the tickborne diseases in each country covering from the tick vector, the location of ticks and farmer knowledge of the disease. This research focuses on the relationship between theileriosis and the veterinary extension and farmer, thus, focus on previous researches on tickborne disease in Africa.

Tanzania is one of the African countries that has the largest livestock population boasting of over 33.9 million cattle, 87.7 million chickens, 24.5 million goats and 8.5 million sheep which play an important role in the country's economy (Ngunyale, 2023; FAO 2022). Tanzania accounts for at least 11% of the total African cattle population and 1.4% of the global cattle population (Ministry of Livestock and fisheries, 2019).

In their study (Kerario et al, 2017) show that theileriosis is a major and serious constraint to cattle production and productivity in Tanzania as it is in other tropical and subtropical countries. This study was an epidemiological study aimed at analyzing the prevalence of theileriosis among pastoral and agro-pastoral farming systems in three regions of Tanzania. The study used genomic DNA samples extract from 648 cattle to determine presence of theileriosis, on the other hand they collected information to do with animal age, animal sex, region, tick burden, tick control method used and frequency of acaricide application. This study showed that there was a 14.2% prevalence of Theileria parva across the regions in the study, the highest region had a 21.8% prevalence and the lowest had 7.4% prevalence. The study recommended that there must be implemented region specific control measures in order to control the prevalence of theileriosis. This study shows lower prevalence as in parts of sub-Saharan Africa because Tanzania has a vaccine program that is in place. Focus on the genomic DNA in this study neglects the idea that the prevalence can also have to do with the farmers as the tenders of the cattle. Testing the cattle only can show disease presence but leave a gap in understanding dynamics on why the disease may be present in a cattle head. The gaps in this study may be understood in the context of the research of Allan et al, (2021) on theileira parva prevalence and vector control in wildlife-livestock interface in Northern Tanzania.

The research by Allan et al, (2021) aimed at analyzing the prevalence on Theileria parva in cattle as a result of interaction between livestock and buffalo and to ascertain how livestock keepers controlled ECF and other tick-borne disease in cattle. the research used a randomized cross-sectional cattle survey and employed a questionnaire on control practices conducted by the farmers. The researchers collected blood samples from 770 cattle from 48herds and 120 farmers were interviewed and there were focus groups and workshops to discuss results from the study. The study showed that overall Theileria parva prevalence in cattle was 5.07% and that at least 78% of cattle had no ticks on the body. Farmers practicing the spraying or dipping were 41% and some farmers reported very frequent spraying as often as every four days however the dose per animal was reported to be insufficient. The high level of usage of acaricides can be credited for the low prevalence in Theileria parva and the low tick count.

The research show that the vector control is farmer-led controlled and this is positive but the level of acaricide use raises concerns on sustainability and resistance development in ticks can be a risk issue. The researches recommend that vaccination must be integrated as part of community-based disease control which will help alleviate dependence on acaricides and also need to increase understanding of Theileria strains circulating in livestock-wildlife interface. This research closes the gap left by Kerario et al, (2017) who only focus on the existence of Theileria parva and does not focus on the farmer. In this research, the main methodology creates an understanding of the prevalence and the activities done by the farmer. This creates a clearer understanding on the reasons for the low prevalence of theileriosis on parts of Tanzania.

However, this research leaves the activities of the veterinary officers out of the picture and only focus on the farmer and the cattle, which leaves a gap on research as the researchers suggest that there must be increased understanding of Theileria strains and this is mainly the function of the veterinary in communicating and educating the farmers. The recommendations by this research that farmer-led initiatives do produce results especially when transformed into community-based disease control initiatives is of great importance especially in countries where veterinary services are constrained like in Zimbabwe where the farmer-veterinary extension officer ratio is very huge making it complicated to reach all farmers timeously. Thus, on this basis the need to research on the need to improve farmer-led initiatives in Theileriosis control is needful especially in resources constrained regions but with high disease prevalence and this is then the Zimbabwe situation which could be answered by finding ways to close the gaps identified in the researches done in the Tanzania livestock industry.

ECF in Kenya is an important economic disease as it has the capacity to reduce the productivity of livestock. In the research of Gachohi et al, 2012, they analyze the epidemiology of tick-borne diseases especially ECF of cattle in Kenya. The research showed that the effective control of ECF in Kenya relied predominantly on the control of ticks using acaricides and chemotherapy. This study was done when the immunization program was still being rolled out. The researchers concluded that there is need to have geographical are-specific integrated tick control strategies, thus this will help marginalized areas to have robust programs and economic analysis for the control strategies implemented. The research outlined that with the roll out of the vaccine it would be possible to eliminate ECF and improve cattle productivity.

The research recommends future research on livestock management systems and patterns of land use, this shows that the current strategies being applied in the Kenya livestock industry shows that there has been success in reducing the prevalence of ECF in

Kenya and focus is on other issues. However, the researches in Kenya despite showing success in controlling the spread of ECF, there seem to be little research on the interaction of the farmer and the livestock in relation to this tickborne disease.

The lack of farmer-oriented approach in disease control leave weak links in controlling the disease in long term and also weak ties between the farmer and veterinary thus gives opportunity to resurgence of a disease if there is a lax in legislation of other control measures. Since the farmer plays a key role in the keeping of livestock and in the rural economy, there is need for a focus on farmer behaviors towards technologies put in place to control a disease. Since the study recommends research on systems, it leaves socio-economic factors and farmer characteristics that can influence the sustainability of a strategy of policy. The study of the links between farmer and veterinary, their relation to the disease will also help manage the issues of policies and legislations that will be pro-poor farmer in nature and help improve rural farmers livelihood.

One of the key issues when it comes to disease control, is the farmers knowledge and perceptions towards the disease. Tickborne diseases especially ECF is considered as an important economic endemic disease in East Africa. Kenya, Uganda and Tanzania regard the control of ECF an important aspect of improving cattle productivity and eliminating poverty. These three countries share a common water body, Lake Victoria and because of that a study was conducted on farmers along the river basin on each side, (Kenya) Kisumu, (Uganda) Kiruhura and (Tanzania) Tarime with the aim of assessing the farmers' knowledge and perceptions of tick-borne diseases. In this research (Chenyambuga et al, 2010), assesses the farmers knowledge of any issues that reduce productivity in cattle, which revealed in all the three countries that livestock diseases and huge impact on animal health with tickborne diseases being singled out as more dominant. The research was done on 12 villages selected through a multistage sampling technique was employed on district, village and finally household. A total of 10 households were sampled per village thus in total 120 households participated in this research.

A questionnaire was administered per household and further in each village focus groups were conducted with key informant from each village. The data collected from the three countries show that majority of the farmers in all the areas surveyed had a high knowledge of tickborne disease but have challenges in identifying the tick vector that spreads the diseases to their cattle but this did not affect them on using the right method to control ticks. Farmers in this research were more dependent on acaricide but they could only buy them when the resources permit. In Uganda the farmers reported to be using acaricides which can be attributed to training by Veterinary extension on usage of acaricide especially on hand spray, which is considered cheap, effective and convenient

(Migusha et al, 2005). This study findings will be different in other parts of Sub-Saharan Africa where the acaricides prices are high and using the spray can is for the farmers who can afford, most of the farmers rely on government free or subsidized service.

The other reason for the limited impact of tick-borne disease is that the farmers considers their cattle breed tick resistant and thus less need the acaricides. Despite that understanding there is prevalence of ticks, the effect was not so high as there were high Theileria parva antibodies in the cattle. However, need to develop pro-poor tick control strategies was highlighted as they are easy to adopt. This research is wholesome as it focuses on different famer experiences in 3 countries and also collects both data from the farmer and the cattle. The study was conducted in a region where active vaccination of cattle is taking place thus evaluating the impact of knowledge on reduction of disease prevalence is this region is difficult to measure as the farmers inability or ability to identify key signs is compensated by immunization. However, this research contributes to the importance of vaccines and appropriate cattle breed as a way of disease control.

The above-mentioned researches have contributed much to the body of knowledge on theileriosis and its effect on animal productivity. These studies are epidemiology in nature and focus mainly on the ticks but leave a gap on the characteristics of the farmer that are key in impacting knowledge and attitudes that influence behavior for disease control in developing countries. This current study is an attempt to create an understanding of the characteristics of farmers in Zimbabwe and how they impacted the nature of the relationship between the veterinary and the farmers in the control of theileriosis. The aim of this study will be to help the veterinary extension understand the diversity of the farmers in Zimbabwe post the land reform and create policies and strategies for closing the information gap in livestock production.

1.3 Research Objectives and thesis structure

The main aim of this research is to study the impact of information asymmetry on the principal-agent problem between veterinary extension and farmers in the control of theileriosis in Zimbabwe. This study was be carried out in a way that will create a better understanding of the farmers and basing on the literature review which showed the gap existing as a result of the principal-agent relationship and the outstretched veterinary which has resulted in little farmer knowledge due to information asymmetries in the veterinary extension. Therefore, this study seeks to fill the following gaps that are arising in Zimbabwe livestock production and failing to manage the prevalence of theileriosis:

1. Identify the socio-economic characteristics of the farmers in Mhondoro Ngezi that impact the control of theileriosis
2. Explore the nature of communication between farmers and veterinary and its impact of control of theileriosis in Mhondoro Ngezi
3. To examine how cattle dipping behavior of the farmers is impacted by the farmers knowledge and attitudes of theileriosis.

This thesis is comprised of seven chapters which are as follows: Chapter 2 Livestock production and animal disease issues in Zimbabwe. This chapter also gives a detailed explanation why theileriosis has been selected for this study.

The following chapters which are chapter 3, 4, and 5 are focused on the results obtained in this study and this is detailed as follows:

A summary of the details in this thesis is illustrated in the flow of chapters below

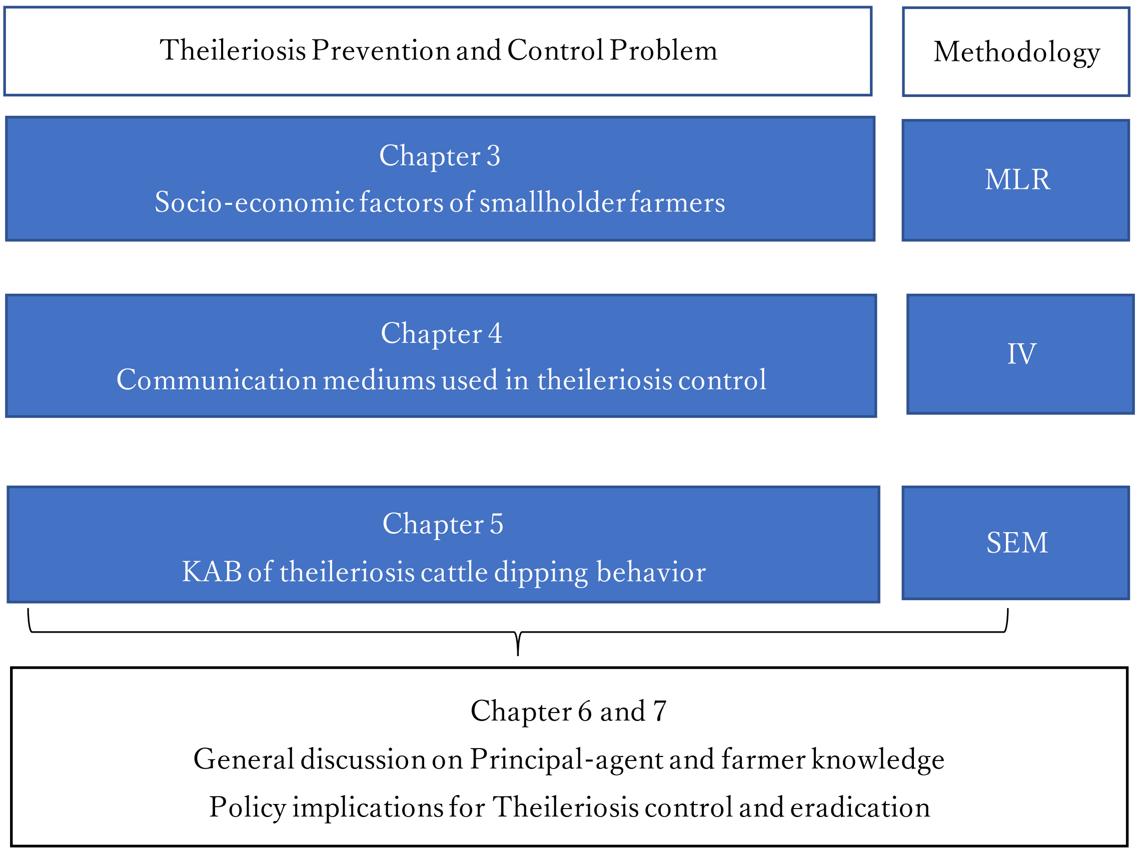

Figure 1.1 Outline of the thesis

Note: MLR – Multivariate Logistic Regression; IV – Instrumental Variable; SEM – Structural Equation Modeling;

Chapter 3 focuses on the socio-demographic characteristic of the farmers and its impact on theileriosis control and prevention in rural Zimbabwe, Chapter 4 establishes the communication between farmer and veterinary and how communication mediums used impact the knowledge of theileriosis. Chapter 5 identifies how the cattle dipping behavior is enhanced by the farmers knowledge and attitudes. Chapter 6 is the general discussion and Chapter 7 Conclusions and policy recommendations.

1.4 Area of Study

This research was conducted in Mhondoro Ngezi district in the Mashonaland West Province. Mhondoro Ngezi is 9,327.41km^2 in size and has 16 wards with a total population of 140,994 people and a household size of 35,495 households and a farmer population of 6,077 farmers. Mhondoro Ngezi district is in farming region 3 which is semi-intensive farming, where the rainfall is moderate in total amounting to 650-800mm, however the challenge is much of the rain is accounted for by infrequent heavy falls and temperatures are generally high, thus the effectiveness of high rainfalls is reduced.

The farming system that conforms to the rainfall and the rainy seasons in Mhondoro Ngezi, with its natural conditions is based on the both livestock production and cash crops under heavy management. The farmers that were selected in this research were a representative of the farmers in all the 16 wards but mainly selected from dip tanks across the district. The use of dip tanks as reference points was due to the fact that livestock farmer population is easily accounted for with dip tanks as in some wards there are mines and large-scale commercial farms thus not possible to represent the whole farmer population.

The choice of Mashonaland West Province and Mhondoro Ngezi was made on the basis that Mashonaland West had the first recorded cases with the district being one of the areas that first recorded the outbreak of theileriosis between November 2017 and May 2018 (Africa-Press, 2021; Zim-eye, 2019; Nkwala, 2018; Mabhena, 2018). Mhondoro Ngezi was then selected due to its accessibility as there is a road network that makes easy access to farmers and proximity as it is closer to the DVS office in the Provincial office of Kadoma.

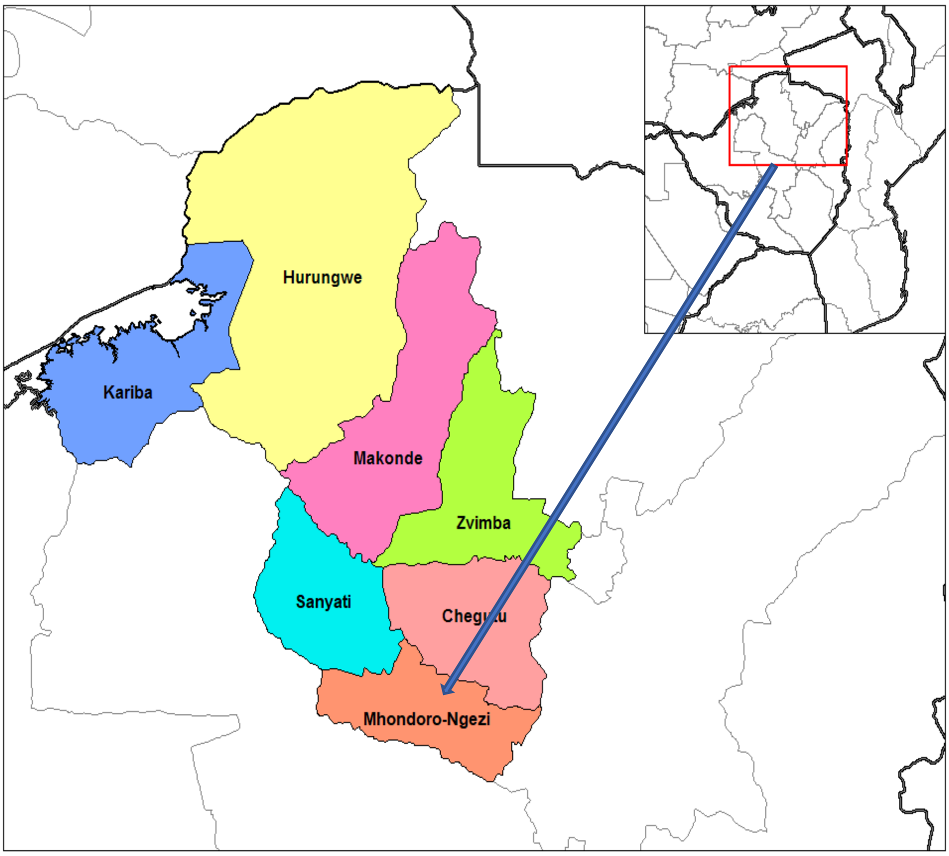

Figure 1.2 Mhondoro Ngezi

Source: GoZ

1.4.1 Livestock production in Mashonaland West

Livestock production play a key role in Mhondoro Ngezi District because of a number of reasons. Livestock is for draught power, meat, milk, manure, transport, source of wealth, income and for ritual purposes. This means that even crop production is to some extent dependent on livestock production thus the need to have better livestock production in Mhondoro Ngezi and other parts of rural areas in Zimbabwe is undoubted. Mashonaland West were Mhondoro Ngezi district is located is the holds the third largest population size in Zimbabwe, with 12.5% but holds the second lowest cattle population in the country (Zimstat 2022, CLAFA-1, 2023).

1.4.2 Data collection

The study was conducted between October 2021 and October 2022. The 360 farmers who participated in this research were selected using 2 methods. First stratified sampling in which the selection was based on the dip tanks that exist in the area, and them systematic random sampling in which farmers were selected randomly per dip tank. This was achieved using the veterinary extension officers and the names of the farmers in their area of supervision were written on pieces of paper and folded then put in a hat and shuffled and another extension officer picked the names and they were recorded. The data collection was done through the use of questionnaires and focus groups. The questionnaire was written in English which an official language of communication in Zimbabwe and when administering the questionnaire, the extension officer would be asking the questions and where necessary translate to Shona the local language. The extension officers were thoroughly trained on how to administer the questionnaire and some of them participated in drafting the questionnaires used. Pre-testing was done on 36 farmers translating to 3 farmers per enumerator.

Chapter 2 Livestock production in Zimbabwe

2.1 Introduction

Zimbabwe is a topical country in the Sub-Saharan Africa located in Southern African and landlocked bordering with Mozambique, Zambia, Botswana and South Africa. The total land area of Zimbabwe is 390,757 sq km and the population is 15.17 million people (ZIMSTAT, 2022). Agriculture is the backbone of the economy of Zimbabwe and contributes 11-14% of the GDP, employing about 70% of the population while supplying 60% of the raw materials needed in the industry. Agriculture contribute about 45% of the total country's exports (GoZ, 2023).

Livestock production contribute about 35% of the agriculture GDP (GoZ, 2021). Livestock production in Zimbabwe is primarily driven by smallholder farmers' in a mixed crop and livestock agriculture system. Most of the cattle are raised in semi-arid regions, making up almost two-thirds of the cattle herd. The cattle population is about 5.6 million herds and goats are about 4.7 million (CLAFA-1, 2023). The cattle population in Zimbabwe is divided according to the province for which there are 10 provinces in Zimbabwe but two are metropolitan so the data representation of the provinces in the table below show the cattle population of the past two farming seasons.

Table 2.1 Cattle population in Zimbabwe

Province	Beef Cattle Population	
	2021/2022	2022/2023
Manicaland	624,899	623,133
Mashonaland Central	512,596	473,253
Mashonaland East	584,747	671,063
Mashonaland West	495,383	518,844
Matabeleland North	681,879	707,761
Matabelelnad South	653,223	687,386
Midlands	944,854	956,891
Masvingo	1,009,402	995,069
Total	**4,509,983**	**5,642,400**

Source: CLAFA-1, 2023

2.2 Cattle management system in Zimbabwe

Cattle management systems and production in Zimbabwe is divided into two contrasting categories and these are uncontrolled grazing mainly in rural or communal areas and controlled grazing in commercial farming areas (Tavirimirwa et al, 2013; Assan

2012). Controlled grazing in commercial farms is for the private owner farms and they aim at profit maximization and have specific production output for milk and meat, with their livestock being kept in paddocks grazing is controlled and often improved with forage while rotational grazing in highly practiced (Tavirimirwa et al., 2013; Tawonezvi et al., 1988). In the communal or rural areas, the cattle management system is very different from the commercial as the communal are driven by diverse reasons for keeping cattle and some of which have been highlighted in the previous paragraphs (Mapiye et al., 2006).

The main form of managing cattle in communal/rural areas is the uncontrolled grazing method and it is mainly managed through the cattle herding system (Tavirimirwa et al., 2013). Because in the communal areas the grazing land is common, cattle are herded during the day and at night penned, in some cases where the grazing field is limited, the village combine the cattle and consider it as one flock with no attempts of controlling interbreeding or mating (Tavirimirwa et al., 2013). This means herds from different households in the same village normally graze separate but in case of limited grazing lands the village herd grazes together. The cattle grazing system is managed in two ways as during the cropping season the cattle is guided in the common grazing fields and after crop harvesting cattle herds are let loose to feed of the harvesting residue which stretches until the next rainy season (Tavirimirwa et al., 2013; Mapiye et al., 2006). The disadvantage in the communal cattle open grazing system and production is that the cattle is rarely supplemented with improved and commercial feeds thus the result is poor feed quality which limits productivity affecting both the milk production and milk outputs and even meat quality (Tavirimirwa et al., 2013, 2012; Ngongoni et al., 2007). Because of the common grazing land cattle owned by communal farmers are exposed to endoparasites in dry season and also result in poor body conditions while furthermore the tropical areas suffer from water availability in drier seasons with some farmers traveling between 10km and 14km to the nearest water points during the dry season (Maburutse et al., 2012; Masikati, 2010; Mashoko et al., 2007 and Scoones, 1992).

Cattle productivity in rural areas in Zimbabwe as in many other developing countries is challenged in different ways (Nyathi, 2008). The main challenge included high prevalence of parasites and diseases, low level of management, limited forage availability and poor marketing management (Mashoko et al., 2007; van Rooyen, 2007; Ngongoni et al., 2007; Mavedzenge et al., 2006; Mapiye, 2006). In Zimbabwe rural areas disease and parasites are the major constrain to the productivity of cattle and are regarded as endemic in most communal areas (Tavirimirwa et al., 2013 and Ndebele et al., 2007). The impact of parasites is huge as it results in high mortalities, dry season weight loss ultimately resulting in reduced fertility through nutrition induced stress and low productivity (Chimonyo et al., 2000). There are high negative financial and productivity implications when there is poor control of disease with research showing that about 70% of calves born in dry season (Ngongoni et al., 2006; Chawatama et al., 2005). Though overall herd mortality is recorded at 6%, rural cattle herd mortality is as high as 18% and diseases account for almost 83% of the cattle that died in 2022 while previous years the recorded mortality was at 60% figure below illustrartes 2022 mortality rates (CLAFA-1, 2023, Masikati, 2010, and Mavedzenge et al., 2006)

The most common cattle diseases reported in Zimbabwe by farmers are anthrax, Foot and Mouth, Anaplasmosis, Babesiosis, Heart water, Blackleg and Theileriosis (CLAFA-1, 2023, FAO, 2023; Masikati, 2010). The disease situation in Zimbabwe is worsened by the fact that drugs are unavailable and when available they are highly priced and on the other have there is high farmer the veterinary extension officer ratio because of inadequate extension officials with the prescribed being 1:575 but due to incapacitation some extension officers serve as many as one thousand farmers that the ration is around 1:1000 making it difficult to serve the farmers effectively and efficiently (FAO, 2023; Bhasera, 2023; Chifamba, 2022; Ndebele et al., 2007; and Chawatama et al., 2005).

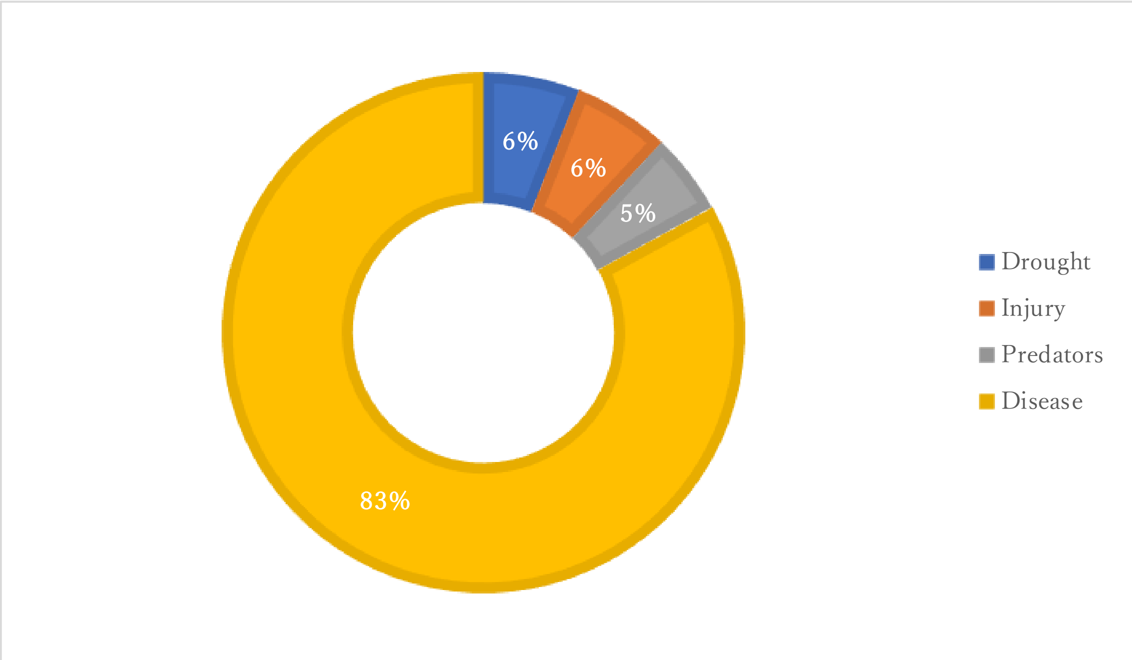

Figure 2.1 Cattle mortality 2022

Source: DVS, (2022)

This shows that many farmers have challenges in having direct contact with veterinary extension officers who are a vital link in livestock productivity and research shows that farmers end up having limited access only to dip attendants during dipping days (Mashoko et al., 2006). It can be concluded that there are gaps in the livestock production starting with the link with veterinary, which then gives room to slow progress in information exchange and thus the difficulties in fighting diseases.

The three major livestock diseases that kill cattle in Zimbabwe are Foot and Mouth, Anthrax and Theileriosis (Zim-eye, 2019). While the government has made efforts to control Anthrax and Food and Mouth, Theileriosis has been on the rise killing more than 60% of total animal death in each year since 2018 and coupled with a fatality rate of 90% of the infected cattle while the cost of treating each affected cow is more than $40 per dose (DVS, 2022; CLAFA, 2021, and Zim-eye 2019). This makes theileriosis a disease of high interest thus in this research theileriosis has been chosen because of its importance to the economy and the effect that the nation of Zimbabwe has felt over the past few years. The choice of this disease is also to see how there can be created a clearer understanding of theileriosis, the coordination that must be put in place by the government DVS and the farmers in order to eliminate this disease and its effect which has potential to cripple even crop production as drought power is reduced.

2.3 Tick borne disease in Zimbabwe

Tickborne disease in Zimbabwe were first recorded in the early 1900s, when East Coast Fever (ECF) was introduced in Southern Africa after cattle were brought in from Tanzania and Kenya, following an outbreak of Rinderpest which had killed many cattle in the late 1890s (Norval, 1979; and Norval et al., 1983). To deal with ticks a policy regulating compulsory dipping of cattle in acaricides was implemented in 1914, aimed at controlling ECF and this proved successful as by the year 1954 the disease was totally eradicated (Norval, 1979). The results of compulsory cattle dipping did not only eradicate ECF but also other tick bone diseases such as heartwater (*Cowdria ruminantium*), Redwater (*Babesia bigemina*), gallsickness (*Anaplasma marginale*) and Rhodesian theileriosis (*Theileria lawrencei*) (Norval, 1979). This created a tickborne disease free territory until the 1973 when the North East part of Zimbabwe was infiltrated by insurgents and thus cattle dipping stopped (Lawrence and Norval, 1979). This disruption in cattle dipping stretched until 1978 leaving only 20% of the 6,000,000 herd of cattle having access to regular dipping (Norval, 1981). Thus, the inconsistency and disruption in cattle dipping created and triggered an increasing complex sequence of events in tick species and tick-borne diseases. This it can be noted that an incomplete dipping cycle and inconsistency in cattle dipping has resulted in the increase in tick borne diseases in Zimbabwe and over the years affected the overall national herd.

The major tickborne disease that is recorded in Zimbabwe to have occurred and recurred it theileriosis. Theileriosis is a tickborne disease that affects cattle and bovidaes like African buffalo (*Syncerus caffer*), zebu (Bos indicus), waterbuck (*Kobus spp*) and Indian water buffalo (*Bubalus bubalis*) (Laury et al., 2020). Theileriosis is cause by a protozoa parasite called Theileria, belonging to Apicompela phylum (OIE, 2020). The sportozites of the parasite are transmited to the animal through saliva of the feeding ixodid tick (OIE 2019). There are six theileria spp that have been identified and the two most pathogenic and economically important are *Theileria parva* and *Theileria annulata*, for which *Theileria parva* was discovered by Koch (1898) but the name theileria is derived for the extensive researches of Arnold Theiler on ECF (Laury et al., 2020).

These two strains are mainly found in Southern Africa and Easter Africa and they cause of ECF in cattle (OIE, 2020). ECF leads to severe economic constrains in Sub Saharan, and in the year 1989 countries like Burundi, DRC, Kenya, Malawi, Mozambique, Rwanda, Sudan, Tanzania, Uganda, Zambia and Zimbabwe suffered a loss of about US $168 million (Laury et al., 2020, Mukhebi et al., 1992). Thus, it should be noted that the strain of theileriosis in Zimbabwe is from Theileria parva which is recorded to be economically important and once there is discord in the cattle dipping, the resulting effects are far reaching and may have effect on both the national herd and the individual farmer welfare and income.

Theileriosis in Zimbabwe has a different treatment method from other parts of Africa, and also known as January Disease because it has been active during the peak of the rainy season in January (Lawrence and Waniwa, 2019). In East Africa its known as ECF and the major treatment is vaccinating cattle using the Muguga Cocktail, which is used both as a preventative and treatment measure (Gwynneth, 2023; Allan and Peters, 2021 and Patel et al., 2015). However, in Zimbabwe the current method is cattle dipping as there was not vaccine developed in the past, however, DVS is working on vaccine development specific to the Theileria strain in Zimbabwe (FAO, 2022). The table 2.2 below shows the dipping situation in Zimbabwe.

Table 2.2 Status and required dip tanks in Provinces in Zimbabwe

Province	Existing	Additional Dip tanks Required	Dip tanks the need Rehabilitation	% Dip tanks the needed rehabilitation
Manicaland	544	22	487	89.52
Mashonaland East	487	17	365	74.95
Mashonaland Central	274	60	75	27.37
Mashonaland West	414	18	318	76.84
Midlands	487	20	380	78.03
Masvingo	697	14	416	59.68
Matabeleland North	358	40	309	86.31
Matabeleland South	467	16	287	61.45
Total	**3726**	**207**	**2637**	**70.77**

Source: Auditor General Report 2018 adopted from Annual Reports (2015-2017)

The status of dip tanks and the distribution of dipping chemical for the period up to 2017 shows a situation of a department under resourced and giving opportunity for disease to spike and as record show, after 2018 there is an increase in the cases of theileriosis and cattle deaths as a result. The huge percentage of dip tanks which need rehabilitation (70.77%) creates interest in the disease as it seems neglected.

Records show that there was disruption in cattle dipping during the fast track land reform which saw an increase in smallholder farmers and expansion in rural or communal farmers but no corresponding veterinary services expansion (Manyenyeka et al., 2020). The theileriosis disease cases recorded cumulatively leading up to 2018/2019 farming season can be better represented in the Table 1.1. showing of cases and financial value of loss

Table 2.3 National Number of Theileriosis cattle deaths and Value

Year	No. of Cattle Deaths	Value in USD$
2017	50,221	40,176,800.00
2018	120,554	96,443,200.00
2019	201,100	160,880,000.00
2020	300,000 (Projected)	240,000,000.00 (Projected)
Total	**671,875**	**537,500,000.00**

Source: DVS, 2019

The efficacy of dipping cannot be disputed and Zimbabwe farmers are encouraged to rely on dipping as it is the only reliable prevention and control method using dipping acaricide such as Triatix, Decatix, Supadip, Spoton, Tick grease, and Amitix. In the event of an outbreak farmers are encouraged to increase dipping intervals to the 5-5-4 method. This method entails that dipping must be done thrice in two weeks, with two five-day intervals and then after four days (DVS, 2022). The 5-5-4 method is aimed at cutting the 7-day tick life cycle. For use on the dip tank is the Decatix concentrate, which is a premix and is mixed in water approximately 10 times its volume and the mixture is added to the bulk water in a dip tank or a spray race sump.

The famers are warned and encouraged not to buy cattle of other animals from theileriosis-infected farms and areas, because the presence of carrier cattle in their herd will pose a big threat to their herd and make it difficult to protect the herd against subsequent theileriosis outbreaks. Some regulations have been put in place, which include application for a permit to move cattle which is given from DVS and also endorsed by Zimbabwe Republic Police (ZRP).

Treatment for theileriosis is done by providing food, water, shade, shelter, and protection while administering anti-protozoal drugs through injection such as BUPARVEX at the ratio of 1ml/20kg body weight. Since theileriosis is a NOTIFIABLE disease any outbreak must quickly be reported to the veterinary department through the veterinary extension officer. The current drug Buparvex can only be prescribed and supplied by a veterinary surgeon supplied through a pharmacist (Zimunda, 2021). In addition to Buparvex cattle can also be treated with oxytretacyclines such as Coopermycin LA using the ratio 1ml per 20kg.

The use of Coopermycin LA can be used alone only in areas there is low-grade infections but it is not effective when the cattle has a fever of 40 degrees Celsius and above. Spoton and Tick grease are a solution applied to the tail head and as a strip down on each side on the midline from the shoulder to the rump, it is applied on a ration of 1ml per 10kg body weight.

2.4 Livestock production and Veterinary extension

The veterinary services in Zimbabwe has its origins and development shaped by contemporary and historical factors which include colonial influences, post-independence reforms, eternal pressure such as economic structural adjustment programs and then land reform (Maposa et al., 2023). During the colonial period the veterinary services was primarily focused on control of disease such as rinderpest which killed thousands of cattle in the 1890s (Maposa et al., 2023). These veterinary services were centralized around the settler (colonizer), with provision of services being racially biased leaving local African natives with limited access, thus livestock disease control was used as a means of reinforcing the alleged white supremacy and a means of social control (Mwatara, 2014).

After the 1980 independence the new government recognized the need to improve the structure of veterinary services to achieve efficient and equitable access of services by smallholder and rural farmers (Maposa et al., 2023). This resulted in the decentralization of services and necessary resources thus leading to the establishment of veterinary training institutions such as the Mazowe Veterinary Institute, University of Zimbabwe Faculty of Veterinary services with the main aim of training veterinarians, animal health experts and veterinary extension workers. The government went on to establish animal health management centers (AHMC) across the country, staffed with Veterinary Extension workers (VEWs), for the purpose of providing preventative, curative and promotive veterinary services to rural and smallholder farmers and this was accomplished by set ups of Provincial and district veterinary office in all the 10 Provinces and 52 districts in Zimbabwe (DVS, 2021). A detailed representation of the structure of the DVS is illustrated in figure 2.2 below

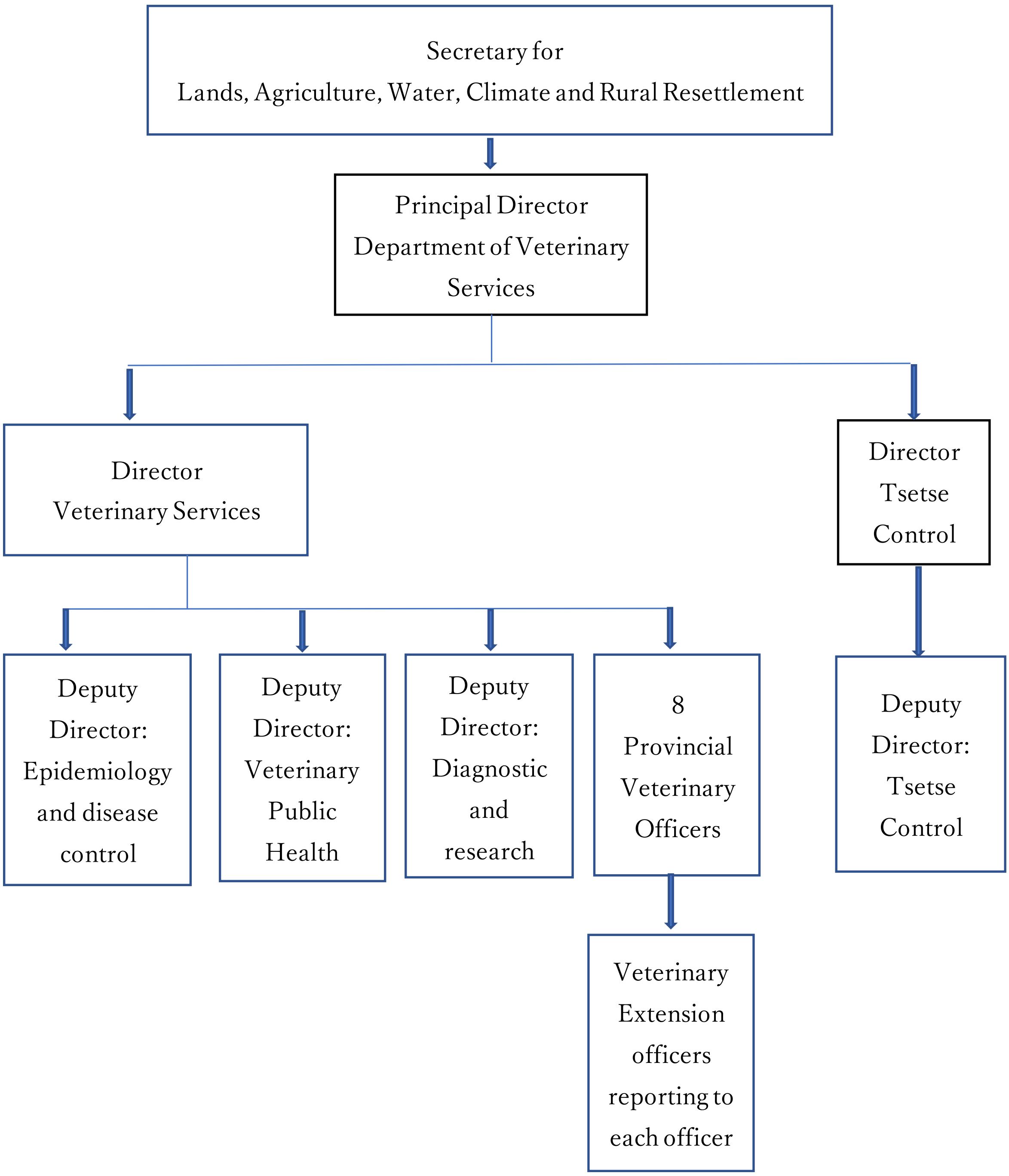

Figure 2.2 Department of Veterinary Services Structure

Source: DVS, 2014

The veterinary services implemented disease control measure which included livestock vaccination, strict dipping cycles, and control of animal movement and this was supported by a robust legal framework (DVS, 2021). DVS partnered with the European Union (EU), receiving a substantial amount on money as support and this led to significant success in beef export mainly to Europe (Maposa et al., 2023). The main aim was at every district to have a qualified veterinarian heading the station, however this plan has been hampered by the limited resources in the current structure thus affecting effective execution of field operations (Maposa et al., 2023 and DVS, 2021).

In the post-independence Zimbabwe, veterinary services have been closely linked with the land reform of the 1990s until the early 2000s. The land reform was aimed at addressing land inequalities and discussed in the previous chapters however this had negative impact on veterinary services and control measures that had been put in place. During the land reform there was uncontrolled movement of livestock, vandalism od veterinary boundary fences, disruption in cattle dipping programs, poor maintenance of dip tanks, and inadequate infrastructure and personnel to cater for the increase in famer number in the newly resettled areas thus ultimately disrupting disease control and prevention protocols leading to spread and occurrence of various animal diseases (Maposa et al., 2023; Bennet et al, 2019 and Mwatara, 2014).

The post land reform era has made the government to make changes in order to align the veterinary services with the current farmer needs. While there have been efforts to improve the veterinary services in Zimbabwe, there are challenges that remain and this is in the area of resource allocation. Though the DVS has tried to increase the number of veterinary staff but this has not matched with the need in provision of required resources such as pharmaceuticals and transportation thus limiting the effectiveness of field operations and also the increased staff has not matched with the required ratios in veterinary to farmer rations as highlighted before (Center of Public Impact, 2017; Leonard, 2000). It can be concluded that the land reform while being implemented to equitably distribute land it created mayhem in the veterinary which has had effect that have more economic and human resource demands.

The increase in farmers due to land reform demanded the provision of veterinary services through multiple actors and these include the public sector, private sector, ethnoveterinary practitioners and community animal health workers (CAHWs). The livestock industry is dominated by non-veterinarians and because of the limited involvement of veterinarians in the sector it poses challenges to the quality and sustainability of veterinary services (Maposa et al., 2013). Historically the provision of veterinary services in Zimbabwe has been primarily a function of the government department of veterinary with a main focus on protecting the large-scale commercial farmers but with limiter and hardly any presence with smallholder farmers (Mwatwara, 2014). The public sector through DVS has been providing services to smallholder farmers with the rational that the smallholder farmers are financially incapacitated to afford private services thus leading to free services by the government (Ahuja, 2004). This approach left the public services crowded and was even worsened by the land reform as the smallholder farmers increased by a more that 10 times with the public sector not expanding as such, ultimately this crowded out services providers and suppressed participation of private sector in the smallholder as they only looked forward to free services (Lwapa et al., 2009).

The private sector can play a critical and pivotal role in providing veterinary services to smallholder farmers but is inhibited by challenges including high transactional costs such as transport, low productivity in the sector, and inadequate infrastructure that promote development of business (Kasanda, 2017). Community Animal health workers (CAHWs) emerge as an important group of actors in the delivery of veterinary services especially at primary health care level. CAHWs are community selected individuals who go for training learning to provide affordable, accessible and trustworthy services (Fedlu et al., 2019). Critiques argue that in the veterinary services distribution, the dominance of CAHWs in the form of paraprofessionals and paravets, has led to a decline in the quality of service delivered which has negative implications on livestock productivity and food security (Ilukor and Birner, 2014 and Bonnet et al., 2011).

Ethnoveterinary practitioners are significant actors in smallholder farmers sector, these often resort to traditional or indigenous practices due to the high costs and unavailability of veterinary medicines (Nyahangare et al., 2015). Their practice is locally available, cheap and sustainable alternative to conventional medicines, however, there is need to validate the claims scientifically as well as documenting the effectiveness and potential of the ethnoveterinary practices (Mudzengi, 2014).

Smallholder farmers in Zimbabwe have access to both the public and private sector, however, due to the limitation in some of the characteristics on the farmers it may be difficult to access the services fully and there maybe costs involved ad access limitations. Despite this fact, the service providers have their strengths and limitations and these if well managed with proper coordination and collaboration among the actors can result in improved services for the smallholder farmers and thus better livestock health in smallholder farmer areas. One of the key issues is the access mainly looking at the connection between the farmer and the service providers through communication and information transfer.

Provision of veterinary services to smallholder farmers in Sub-Saharan Africa and other developing countries is recognized as a significant challenge (Ilukor et al., 2015). Zimbabwe is no exception to the challenges in smallholder veterinary services and though generally highly subsidized and provide free by the state through DVS the public veterinary services in Zimbabwe have faces a lot of problems, which are documented and, in some cases, have led to reforms (Maposa et al., 2023).

Studies in Ghana highlight that smallholder farmers` had limited access to veterinary as veterinary officers gave priority to farmers with more resources who incentivize them (Amankwah et al., 2014). The research went on to establish that under resourcing the public veterinary service affects coverage of service in particular to smallholder farmers.

In the Zimbabwe situation there are gaps that exist in the veterinary service delivery and these have been highlighted in the performance evaluation reports of Veterinary services done by WOAH in 2009 and 2014 which concluded that veterinary services in Zimbabwe fell short of optimal levels thus leading to failure of previous successes in animal disease control program (WOAH, 2014). The WOAH report indicated lack of training for paraprofessionals and inadequate supervision of field operations by veterinarians (WOAH, 2014). This means that the current state of affairs in smallholder farming and veterinary services is grossly inadequate and is deemed a situation of information asymmetry as a result of government incapacitation to deliver enough service.

This situation has resulted in an increase in animal disease outbreaks and there has been reported and recorded high mortality rates in Zimbabwe in recent years, which is a demonstration of the lack of capacity to prevent, control and contain livestock diseases in the smallholder farming sector (DVS, 2022). The outbreak of animal disease has significant negative impact on the overall economy and household level and in the drier regions of Zimbabwe the impact is harder as the main agriculture activity that support their livelihoods depends on livestock production. Thus, there is need for the DVS to address challenges in the veterinary services through provision of strategic management and organizing the veterinary services in line with the WOAH report (WOAH, 2014). The report places special emphasis on allocation of adequate resources aimed at delivering critical disease prevention and control programs. One of the critical issues to be addresses and information and access to relevant and timeous information is vital in reducing and asymmetries at hand.

Livestock production is predominantly dominated by men in Zimbabwe with women being the home keepers but with less decision-making powers on livestock production. However, in Zimbabwe there are some interesting statistics which has promoted the participation of women in livestock production. It is accounted that of the 80% of rural people that depend on agriculture, the labor force in agriculture productivity is dominated by women with 60% input. Statistics also show that 70% of the rural population live in poverty and a great number of these households are headed by widows, divorcees and children (ZimStat, 2014).

Table 2.4: Livestock related responsibilities in Zimbabwe (within farming households)

Activities	**Labor source % within farming households**			
	Men	**Women**	**Children**	**Hired Worker**
General Livestock Management	46.2	5.1	0.0	48.7
Milking cows	33.3	2.6	2.6	61.4
Feeding calves	10.3	48.7	7.7	33.3
Harvesting & transporting crop residue	52.0	11.0	10.0	27.0
Mean	35.4	16.5	5.6	42.5

Source: Chawatama et al., 2005

The above table 2.4 shows the contribution of women in livestock production in Zimbabwe. While women participate in the livestock production, they are limited and there is need to improve the extent to which women participate in this sector.

2.5 Land reform

Zimbabwe was under British rule until 1980 and after the Zimbabwe war that lasted from 1963 to 1979 an agreement was reached and the war ceased (Mugabe, 1983). The culmination of the liberation war was also sealed by the famous Lancaster house agreement which also saw the drafting of a constitution and addressing the main issue that had caused the war; which was the land question in Zimbabwe (Makumbe and Charumbira, 2018). The distribution of land was such that 5,700 white farmers owned at least half of the productive land, which was 3% of the population controlling 51% of the country's farming land, while the black peasant farmers where pushed to the inferior land in drier and drought ridden parts of the country (Shava, 2010). The need to redistribute land was urgent and needed attention post-independence as if formed key part of the struggle that had taken place in Zimbabwe. The main reason for redistributing land would also be to reduce poverty in Zimbabwe by having local farmers own productive agriculture land thus at least meeting the SDG goal 1.

In the late 1990s the government decided to implement a land reform aimed at meeting the growing demands of the population and to also meet with the promises made when Zimbabwe gained its independence. Thus, in this phase of the land redistribution the government launched the so-called Fast track Land resettlement program (FTLR) (Thomas, 2003). The TFLR was aimed at empowering the local farmer and redistribution of land and this happened in a way that produces a four-way model for Zimbabwe farmers (Marongwe, 2009).

The model created by the government for the main resettlement in land allocation with Model A, allocated settlers were individual farmers got arable plots of land and common grazing land; Model B, allocated to cooperatives schemes aimed at small scale commercial production utilizing infrastructure in the acquired farms; Model C, was centered around the Agriculture Development Authority (ARDA) which would focus more on research and development in agriculture and Model D, designed for farmers in drier regions of Zimbabwe (Marongwe, 2009). Model B was later disbanded into two groups, which are A1 and A2, with A1 being a modification of model A while A2 was predominantly commercial in nature (Marongwe, 2009).

The aftermath of the land reform in Zimbabwe saw an increased farmer population. The increase in farmer population can be summarized in the following figure which illustrates how the government had achieved success in distributing land. It must be noted that by 1997, the Zimbabwe government had acquired 3,498,444 hectares of land and 71,000 families were resettled, until 2003 127,192 A1 farmers had been allocated land (Scoones et al, 2011 and Marongwe 2009). Thus, figure 2.3 show that by completion of phase 2 of resettlement at least 200,000 families had been given access to land.

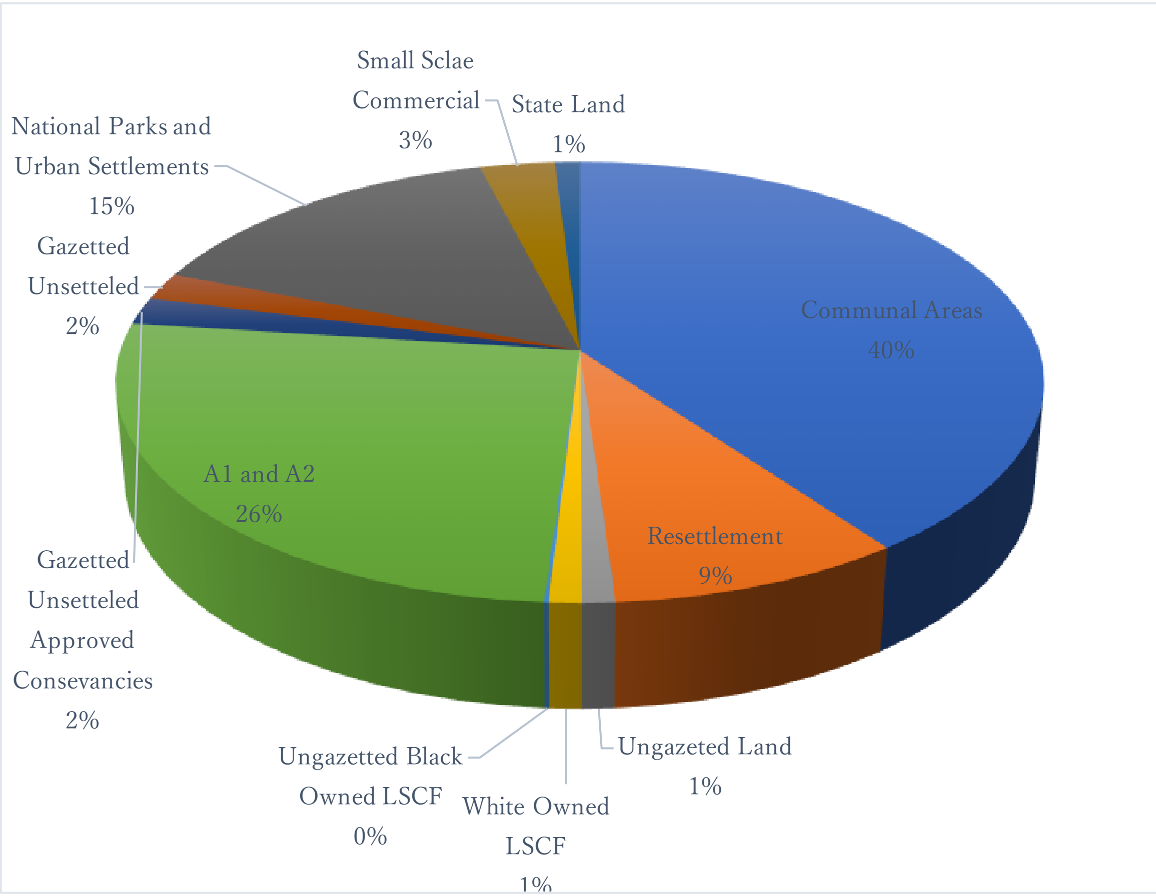

Figure 2.3 Zimbabwe Land Categories after Land Reform

Source: ZIMSTAT

The change in cattle distribution as shown on the figure above over the period to the years after the land reform show that there has been a shift in the population of cattle and in the numbers help by each farming group. The current cattle population is estimated at 5,642,400 for which 85-90% of the cattle is owned by rural farmers otherwise known as communal farmers (CLAFA-1, 2023) figure 2.4 below illustrates.

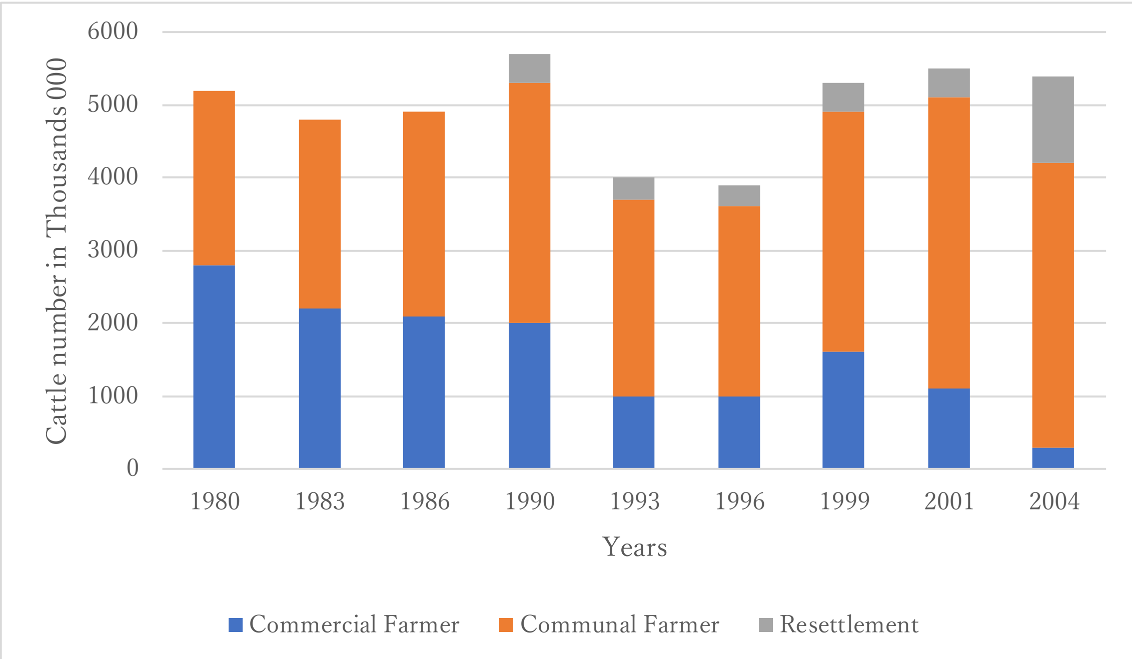

Figure 2.4 Cattle Population 1980-2004

Source: FAO, 2006

The livestock population over the years has fluctuated between 6milliom cattle and 5 million cattle, with the former being the highest number of cattle productions in

Zimbabwe before land reform and the latter being the numbers after land reform (Homann-Kee Tui et al., 2022). The figure 2.3 illustrates the trends and the effect on livestock productivity as a result of land reform. It can be noted and concluded that, after land reform there has been an increase in the number of farmers and a shift in terms of general landholding and cattle production paralleled by a general decline in cattle numbers. This general decline cannot be pinned to the distribution of land only but also to the aftermath of the land reform that may have made the decline in cattle numbers possible. This decline in cattle numbers may either be a factor of the farmer or disease or other natural causes, however this research does not dwell on the other causes.

2.6 Conclusion

The livestock sector in Zimbabwe is of huge importance to the nation and smallholder farmers who are critical to the eradication of poverty. Livestock disease affect the productivity of cattle and reduces overall agriculture production in Zimbabwe and due to the land reform, the cattle situation has changed in terms of number and also ownership, which has resulted in a strain in veterinary services distribution. The aim of veterinary is to improve the surveillance, prevent diseases, control the spread and eradicate disease.

Chapter 3 Socio-economic determinants affecting the rural farmers knowledge of theileriosis and contact with veterinary in Mhondoro Ngezi

3.1 Introduction

Tick borne diseases in Sub-Saharan Africa has had huge negative economic costs to the farmers and the countries affected. Governments in the affected regions have always tried to focus on disease eradication strategies and in wealthier countries they have also compensation for the farmers in the areas affected. In developing countries, the main strategy is usually a focus on the prevention, control and treatment with little or no compensation. It can be noted that tick-borne disease intensive control is deemed prohibitively expensive, thus making it difficult for governments of developing countries to totally (FAO, 2022).

In Sub-Saharan Africa theileriosis or East Coats Fever alone accounts for the death of 1.1 million cattle annually with an economic or financial value of USD $168million per annum accruing due to veterinary interventions, mortality, productivity losses and secondary infections due to poor resilience (Duthie and Ferguson, 2022). The costs incurred and associated with tickborne disease are huge and thus governments want to eradicate this disease in order to reduce the effect and impact of tick-borne diseases.

3.1.1 Socio-Economic factors and Animal disease control

The eradication of tick-borne disease or any animal is a factor of the activities of both the government and the farmers. This means that cooperation and understanding of these two groups can be an effective way when dealing with control and eradication of any cattle disease. Focus on disease management and control has for long focused on what the government wants the farmers to in order to implement the strategies being put in place. This one-sided focus creates gaps in implementation of strategies for the eradication or control of a disease. The farmer as the agent in the implementation of the control and prevention strategies needs to be understood in terms of their characteristics and factors that influence them in participating in disease control.

The major economic losses caused by ticks and tickborne diseases are listed as milk loss, weight loss, costs of controlling the diseases through chemotherapy, treatment methods and control of ticks and ultimately cattle mortality (Homewood et al., 2006; Kivaria, 2006). For the African poor rural farmer, the costs may be more than affordable and such treatment expenses may be unrealistic. This means that a clearer understanding of the farmer's socio-economic position, characteristics and status can aid in having a better understanding on how disease control can be implemented.

The study on the effect of theileriosis have been focused mainly on its economic impact. It is also the aim of this paper to show the impact of the disease economically on the farmer groups affected and, on the estimate, financial loss that was to be incurred. The necessity of such an analysis and impact assessment will help the major stakeholder, i.e., the government and department of veterinary services to understand the farmers and put in place strategies that make the disease control and cattle production system economically viable for rural and smallholder farmers.

The control of tickborne diseases in different countries has over the past proven to give different results under different strategies. In the year 1943, USA achieved complete eradication of tick-borne diseases by using multiple methods which included restricting animal movement, disease surveillance, restricting transport, isolating sick animals, inspection for compliance and compulsory dipping. Taking lessons from America, was the government of Australia in their bid to eradicate tick-borne diseases in their territory. The American blueprint was taken and applied as is and all elements of the American strategy were applied to which the results did not tally with those of America as they failed to eradicate the disease. This was due to the fact that the farmers resisted the methods used and there was no corresponding sanction from the government to enforce the disease control methods proposed (Angus, 2003).

In developing countries, the Caribbean in the early 2000s were dealing with tick borne disease and they came up with a 12-year strategy aimed at eradicating ticks in their territory and this was to be done in collaboration with the US department of Agriculture and other agencies (Pegram, 2010). The farmers in the larger islands did not see any sufficient reason to participate in the eradication of the disease and thus the program faced resistance, while in the smaller islands it was easier to control and the disease was eliminated (Ahoussou et al., 2010; Pegram and Eddy, 2002). The recommendation given was that there is need for a comprehensive combination of enforcement and good management (Walker, 2011).

On the other hand, the Zimbabwe experience with theileriosis has a long history and is one of success and failure. By 1954 Zimbabwe had eradicated theileriosis and this lasted not more than 20 years as thereafter the Zimbabwe war was being fought and it became difficult to control animal movement and monitor cattle dipping. (Walker, 2011). The success in controlling tickborne diseases in Zimbabwe was due to effective dipping and also due to the fact that most cattle was being owned by a few people, after 1980 independence and land reform the cattle ownership structure changed resulting in difficulties in disease control (Lawrence, 1992).

The focus on disease eradication has been predominantly focused on the animal and little on the farmer. The failure in Australia, the Caribbean and the change in the cattle ownership in Zimbabwe is a clear indication that the farmer plays an important role in the eradication of disease. To support this are the suggestion of (Kanduna, 2018), who highlighted that despite the many strategies being used in Kenya, tickborne disease continued to persist and suggested that there is need to intensify activity and also to understand the farmer better who is the implementing agent.

3.1.2 Objectives of the research

It is against this background that this research is established to establish the socio-economic characteristics of the farmer that influence in the control of theileriosis in rural Zimbabwe. The basis of this research if founded on the understanding that since much of the study only focus on the economic effects of the diseases, researches leave a gap on the socio-economic factors that impact farmer to participate in disease prevention, control and eradication. The specific objectives will be:

1. To establish the socio-economic characteristics that affect rural of farmers knowledge of theileriosis in Mhondoro Ngezi.
2. To identify the farmer characteristics that impact choice of information source and level of theileriosis knowledge in Mhondoro Ngezi.

3.2 Methodology

This study used both the qualitative and the quantitative. These two approaches in research are each relevant in certain situation and neither one is totally perfect, thus, using the two in one research gives better results (Mark, 1996; Scoones and Thompson, 1994). The use of both quantitative and qualitative research approaches was necessary in order to have an in-depth exploration on the research objectives on socio-economic factors and to see the characteristics from the perspective of those being studied. The qualitative method used in this research was included participatory research methods and existing or past case studies, while the quantitative methods included analysis of data collected.

This study was done in Mhondoro Ngezi district in Mashonaland West Province. Mhondoro Ngezi has a population of 6077 farmers spread across 16 wards. A total of 360 farmers were surveyed in this study Sample size was determined using this formula:

$$S = \frac{Npq}{CI^2/4} + pq$$

Where S in the sample size desired; N, the number of farmers in the district; p is the proportion of the farmers affected by theileriosis (90%); q is 1-p (10%) and CI is the confidence interval (5%) (Sharma, 2014).

The data was collected through the use of veterinary extension officers and they were assigned to an arear that they do not supervise so as to remove bias. Selection of the farmer to be surveyed was done using the dip tank as the reference point, thus, farmers were selected according to the dip tank used. After this stratified selection, the farmers in each dip tank selected were chosen using random sampling. The period in which data was collected is October 2022. The data was not collected on the exact same group of farmers though collected in the same district.

3.3 Conceptual framework

By nature, and orientation socioeconomic environment refers to a wide spectrum of interrelated or interconnected and diverse variables and aspects relating to or involving a combination of economic and social factors (Abdrabo, 2003). The variable and aspects can be generally categorized like economic, public services, demographic, social and fiscal, with social aspects such as community life, as well as social and cultural values and attitudes. Demographics issues can include population growth, distribution and density. On the other hand, Economic factors may be including, structures and changes in the economy and economic activities. Thus, it can be concluded that a socio-economic assessment is a way of learning about the social, economic, cultural and political conditions od stakeholders including communities, groups, individuals and organizations.

Doing a socio-economic study is for the intention to achieve the following 3 main objectives: a) assessing the socioeconomic conditions in the area under study. This will include provision of a baseline for study and characterizing the state of current situation in the study area. The importance of this first step is to identify the main areas of concern. b) analyzing the impact of the prevailing condition in the socioeconomic environment on the subjects under study and c) developing a set of guidelines used to establish viable communities (Muddock et al., 1986).

Socio-economic studies have been used in various fields of study. It has been used in public health to determine how socioeconomic status play a role in the family structure, family function and standard of living (Booysen et al., 2021). In the field of tourism, the study was applied to show the socio-economic impact of Africa's oldest marine park, in which they analyze the contribution of the park to the surrounding community. The main area of interest is the environment and proximity impact (Oberhilzer et al., 2010). In the field of agriculture there has been extensive research, in a study in Sudan, after the construction of a mega-dam a study was done to establish the economic contributions perceived by the local and displaced communities (Abdullah et al, 2020). There are many studies on the socio-economic conditions, effects, impacts and conditions as a result of different project and policies and there are different ways of measuring these. In recent years especially between 2020 and 2023 studies have been done to assess the socio-economic impact of Covid-19 on different communities and different environments and different countries (Pangarso, 2021). The importance of socioeconomic studies can never be over emphasized as they are important to create a proper understanding of the area under study or providing a baseline of the subjects under study in order to create intervention or policies. It is with this understanding that a socio-economic study is to be done in the livestock production in Zimbabwe to understand the characteristics of the livestock farmers in Mhondoro Ngezi and to establish how these characteristics impact the control, prevention and eradication of theileriosis in Zimbabwe.

3.4 Econometric Model

The assumption in this study is that farmers in Mhondoro Ngezi had multiple sources of information for the knowledge of theileriosis. The proposed methodology in this study will help derive insight into the farmer's socio-economic factors that impact access to veterinary information and knowledge of theileriosis. The null hypothesis in this research is, there is no significant difference between socio-economic factors of farmers and their knowledge of theileriosis, thus, this assumes that farmers despite of their landholding, age, education and income will have knowledge of the disease.

The choice of model to be used is the multinomial or multivariate regression analysis. The underlying assumptions on the multinomial models it that there is independence in irrelevant alternatives tis that there is mutual exclusivity on error terms of the choice equations (Greene, 2003). It can be noted that choices on the information sources for the farmers is not mutually exclusive as access to information from one or more sources can be correlated. Thus, in this research consideration for using multivariate model is on the basis that it allows for the possible contemporaneous correlation on the choice of information and knowledge of theileriosis.

The multivariate probit estimation which has been used in different researches to evaluate adoption of agriculture technologies is adopted and used in this research (Jenkins, 2011; Gillespie et al., 2004). This approach was used by Jenkins to evaluate factors affecting cotton famers adoption of different information sources, between private, media and agriculture extension, while Gellispie et al., (2004), estimated factors affecting adoption of four breeding technologies in hog production. These researchers argue that to increase efficiency in estimation modelling decisions using multivariate probit framework was befitting. The empirical model can be specified as:

$$y_{i^1} = \beta 1 x'_{ij1} + \mathcal{E}_{i^1}$$

$$y_{i^2} = \beta 2 x'_{ij2} + \mathcal{E}_{i^2}$$

Where i = farmer id, $Y_{i^1} = 1$, if the farmer has knowledge about theileriosis (0 otherwise), $Y_{i^2} = 2$, if the farmer has access to veterinary information of control of theileriosis (0 otherwise), x'_i = Vector representing factors affecting the farmers knowledge of the disease and access to veterinary, β = unknown parameters vectors j = 1 and 2 and $\mathcal{E}$ = error term.

This hypothesis can be tested by running two different independent binary logit and probit models with the assumption that error terms used are mutually exclusive. However, a decision for adopting knowledge of disease and information source can be correlated, which might make the elements of the error term to experience stochastic dependence. The assumption that error terms (across j = 1～m alternatives) hold that the alternatives are multivariate and normal distribution exists with the mean vector being equal to zero, thus the unknown associated parameters in the second equation maximum likelihood is used in estimation. The above-mentioned methods achieve this using the Geweke-Hajivassiliour-Keane which is a smooth recursive conditioning simulator procedure, used to evaluate normal distribution in multivariate models. This estimation is achieved by using Stata 17 software.

Table 3.1 Description of Variables

Independent Variable	Description	Average	Std Dev
Land holding	Rural 1; Smallholder 0	0.722	0.447
Age	Number of years	53.0	15.0
Gender	Male 1; Female 0	0.819	0.384
Education Secondary	Farmer has reached secondary school 1; none 0	0.738	0.438
Employment	Employment 1; Not Employed 0	0.816	0.386
Cattle herder	Employed Worker 1; None 0	0.437	0.258
Cattle number	Number of cattle owned by farmer	11.0	11.0
Cattle dead to Theileriosis	Number of cattle dead to theileriosis	2.7	5.1
Income source	Crops and Livestock 1; Otherwise 0	0.586	0.491
Household income	Monthly household income ($)	130.0	265.0
Annual Livestock Income	Annual Income from sale of livestock ($)	740.0	1094.0
Assets: Radio	Ownership of Radio 1; None 0	0.716	0.449
Assets: Mobile Phone	Ownership of phone 1; None 0	0.455	0.497
Dependent Variables			
Knowledge of theileriosis	Farmer can tell theileriosis signs 1; no 0	0.7	0.5
Veterinary information Source	Veterinary Extension 1; Other sources 0	0.4	0.5

3.5 Results and Discussion

3.5.1 Socio-economic factors of Mhondoro Ngezi Farmers

In this research, only 40% of the farmers reported to be actively in contact with veterinary extension officers for all animal health information, while on the other hand the other 60% of the farmers relied on other sources of communication like the family, neighbors, veterinary medicine distribution centers, and other private sources. When it comes to the farmers being able to tell the signs of the disease, at least 70% could identify the key signs such as salivating and teary eyes while 30% could not tell the specific signs of the disease. Despite the low contact with veterinary, the level of knowledge is average which is an indication that, thus it can be noted that the knowledge of the disease can be stimulated by other things other than just contact with veterinary.

The average age of the farmers in this study is 53 with an age range of starting from 19 years to 94 years and a standers deviation of 15. According to the Zimstat, (2022) from the 2022 census, the economically active population in Zimbabwe is between 16 years and 64 years, thus in thus research the minimum age fall within the economically active at 17 years but the maximum age 94 years is well above the economically active age. The age range that is above the average age of 53 years is 49.7%, while the age range that is above the economically active is 26.3%. this chows that the farming age in Mhondoro

Ngezi, Zimbabwe is constituted by a large percentage of the aged population.

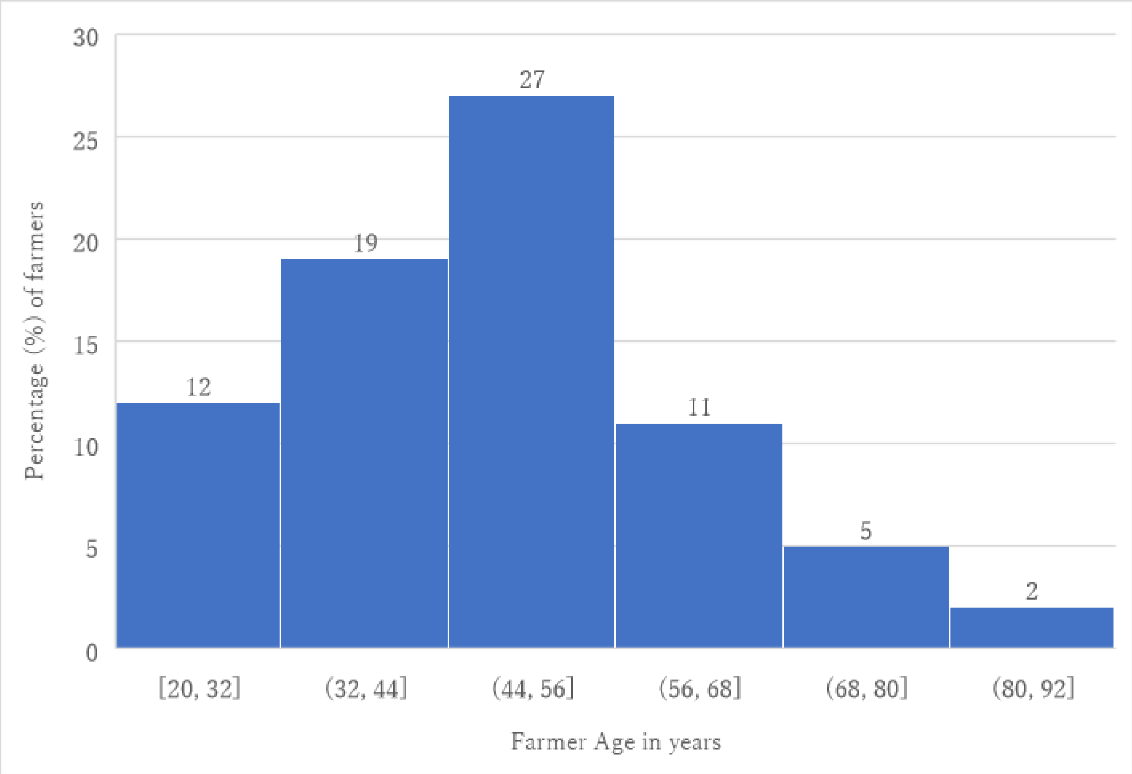

Figure 3.1: Age distribution of farmers in Mhondoro Ngezi

Having an aged population has its challenges and mainly on the fact that they may not be active in participating in implementation of certain programs and are generally not receptive to new technologies (IRIN, 2004). It may be an advantage to have aged farmers as they bring in experience but when it comes to labor intensive and technology adaptation it is a disadvantage. In Zimbabwe many elderly farmers are said to be excluded in the implementation of many projects and even farmers support organization like NGOs, shun to use more aged farmers in projects and even in the classification of age bracket the 15-49 age bracket is less than the average age in this study which means that the population average in this study is considered aged and can be excluded more in programs and communication.

The gender of the farmers in this research is more inclined to the male as the with 82% of the participants being males and only 18% as females. According to Zimstat, (2014), more than 80% of the population in Zimbabwe rely on agriculture and more than 60% of the labor force in agriculture is provided by women. In this research the representation of women is only 18%, which is a fraction from the contribution made by women to the total agriculture production of 60%, However, this could be understood in that the decision making in agriculture or mainly livestock production is mainly to the males and only the few houses headed by females have more decision making on cattle and goats by women (Senda et al., 2011).

The education attained is key in agriculture development. In most of the developing countries, agriculture practiced by a large percentage of the population, for example in Zimbabwe more than 60% of the population is in the rural areas and cattle population is tipped 90% to the rural and smallholder farmers (Warmbrod, 2019). It can be noted that one of the contributions to less development in agriculture and any other sector, is illiteracy and being uneducated, thus education becomes a key aspect of development. And its absence or lack is also a hindrance to development. In this research the farmers were evaluated in their education and the results show that only 0.01% had not attended any school, 25% had only primary or elementary education, 68% had secondary school education and only 0.05%had attained tertiary education. This shows that there is a high degree of literacy among the farmers in Zimbabwe and this is owed to the massive education rollout made by the government of Zimbabwe post 1980 independence which gave opportunity to all to study by declaring education a basic human right (Kanyongo, 2005).

The employment and cattle herding situation in this research was aimed at analyzing if the farmer has some other employment and if they have assigned another person to herd the cattle. The research shows that only a few farmers did herd they own cattle 13% of the farmers while 26% did employ a worker to herd their cattle and the remainder 61% did not indicate who is responsible for the cattle, in most circumstances the children or anyone at home looks after the cattle on that day. On the other hand, the 81% of the farmers reported to be having some form of employment other than being fulltime farmers, this could be a means to supplement the family budget in the dry season and because of climate change yields are sometimes affected and the poor farmers opt to get some employment.

The number of cattle owned by each farmer is key in understanding the livestock production in Mhondoro Ngezi. The average number of cattle owned by the farmers in this research is 11 cows, with the lowest being those with none and the highest being 89 cattle. this research was done in the middle of the theileriosis outbreak with many farmers having lost a number of cattle and it was necessary to check the number of cattle that was lost in the previous years to estimate the loss. The average cattle lost per farm was around 3, with the highest loss being 36 cattle and the lowest being 0, thus we can see the extent of theileriosis in Mhondoro Ngezi was severe as the number of cattle lost was huge across the district.

Farmer income is a both monthly household income and livestock annual income is a major determinant in the standard of life of the farmers. The average household income shows a $130 per month tis means an average of $4,33 per day and this can be categorized at poverty as the World Bank categorizes extreme poverty as living below $2.15 per person per day thus $4.33 per family is an extreme poverty case giving an average of 4 people per family according to ZIMSTAT, (2022).

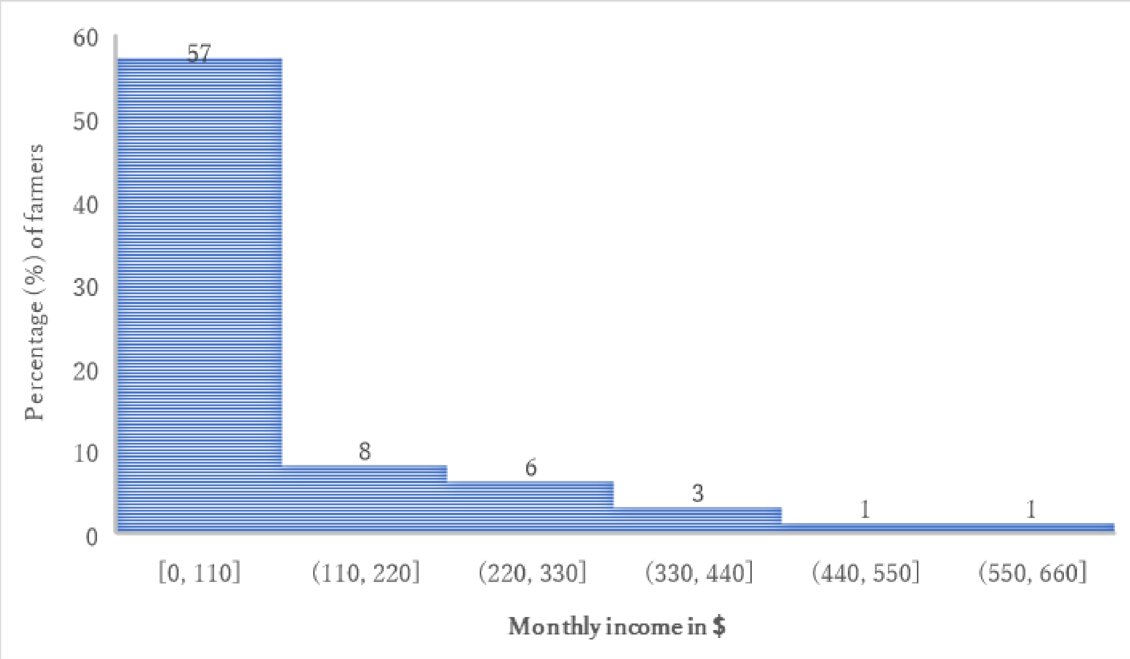

Figure 3.2: Farmers monthly income in Mhondoro Ngezi

One of the issues that enhances communication and connectivity is having access to communication technologies. This research asked the farmers if they owned assets for communication in particular, radio, and cellphone. As for radio ownership 71% of the farmers owned radios and for cellphones only 45% of the farmers owned. The Herald Zimbabwe (2022) shows that there is an 87% mobile phone penetration in Zimbabwe and a 36.2% usage of radios. This shows that there is increasingly usage of phones in Zimbabwe, however due to the Covid-19 pandemic a survey done shows that 60% of the citizens relied more of the radio as source of news. However, the study shows that despite the high percentage of mobile phone ownership the percentage of internet access is below

50% (Chingwete and Ndoma, 2020).

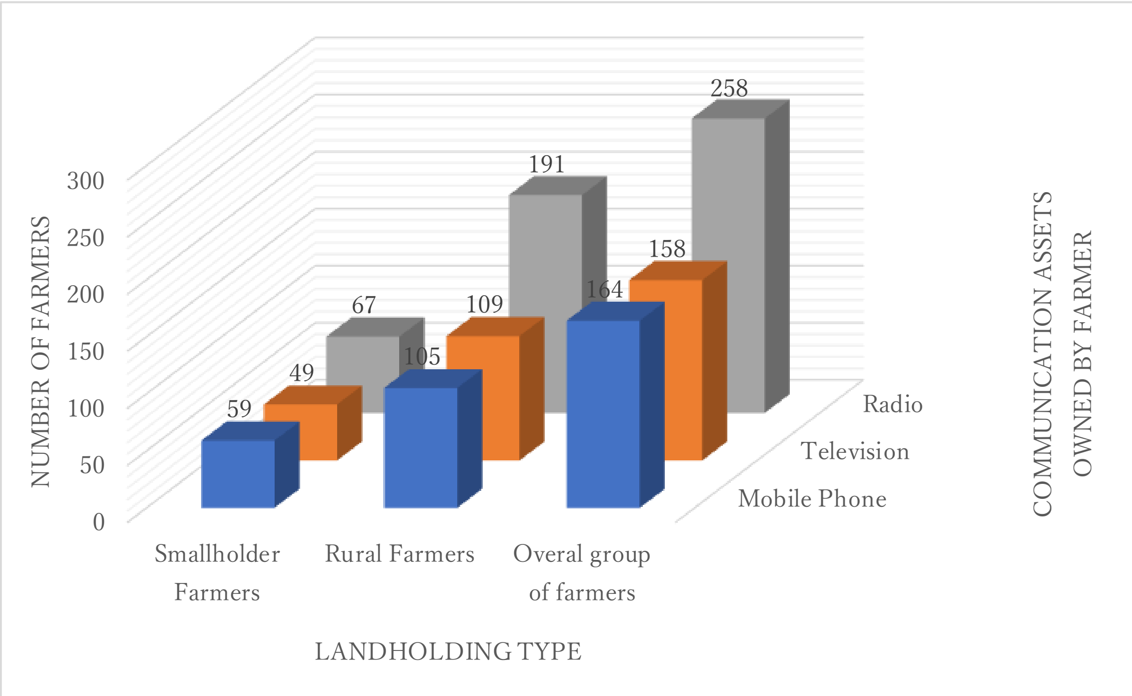

Figure 3.3: Communication assets owned by farmers in Mhondoro Ngezi

3.5.2 Multivariate regression results

The multivariate regression in this research set out to identify the socio-economic factors that impact the farmers in gaining knowledge of theileriosis and in the sources of veterinary information. The independent variables in this regression were to be checked against two dependent variables which have a contribution to the knowledge of the disease and influence even control of the disease.

Table 3.2 Multivariate regression results on Knowledge and Source of information

	Knowledge of theileriosis		Source of Information Veterinary	
	Coeff	P> ltl	Coeff	P> ltl
Landholding	-0.0279	0.118	-0.0689	0.002***
Gender	0.0962	0.078*	0.023	0.731
Age	0.0031	0.037**	0.0009	0.616
Education	0.0645	0.111	0.1351	0.007***
Herder	-0.0184	0.263	0.0379	0.061*
Employment	0.0341	0.542	-0.1310	0.057*
Cattle dead to theileriosis	0.0288	0.045**	0.0302	0.087*
Household Income	-0.0719	0.101	0.0286	0.594
Asset Radio	-0.1431	0.002***	-0.1641	0.003***
Mobile phone	0.0732	0.093*	0.0363	0.497
_cons	0.6256	0.001	0.3235	0.149

NB# *, **, *** significant at 10%, 5% and 1% respectively

When it comes to the knowledge of the disease, its cause, signs and symptoms and other factors that contribute to identifying the disease, it can be noted that there are significant socio-economic variables that impact the farmer. Gender had a significant positive impact at 10%, this means that the male farmers were more likely to tell the signs that the female farmers. This could be as a result of some factors like the livestock decision making power in some rural areas is more inclined to the makes especially for large stock like bovines while the females take ownership and responsibility if the small sock and poultry. These findings are supported by Awan et al, (2021), who highlighted that women participation in livestock production enhances productivity more than men and another study Usman et al, (2022) concluded that women participation increased farm income.

On the other hand, the age of the farmer was at 5% a significant factor in the knowledge they have about theileriosis. Meaning that farmers who have more years are likely to be experienced in terms of animal health and disease management and some of the experience come just by exposure to the disease. Farmer age was studied by Hlouskova and Prasilova, (2020), who discovered that the older the farmer the less the farm debt and more in farm management finance management. While most organization in developing countries want to fund more of the young farmers, this research focused on debt level and farm output. However, in this research the findings are only inclined to experience with disease other than overall farm income. Older farmers have more experience dealing with cattle but maybe limited in dealing with new technologies of communication and disease control.

The number of cattle died to theileriosis weighed in the previous farming season contributed much to the knowledge of the farmer about the disease. Thus, farmers who had their cattle died from theileriosis seemed to know much about the signs that cause the disease and would identify the symptoms faster. This means that the farmers who did not lose cattle as much of were not affected by the disease, had little knowledge about the disease when compared to those who had suffered loss.

Ownership of mobile phone contributed much to the acquisition of knowledge for disease prevalence, control and eradication of the disease. The mobile phone has its advantage among others being ease of access to information and handy to move with allowing always available service. Farmers who owned mobile phones which have internet access can even have extra information from other sources like the internet and Facebook. However, in this study less than 40% of the farmers owned a mobile phone, which makes the mobile phone a needed resource of knowledge gathering.

When it comes to the source of information, it can be concluded that contact with veterinary is also impacted by the socio-economic status of the farmers. The landholding, and ownership of assets like radio had a negative significance at 1%. This means that the farmers in the rural areas did not have the veterinary and he major source of information, while on the other hand farmers that owned radios did not rely on veterinary for livestock health information. Ownership of radio is supported by Africa barometer, (2022) and APNews (2023), who indicate that rural population in Zimbabwe trust more of the radio as a source of information. However, in this case the farmers listened to the radio as a trusted source but the veterinary has no active presence in radio program thus the impact of radio is negative. The farmers showed that they trusted the source of information to be veterinary over other sources of information, however the farmers still used other sources of information especially in the rural livestock production. This could be because though trusted by farmers in the rural arears, the time of availability and contact is limited and strained hence farmers rely on other sources.

Farmers that had more education like any level above the primary school level used the veterinary as the main source of information. This means that the more farmers had access to basic education, the more they trusted the veterinary as the formal and official source of information about animal health and disease control. The regression result shows that there is a positive relationship at 1%, thus giving the understanding that general education helps the ordinary person to want to learn new things and from different sources, thus it is easy for an educated farmer to rely of the veterinary for information and knowledge about theileriosis. A study done in Vietnam proves that education has a huge impact on agriculture output which was to be translated to policy to provide better education to rural people (Ninh, 2020). Thus, in this case education in Zimbabwe can be used as a tool to improve agriculture knowledge with farmers.

Farmers who have employment other than just subsistence farming did not rely on veterinary as the source of information. The regression shows that there is a negative relationship between having employment and source of information as the veterinary at

10% significance. This means that if the owner of the cattle is formally or unformal employed they tend to trust other sources of information which are not the veterinary extension. On the other hand, farmers who has cattle that died to theileriosis in the previous years of seasons did have a positive relationship with veterinary as the source of information at 10% significance. This means that because of their experience with cattle disease and the cows dying to the disease it made them become more reliant on the veterinary for animal health information.

The socio-economic factors are significant on both the knowledge attained by the farmers and the source they get the information about veterinary. The importance of education was researched in Cote d`Ivoire and they found out that the farmers who had more education were keen to used insecticides and were more aware of the disease than the less educated farmers (Kouame et al, 2022). These findings concur with this research, not only pointing on education but on other socio-economic indicators that impact increased knowledge about theileriosis.

Farmers in Sub Sahara Africa are impacted with socio economic factors positively or negatively. The adoption of usage of mobile phones for agriculture purposed in Nigeria was impacted positively by the size of the family and size of the farm while other factors like gender, marital status and age of the famer had a negative effect on adoption and use of mobile phones in agriculture related activities and production (Akinola, 2017). The nature of the socio-economic factors that impact and or affect the adoption and use of agriculture related information and technologies differ from community to community, country to country, but the principle that adoption, usage and acceptance is impacted positively or negatively remains.

3.6 Conclusion

The study showed that the level of knowledge that can be gained by the farmers is constantly being influenced by the socio-economic factors that characterize the farmers in the Mhondoro Ngezi area. This means that if the veterinary extension is to craft strategies that are inline the specific needs of the farmers on the area it will be easy to influence the way they receive the messages on animal health and also create trust with the sources of information. The rural farmers characteristics have a huge impact and effect on the level of knowledge and information they receive which impact disease control and tailor making communication for the rural farmers in their socio-economic categories can help cover the knowledge gap. A proper understanding of the socio-economic characteristics of the farmers can help the veterinary to craft strategies for contact and communication to enhance disease knowledge in Mhondoro Ngezi.

The majority of the farmers in this research were in the rural areas and their age range is above the economic productive age with an average age of 53 which shows that the farmers are old and some are not educated enough to accept new forms of technologies for communication. This has impact on the communication that can be done by the veterinary. The low percentage of mobile phone ownership is an indication that the farmers do not have access to timeous remote information which can be given by the veterinary extension officer though the mobile phone.

This study showed that the socio-economic indicators of the farmer population in Mhondoro have a significant negative impact on how the veterinary must communicate as use of technologies may not give desired outcome of increased theileriosis knowledge. The government must put in place communication technologies that meet with the needs of the rural farmers who are illiterate, poor and in remote areas and these may include having radio programs and promoting use of posters and brochures to be distributed to these farmer groups.

Chapter 4 The impact of communication medium used by veterinary on rural farmer knowledge of theileriosis in Mhondoro Ngezi.

4.1 Introduction

4.1.1 Farmer Knowledge

Farmer knowledge is essential for developing agriculture and increasing productivity (Janc, 2012). In veterinary extension, farmer knowledge includes understanding animal health practices and methods to prevent and contain diseases. In animal health, knowledge is determined by the ability to know the cause of the disease, tell the symptoms, and know the remedies (Ducrot et al, 2011). Building farmer knowledge can be possible when there is effective communication (Adamsone-Fiskovica and Grivins 2021). Investing in communication within agriculture increase farmer empowerment (Faqih and Aisyah, 2019). Agricultural communication prioritized is only a stimulus for the adoption of technologies, and not a complete means of change (Balamatti and Biradar, 2016; Moyo and Salawu, 2018), thus, communication is essential in building farmer knowledge. In Zimbabwe, the Agricultural, Technical, and Extension Services (AGRITEX) is responsible for government to farmer communication, while the Department of Veterinary and Extension Services (DVS) is responsible for communication on animal production (Sungirai et al., 2015). Two key communication pillars are source of information and the medium used, and they can influence public perception and behavior (Wilkins et al 2018). Increasing farmer knowledge depends on efficient communication and enough technical support.

In Zimbabwe livestock diseases are prioritized because of the importance of livestock in production, transport, meat and milk supplies, storage of wealth and generation of household income (Tavirimirwa et al., 2013), with overall contribution of 35%-38% of the Gross Domestic Product (GDP) of the Agricultural sector which contributes 17% to overall GDP (FAO 2020). The contribution to the economy and to individual farmers is threatened diseases like foot and mouth disease and secondly by tick-borne diseases, chief among them bovine theileriosis (Manyenyeka et al., 2021; The Patriot, 2022).

Theileriosis is an animal disease caused by members of the protozoal genus *Theileria* (Lawrence and Waniwa, 2019) mainly affecting cattle in eastern, central, and southern Africa. Its mitigation has relied on effective control of the tick vector *Rhipicephalus appendiculatus*. In Zimbabwe, it is known as "January disease" and specifically a disease of cattle caused by *Theileria. Parva* (Lawrence and Waniwa, 2019). *January disease* is the name used because the disease is highly transmitted at the peak of rainy season in January. Signs of theileriosis include breathlessness, poor appetite, swollen lymph nodes, low milk production and high temperature, among other signs (Lawrence and Waniwa, 2019). In East Africa the muguga vaccine is used (Allan and Peters, 2021), while in Zimbabwe currently cattle dipping is main control method (Muvhuringi 2022).

Cattle dipping, weekly and fortnightly in summers and winter, respectively, is the main control strategy in Zimbabwe (Muvhuringi et al., 2022; Sungirai et al., 2018). Cattle are dipped in a plunge dip filled with water containing chemical to break the life cycle of ticks and during outbreaks the 5-5-4 dipping strategy is recommended by DVS (Muvhuringi et al., 2022). The 5-5-4 dipping method, means cattle dipping twice for 5 days, followed by a 4-day interval to break the life cycle of the tick, because of the short tick engorgement period in wet environments (Muvhuringi et al., 2022; Sekkin, 2017; Walker, 2011). However, there is no recorded data showing with statistics of the effectiveness of the 5-5-4 dipping method while some attribute its effectiveness to low cases of the disease in other parts of the country. Disease control initiatives by the government have mainly been technical; consequently, tick-borne disease outbreaks have always continued. The 2018-2021 period recorded a year on year increase in both cases of theileriosis and deaths of cattle claiming at least 50000 cattle (Muvhuringi 2022; New

Zimbabwe 2022; Lawrence and Waniwa, 2019), this was not the trend in previous years as Zimbabwe was able to export meat because of disease control.

The main affected groups are smallholder and communal farmers who occupy 96% of the agriculture land and account for 90% of the cattle (Zimfact, 2018) and are the main beneficiaries of the Fast track Land redistribution which tilted land ownership in favor of rural population (Sungirai et al., 2015). This led to a shift in cattle ownership and ultimately resulting in constrain to the veterinary services affecting communication and service delivery (DVS, 2022). The communal farmers group is reported to be not fully participating in tick control activities, yet owning more cattle (DVS, 2022), indicating there exist gaps in communication and knowledge of theileriosis among farmers which may have resulted in increase in cattle deaths.

In Africa farmer knowledge is mainly affected and/or determined by socio-economic factors and this varies by country (Mutimura et al, 2018). In rural Kenya farmer knowledge was largely affected by household head age and education among other factors (Mogaka et al, 2021), communication was considered as part of the key solutions to closing the knowledge gap. While studies conducted in Zimbabwe have focused on accounting the tick species, epidemiology of tick diseases, and case locations (Manyenyeka, 2021; Sungirai, 2015; Latif et al., 2001), little attention has been paid on socio-economic factors that determine farmer knowledge of theileriosis in Zimbabwe and how it impact cattle death. Furthermore, research conducted in Zimbabwe showed that farmers lack knowledge, and suggests communication would be necessary to increase knowledge, reduce disease prevalence and increase productivity (Thomas et al., 2020; Musungwini, 2018).

4.1.2 Objective of the research

In recent years much research has focused on impact of theileriosis in Zimbabwe (Moyo et al 2017; Manyenyeka et al 2021), but with the increase in knowledge of the disease and ticks there is little focus on farmer characteristics as determinants of knowledge among the different farmer groups in Zimbabwe and how communication is used. Purpose of this research was to also establish socio-economic determinants of knowledge of theileriosis in smallholder and communal farmers in Mhondoro Ngezi. This study aimed to fill the gap in the impact of communication on theileriosis knowledge and the effect on reducing dead cattle among communal and smallholder farmers.

4.2 Methodology

This study was conducted between September 2021 and October 2021 in Mhondoro Ngezi District, Mashonaland West Province, Zimbabwe. The area spanning 9.327 km^2 is in farming region 3, recording 650-800mm rainfall annually. It contains 16 wards and a farmer population of 6,077. Mashonaland West Province was selected for this study because it recorded the highest number of cattle deaths due to theileriosis between 2019 – 2021. Multistage sampling technique was adopted to select respondents, the first stage was selection of Mhondoro Ngezi district, wherein stratified sampling was performed among smallholders and communal landholders. Systematic random sampling techniques were used to select farmers per dip tank listed from six selected dip tanks in the district. 320 farmers were selected using the formula n=z^2pq/e^2 (Kothari, 2004). Here, n = sample size; z = standard normal deviate set at 1.96, corresponding to a 95% confidence interval; p = proportion of livestock farmers in Mhondoro Ngezi; q = 1-p; and e = maximum allowable error 0.05.

Data were collected using a structured questionnaire for individual farmers through face-to-face interviews, and open-ended questionnaire was used for focus groups comprising five to seven farmers. The questionnaire was pre-tested on five farmers drawn from different dip tanks. Pre-test was limited to a few farmers in the sample size because of the Covid-19 protocols and restrictions on movement. Questionnaires were administered by veterinary extension officers from DVS in Mhondoro Ngezi, who were tasked with collecting data in an area they did not supervise, to remove bias. The data were analyzed in Stata 17 using a Tobit model with endogenous regressor.

4.3 Conceptual model

An empirical challenge exists in establishing a causal relationship (Akter et al, 2020) between theileriosis knowledge and dead cattle % which means endogeneity exists. Farmers may not have the liberty of selecting the communication medium used as there is a strain in the veterinary extension services. This means that the dead cattle % can be affected by other unobserved factors, thus the endogeneity of dead cattle % was associated with not only changes in variable like veterinary access, tick control methods, grazing system and frequency of access but also changes in the error term. To correct this, the instrumental variable estimation was selected for establishing the causal effect of communication on dead cattle %. As there are other variables that do not directly affect dead cattle %, an analysis of their relationship with theileriosis knowledge was assessed using instrumental variable method. Instrumental variable method, a two-stage least square technique used to estimate relationships of interest (Angrist and Alan 2001), was used to estimate relationship between increasing theileriosis knowledge and dead cattle %. Dead cattle % was the dependent variable. The independent variables were socio-economic in nature these are: landholding, age, age^2, sex, income source, cattle herding experience, education, veterinary access, and cattle feeding system. The socio-economic variables were used basing on previous research suggesting that rural farmer knowledge in developing countries is mainly affected by issues like age, household income and education among other (Mogaka et al, 2021; Ermino, 2019; Mafimisebi et al 2012). The endogenous variable was *theileriosis knowledge*, while instruments were *information source* and *communication medium*.

The purpose of using instrument variables was to measure how knowledge of theileriosis is influenced by source of information and communication medium and how if impacts dead cattle %. The instruments used, meet the condition of the instrumental variable because the instruments are exogenous (Angrist et al, 1996), as both information source and communication medium cannot be determined by the farmers but mainly by veterinary.

4.4 Econometric Model

The first stage regression equation can be presented as:

$$Theileriosis\ knowledge_i = \boldsymbol{\delta_0} + \boldsymbol{\delta_1} \cdot Information\ Source\ _i + \boldsymbol{\delta_2} \cdot Communication\ medium_i + \boldsymbol{\delta_3} \cdot Landholding_i + \boldsymbol{\delta_4} \cdot Farmer\ Age_i + \boldsymbol{\delta_5} \cdot Farmer\ Age^2{}_i + \boldsymbol{\delta_6} \cdot Farmer\ Sex_i + \boldsymbol{\delta_7} \cdot Income\ Source_i + \boldsymbol{\delta_8} \cdot Cattle\ herding\ experience_i + \boldsymbol{\delta_9} \cdot Education_i + \boldsymbol{\delta_{10}} \cdot Veterinary\ Access\ Time_i + \boldsymbol{\delta_{11}} \cdot Feeding\ System_i + \boldsymbol{u_i}$$

The second stage regression equation can be presented as:

$$Dead\ cattle\ \% = \boldsymbol{\gamma_0} + \boldsymbol{\gamma_1}\ Theileriosis\ knowledge + \boldsymbol{\gamma_2} \cdot Landholding_i + \boldsymbol{\gamma_3} \cdot Farmer\ Age_i + \boldsymbol{\gamma_4} \cdot Farmer\ Age^2{}_i + \boldsymbol{\gamma_5} \cdot Farmer\ Sex_i + \boldsymbol{\gamma_6} \cdot Income\ Source_i + \boldsymbol{\gamma_7} \cdot Cattle\ herding\ experience_i + \boldsymbol{\gamma_8} \cdot Education_i + \boldsymbol{\gamma_9} \cdot Veterinary\ Access\ Time_i + \boldsymbol{\gamma_{10}} \cdot Feeding\ System_i + \boldsymbol{\mathcal{E}_i}$$

Table 1 summarizes the description of the variables used in this study and mean findings of the data.

Table 4.1 Description of Variables

Variable	Definition	Mean	Std dev
Dead Cattle %	Percentage of dead cattle in farmers' present herd	196.51	469.49
Knowledge of Theileriosis	1 = Have Knowledge about theileriosis symptoms, cause, and prevention 0 = No Knowledge about theileriosis	0.76	0.42
Landholding	1 = Smallholder farmers 0 = Communal farmers	0.32	0.46
Age	Farmer Age in years	56.4	14.80
Sex	1 = Male 0 = Female	0.88	0.31
Income Source	1 = Income from livestock sales and milk 0 = No income from livestock sales and milk	0.43	0.49
Cattle Herder Experience	Years working in livestock farming	25.3	17.71
Education	1 = Basic education 0 = No Basic education	0.06	0.24
Vet Access Time	1 = Monthly access to veterinary services 0 = No monthly access to veterinary services	0.42	0.02
Feeding System	1 = Community land 0 = No community land	0.98	0.11
Information Source	1 = Information from veterinary office 0 = Information from social network	0.65	0.47
Communication Medium	1 = Oral communication 0 = Written communication	0.91	0.28

4.5 Results and Discussion

4.5.1 Theileriosis knowledge

This research showed that 76% of the farmers had knowledge of the disease and 94% of the farmers could identify at least one major symptom especially swollen lymph nodes. The other symptoms are acceptably known and some, such as low milk production and yellow gums are barely known, as depicted in Table 2. Differences in statistics, show that there is a gap in the levels of knowledge between the smallholder farmers and communal farmers, with the communal farmers being less-knowledgeable.

Table 4.2 Knowledge of the symptoms of theileriosis

Symptoms	**% in smallholder farmers** (n=107)	**% in communal farmers** (n=213)
Cloudiness of eyes	39	74***
Swollen lymph nodes	33	44
Low milk production	1	6
Shortness of breath	59	56
Loss of appetite	95	94
Staggering	18	35***
Yellow gums	14	4
Death	15	33
Moving behind	53***	32

***, significance 1%,

We established that there is difference in knowledge levels if the farmer knows the disease, but unable to tell symptoms, preventative techniques, and control methods. To distinguish this clearly, the researchers also focused on differences in knowledge between smallholder and communal farmers.

Preventative techniques are aimed at reducing spread within and between cattle herds. Smallholder farmers relied more on calling veterinary officers and separating sick animals. However, communal farmers relied not only on separating the sick cattle and calling the vet, but also selling the cow to recover the value which can cause health disasters. Figure 4.1 presents the statistics from the research, showing both the category and techniques used by each farmer type.

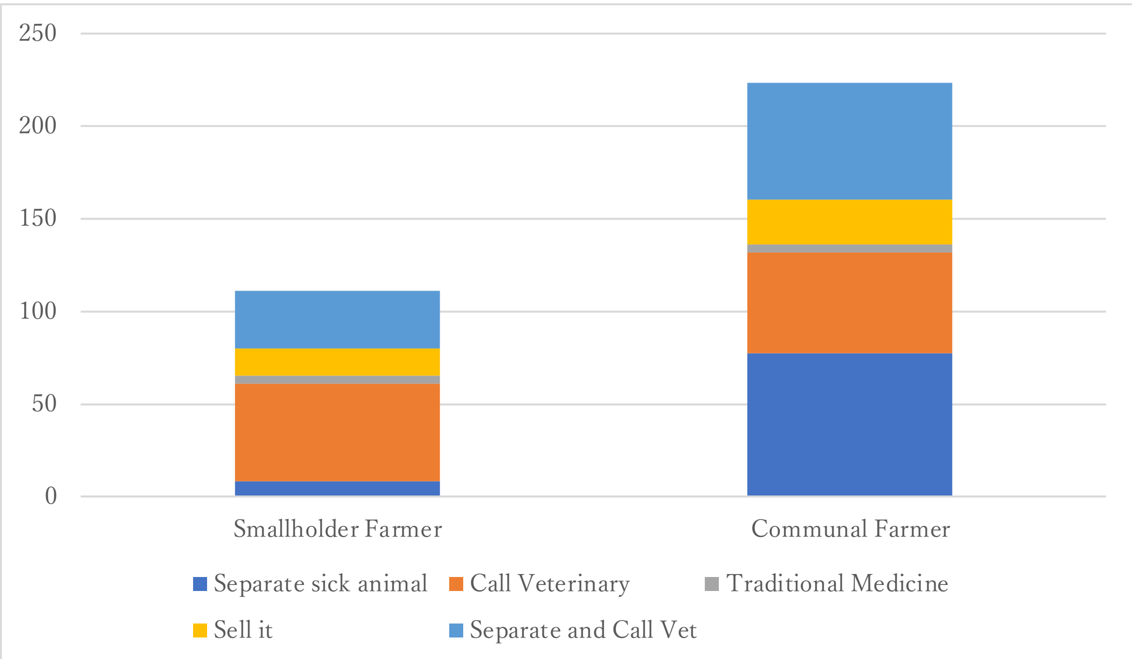

Figure 4.1 Preventative techniques

The tick control methods used in this study included dipping cattle, applying tick grease, using a spray race, and a combination of dipping and tick grease. Communal farmers used the dipping strategy and the combined dipping and tick grease technique, which are services provided mainly by the government. However, with DVS limited resources the communal farmers suffer. In contrast, smallholder farmers used government services as well as the spray can, a self-made method, to eliminate ticks which seemed effective to reduce cattle deaths. Figure 2 illustrates these results.

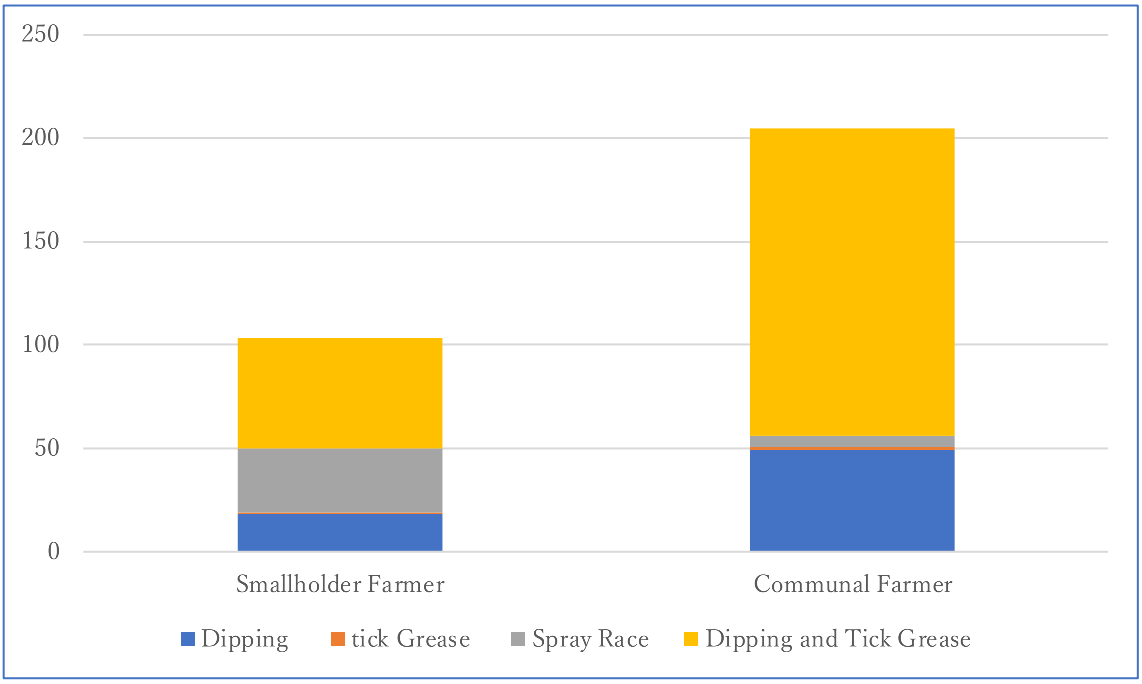

Figure 4.2 Tick control method

Theileriosis knowledge cannot be assessed on its own, additional questions were asked to the farmers regarding disposal of dead cattle, as shown in Figure 3. The recommended disposal method is to burn the cattle. Smallholder farmers followed the disposal recommendations, while some communal farmers buried the dead cattle, sold the dead cow, or cooked the meat for.

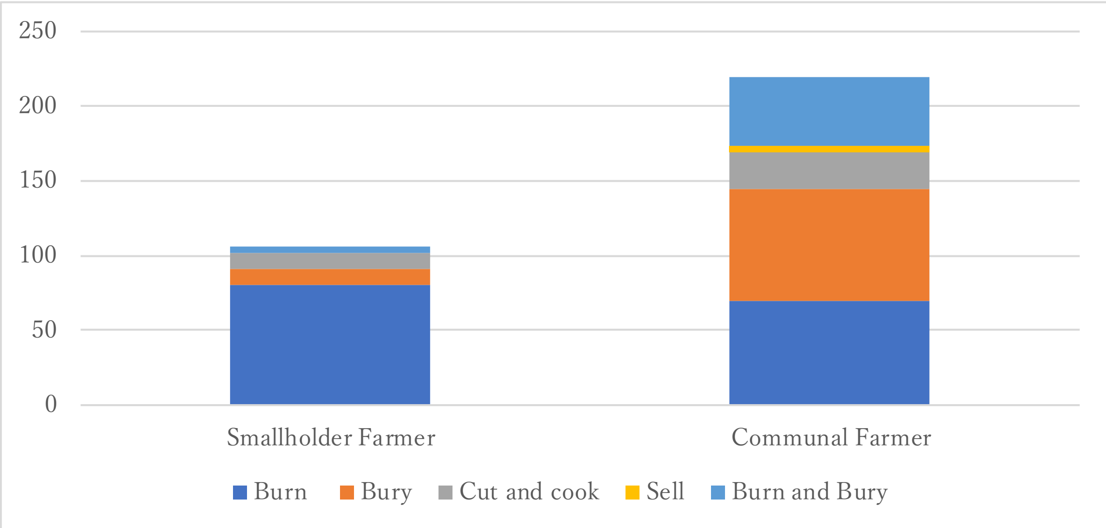

Figure 4.3 Disposal of dead cattle

4.5.2 Factors affecting theileriosis knowledge

Landholding, farmer age, and *education* had significant positive relationships with knowledge of theileriosis at 1% significance level, as shown in Table 4.3. As age increases chances to gain more theileriosis knowledge increase until a certain age, and the *Farmer* Age^2 shows that as age increases, knowledge decreases. *Cattle herder experience* and *veterinary access time* had negative relationships with knowledge of theileriosis at 1% significance level.

Table 4.3 Instrumental Variable Regression on Dead Cattle % and Theileriosis Knowledge

Variables	(A) Knowledge of Theileriosis		(B) Dead Cattle %	
	Coefficient	**P> |z|**	**Coefficient**	**P> |z|**
Knowledge of Theileriosis	-	-	-1296.846	0.005***
Landholding	.1811343	0.000***	14.98209	0.893
Farmer Age	.0260521	0.004***	-2.911411	0.897
$Farmer\ Age^2$	-.0002429	0.005***	.0479316	0.830
Farmer Sex	-.0544862	0.362	20.06153	0.835
Income Source	-.2022601	0.000***	-270.3367	0.073*
Cattle Herder Experience	-.1839945	0.000***	.693127	0.994
Education	.2138603	0.003***	195.8873	0.235
Veterinary Access Time	-.2481961	0.000***	-357.2864	0.015**
Feeding System	-.2003448	0.010**	-433.8759	0.034**
Information Source	.1063687	0.041**	-	-
Communication Medium	-.1927319	0.000***	-	-
_cons	.8430071	0.000	1965.422	0.006
Observation	318		318	
WaldChi2 (13)	37.27***		37.27***	

***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

4.5.3 Factors affecting percentage of Dead cattle

The second-stage regression aimed to understand the variables that can affect the number of dead cattle. The first instrument is the extraction from the first-stage regression, which shows that there is a negative relationship between the *knowledge of theileriosis* and the percentage of dead cattle at 1% significance level. Farmers with agro-based *income sources* relying on animal sales and milk had low dead cattle %. Significant relationship at 10% level indicates that the more farmers engaged in livestock-related income, the more they protected the cattle herd from diseases, the less cattle died. Increased *veterinary access time* showed a significant relationship with dead cattle %.

The *information source* is critical as it denotes how a farmer obtains information about animal health. The variable *information source* had a 5% significance level and was positively related to theileriosis knowledge. This indicates that farmers who had access to veterinary extension officer as source of information were more knowledgeable than those who did not have access. There is a possibility of increasing the level of knowledge of theileriosis if the DVS as the custodian of animal health and surveillance is more active in disseminating information regarding animal health. The use of official sources of information is key to managing the knowledge transmitted to the farmers; however, in the context of Zimbabwe, the strain on veterinary officers, due to an increase in the farmer population, calls for new ways of communicating with farmers, which may include using technology and mass media.

Communication medium had a negative relationship with the knowledge of the disease at 1% significance. This is because the use of oral communication to pass information had no lasting impact on the farmers' theileriosis knowledge. Absence of written communication can be due to a number of reasons, spanning from illiteracy of farmers to financial constraints of the government in producing written communication even in local language. The use of oral communication could have been necessitated by the fact that farmers have limited exposure to writing as a form of communication, given that their education is mainly between the primary and secondary levels, especially in communal areas, while also the government may have limited resources to provide written information. This claim is supported by the UNICEF's 2021 report, which highlighted that secondary school education rate in Zimbabwe is very low reporting high attendance of secondary school and low completion. This will, in turn, impact the level of knowledge these farmers accumulate, as well as the communication medium used.

Study on the socio-economic determinants of theileriosis knowledge among smallholder and communal farmers as influenced by communication used by the veterinarian. The first characteristics was landholding. More farmers were in the communal area while the percentage of dead cattle was higher for the farmers in the communal area. This means that farmers in smallholder category have higher chance of gaining knowledge about theileriosis than the farmers in communal areas, thus they had low dead cattle percentage. These findings are supported by (Obidike, 2011) who highlights that rural farmers have less access to knowledge and at times rely on traditional knowledge.

Farmers who have a basic level of education tend to gain more knowledge about theileriosis than farmers who have no educational background. These results agree with the statistical information that despite the high literacy rate in Zimbabwe, the level of education attendance is low in rural areas (Shoko, 2014). A UNICEF (2021) report shows that primary and high-school dropouts are common in rural areas of Zimbabwe, and that the completion rate for ordinary level education is very low. Higher education can influence the adoption of new farming methods and improve farm productivity (Warmbrod, 2019; Paltasingh and Goyari, 2018). These research findings agree with those of studies on agricultural productivity and education conducted in India and parts of Africa. An emphasis on increasing agricultural education can help disseminate more knowledge about theileriosis in Zimbabwe. There is a need to focus on community training programs for disease awareness and to increase livestock education among those in the school-going age group by engaging veterinary officers in school education as some cattle herders are kids of school going age.

This indicates that the increase in experience affects the accumulation of theileriosis knowledge, considering the average years a farmer has dealt with cattle is 20 years. Farmers who have limited access to veterinary services over the course of a month have limited theileriosis knowledge is limited. Presumably, farmers who have more contact with veterinary services monthly have more knowledge of animal health. Additionally, farmers with fewer years of cattle experience tend to know more about theileriosis because young farmers are receptive to new knowledge and information. Akter et al (2020) highlights that smallholder farmers who adopt to technology improve agriculture productivity, thus if the famer population be more old aged adoption of technologies is low. This is also supported by Musungwini 2018, on a study in Zimbabwe that information asymmetry in agriculture can be solved by introducing technology but the older the farmer the less the technology uptake which means younger farmers are to be supported to be active in agriculture.

Increase in knowledge of theileriosis will result in significant decrease in dead cows. Thomas et al. (2020) highlighted that increasing farmer knowledge will improve agricultural productivity, thus supporting our finding. In the current study, the smallholders were more knowledgeable, and had a lower percentage of dead cattle compared with communal farmers. This means that the group with the largest cattle ownership has limited knowledge which will result in the total cattle population in Zimbabwe being affected. Therefore, is necessary to manage the knowledge transfer among communal farmers so as preserve the national herd.

Higher frequency of access to veterinary services resulted in reduction in dead cattle. Farmers with low access to vet services reported more dead cattle. Farmers in smallholder were more likely to call a veterinarian than communal farmers who relied more on separating the sick cows from the unaffected cows. Pahwa and Swain (2020) showed that there is need for frequent communication and educating rural farmers help reduce the effect of zoonotic diseases. The findings of our study agree with those of the above-mentioned study showing need to frequently educate farmers on theileriosis.

4.6 Conclusion

According to this study, increase in incidence of dead cattle can be attributed to the limited knowledge of theileriosis among farmers, mainly in communal farmer category due to communication issues in veterinary extension. Communal farmers have more years of cattle herding experience and an aging farmer population, both of which have negative effects on gaining knowledge. Relying on an aged population has negative effects to the advancement of agriculture in Zimbabwe, thus the government must put in place policies that empower the younger generation to be active in agriculture and support their activities.

Farmers in the smallholder category could identify more signs of theileriosis and used more tick control methods that relied less on government services and had more income related to agriculture. This enabled smallholders to manage the disease quickly and effectively, resulting in fewer theileriosis-related deaths among the cattle. Communal farmers need more access both markets and information and this will mean more participation in the agriculture value chain thereby reducing the probability of poverty. Policies that promote the participation of communal farmers in livestock value chain to encourage them to be economically active must be considered despite of the landholding.

The farmers obtained most of their information from correct source, the veterinary office, but the access times and communication media used have been important factors. Communication medium that promotes record-keeping and veterinary access times with short intervals between visits are important to promote knowledge of theileriosis. Use of written communication in the form of brochures in local language and in pictorial form can help communicate with the aged. Radio programs can also be used to transmit the message as the farmers have more access to radios than any other mediums.

Chapter 5 Tick borne disease knowledge, attitudes and behavior (KAB), correlation with cattle dipping and livestock productivity in Mhondoro Ngezi.

5.1 Introduction

Livestock in sub-Saharan Africa is threatened by various diseases and tick borne has a significant constrain on livestock production (Bishop et al., 2023, Jongejan and Uilenberg et al., 2004.) Ticks have a huge economic and social impact on livestock and potentially of causing more poverty on sub-Saharan rural farmers (Minjauw and McLeod 2003.) Zimbabwe livestock is by no means spared from tickborne diseases and has suffered much between 2018 and 2022 (DVS, 2022). In Zimbabwe the control of ticks is via cattle dipping, while in East Africa and other parts of Africa there is cattle vaccination. (Shekede et al., 2021, Allan and Peters, 2021)

5.1.1 Cattle dipping behavior and disease prevalence

In a country that has a 65% population in the rural areas it is critical to engage the farmers and ensure that their knowledge and attitude of animal diseases is enough to impact the desired behavior of cattle dipping. The period stretching from 2018 until 2022 saw an increase in cases of theileriosis and recorded cattle deaths were over 500,000. The veterinary services have been engaging farmers encouraging cattle dipping, tick control and identification of signs and symptoms of theileriosis. The 5-5-4 method is promoted with the aim of cutting the tick life cycle by dipping cattle, and according to (CLAFA-1, 2023) dipping is 68% adequate and 32% inadequate, yet places like Mhondoro Ngezi District which are disease hotspots, inadequate dipping exist, figure 5.1 below illustrates.

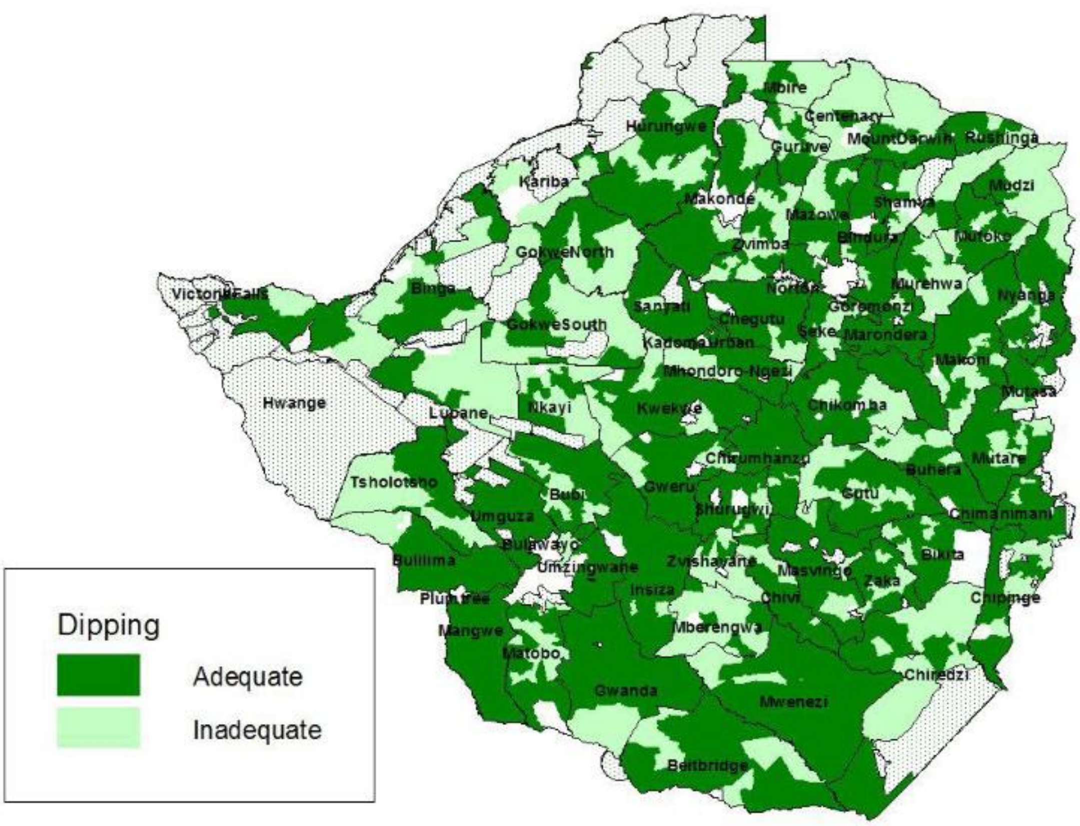

Figure 5.1 Livestock dipping situation

Source: CLAFA-1 2023

While the department of veterinary services has reported increased effort to improve farmer awareness of theileriosis, gaps in the behavior of cattle dipping have resulted in reports of inadequate dipping. This research aims to establish factors affecting 5-5-4 cattle dipping behavior using structural equation modeling and how to increase awareness of theileriosis. Thus, on the basis of this understanding this research aims at establishing why inadequate dipping exist when the government promotes dipping. The findings from this study will be used as a guide for veterinary services theileriosis awareness and control in Zimbabwe.

5.1.2 Objective of the research

Studies done in the past in Zimbabwe have focused on tick vector and its varieties, while others focused on occurrence of ticks and another on farmer perception of tickborne disease (Muvhiringi et al., 2022; Shekede et al., 2021 and Sungirai et al., 2016). This leaves a gap on farmers knowledge and attitudes of disease prevalence and control, which impact behavior practice of 5-5-4 cattle dipping. Therefore, the main objective in this study is to establish the effect of theileriosis knowledge and attitudes on behavior of farmers regarding 5-5-4 cattle dipping in rural Zimbabwe. SEM will be used to reveal the impact of knowledge and attitude on 5-5-4 cattle dipping behavior among farmers.

5.2 Methodology

The empirical data collection was conducted in Mashonaland West province in the Kadoma Districts. Kadoma district was selected because of two reasons, purpose and proximity; purpose in that it was one of the areas that recorded the highest number of theileriosis cases and deaths and its proximity allowed for easy access to farmers in the major landholding zones. Mhondoro Ngezi is the district of research and has 6077 households. Data was collected in October 2022 and the farmers selected were systematically selected using dip tank locations and then random sampling per dip tank. The main veterinary office managing Mhondoro Ngezi district is in Kadoma city and there are twelve Veterinary extension officers.

The sample size for this research was 360 farmers selected using the formula n=z^2 pq/e^2 (Kothari, 2004). Here, n = sample size; z = standard normal deviate set at 1.96, corresponding to a 95% confidence interval; p = proportion of livestock farmers in Mhondoro Ngezi; q = 1-p; and e = maximum allowable error 0.05. Effective selection of the farmers at dip tank level was achieved by engaging the veterinary extension officers who provided the names and details of the farmers per dip tank that they supervised. During data collection the veterinary extension officers were assigned a village which was not the one they usually supervise so as to remove bias.

A structured questionnaire with five section was used to collect the data. Section A consisted of farmer sociodemographic questions and farmer characteristics questions. Section B, C and D focused on Knowledge attitude and behavior with regards to tickborne disease control and management. The last section D was focused on social networks for theileriosis information. Pretesting was done on 36 farmers in the respective areas selected under each dip tank. Data collection process was facilitated by twelve veterinary extension officers and two veterinary extension supervisors helped in the verification of data collected and follow up on any issues needing clarity. The fourteen participants were first trained and oriented on how to answer the questionnaire and areas of concern were noted and corrected. The language used in the questionnaire was English an official language in Zimbabwe and can be used across different language groups and where farmers did not understand explanation will be given in local language mostly in Shona.

5.3 Conceptual framework

The Knowledge, attitude and behavior (KAB) model, an abridged model of KAP knowledge, attitudes and practice, evaluates dependent variables in light of independent variables and intermediate variables (Tufa et al., 2023). The adoption of the KAB model in this research was to establish the link between farmer 5-5-4 cattle dipping behavior and farmers knowledge, attitudes and practice on the control and effects of theileriosis. KAB model is used to measure learning and diffusion on innovation (Bandura, 1976 and Roger, 1995). Innovation acceptance by members in a social system happens in four stages which are, acquisition, persuasion, decision and conformation and individual behaviors are learned through social context (Bandura 1976, Rogers, 1995). These two assertions provide for a framework in understanding relationship between behavior intention and attitude. To manage disease outbreaks, focus on the farmers knowledge, attitude and behavior is key.

In this study knowledge is defined as the understanding of information (Wessman, 2006), conscious and not symbolic. Knowledge can be categorized into four ways: (i) local knowledge, (ii) self-reflective, (iii) scientific and social knowledge and (iv) tacit knowledge (Hume, 2018). Attitude is defined as the positive or negative evaluation of something and Behavior is outlined as regular activities that is influenced by shared norms and beliefs (Azien and Fishbein, 2000 and Bourdieu 1990).

Studies in past confirm that there are interconnections between knowledge, attitudes and behavior, and that individuals hold positive attitudes and behaviors have better motivation towards an issue or subject (Valente, 1998, Hungerford and Volk, 1990 and Ajzen, 1991). Perceived behavior and subjective norms if controlled would lead to formation of behavioral intentions (Ajzen, 1991). According to Liao et al., (2022), "Subjective norms refer to individual receipt of social influences from peers or other important people who wish that the individual would engage in a particular behavior. Perceived behavior control refers to the perceptions of the ease or difficulty of performing the behavior of interest, such as the availability of or ability to implement a new farming practice". We can conclude that if an individual has the ability to control attitudes towards a behavior it will in turn control subjective norms and perceived behavior, thus the more the behavior intention. There are several factors that affect farmer such as environmental conditions and farmer characteristics among other factors (Meijer et al., 2015).

Accordingly, (Tufa et al 2023, Nguyen et al., 2019; Andrade et al., 2020) define KAB model as a structured, standardized questionnaire completed by a target population that can quantify and analyze what is known (knowledge), believed (attitudes), and done (behavior) with regard to a topic of interest. This means that to identify if there are knowledge gaps, attitude barriers and behavior patterns, KAB models are suited to outline that (World Health Organization, 2008). Thus, in this case the necessity of implementing a KAB study is due to the fact that farmer knowledge of tick-borne diseases needs to be assessed to identify if the increase in theileriosis cases and death is related to farmer attitude towards the disease and treatment methods provided by the government.

5.4 Econometric model

Structural Equation Modeling was used as the main analysis for the determinants and variables for Knowledge, Attitude and Behavior which are not socio-demographic in nature. Structural equation model centers on ordinal data basing on the questions asked in the questionnaire. In terms of attitude variables, the range is from 1 meaning not effective, to, 5 meaning very effective. Behavior variables are considered by what researchers assume to be the not desirable behavior or desirable behavior. The use of ordinal data in this research, corresponded with the use of diagonally weighted least square (DWLS) estimators and polychoric correlations as highlighted in the works of Marklinder et al., (2022) and Yang-Walletin et al., (2010). The use of binary variables can be seen as a special case of ordinal variables. In order to perform structural equation modeling, the collected data were processed in excel and them imported into R . The SEM was subjected to goodness of fit test.

In analysis of interrelationships among latent variables in a multiple correlated observable indication the use of structural equation model (SEM) is recommended

(Marklinder et al, 2022). SEM is a multivariate technique used in scientific investigations to determine and evaluate multi variate relationships (Fan et al., 2016). The advantage and differences that exist between SEM and other modeling approaches is that SEM test both direct and indirect effects on pre-assumed causal relationships (Fan et al., 2016).

SEMs have been used in various fields of study including food safety, ecosystem, plant sciences, land ownership, health economics among other fields of research. In this current research SEM is applied to livestock health economics, an area with limited research using this model and no research in particular for Zimbabwe. The SEM in this current research was performed in two stages: in the first stage, relevant questions were selected based on the objective of the analysis. Selection of variables was undertaken with a determined criterion relevant to the analysis.

The second stage was confirmatory factor analysis, and this was testing to establish which variables could be used in analysis. Factor analysis is a standardized measure of a relationship between variables and its underlying structure, this usually range from -1 to 1. Score that is closer to 1 shows that a strong relationship between variables and its factor or between factors.

In preparing factors in SEM, a scoring of a variable to the latent variable is deemed acceptable when it is at or above 0.5, however, other authors propose that a score of 0.3 can be seen as sufficient in forming a structure of a factor (Hair et al, 2014). The cut off point for factor scores in this study was 0. A huge percentage of the variables in this study had scores sufficient for their respective factors and were all relevant for the research. Theoretical framework of the structure adopted in this analysis was established by Marklinder et al., (2022), Baset et al., (2017), and Sanlier and Baser, (2019).

5.4.1 Confirmatory Factor analysis

Different latent variables ($k_1 - k_4$; $a_1 - a_4$; $b_1 - b_4$) forming the factors and are explained in the explanatory variables table. These variables had appropriate factor scoring to be included in this model. $k_1 - k_4$ are variables for K knowledge, $a_1 - a_4$ are the variables for A attitude and $b_1 - b_4$ are the variables for B behavior.

Table 5.1 Knowledge of theileriosis

Variable	Explanation
K	Knowledge of Theileriosis signs: If the farmer can identify the signs (teary eyes, salivating)1, Farmer cannot identify signs 0
k_1	Knowledge of Chemical Mixing: If the farmer knows how to mix dipping chemicals 1 Farmer doesn't know how to mix dipping chemical 0
k_2	Knowledge Source Veterinary: If main source of animal health information veterinary extension officer 1, Farmer uses other sources 0
k_3	Knowledge Part infected by Ticks: If farmer knows the part of the cattle mainly infested by tick 1, Farmer cannot identify part affected 0
k_4	Know Cattle affected by ticks: If farmer can tell the type of cattle usually affected by ticks 1, Farmer can't tell the type affected 0

Questions asked on knowledge in the questionnaire, formed yes/no questions with one or multiple answers were analyzed into binary data. These are dummy variables in which the yes answer is valued as 1 and the rest as 0.

The attitude variables as presented in table 5.2 included approach with cattle dipping, use of hand spray, separating sick animals, cutting tail brush and application of tick grease. The variables were treated as ordinal with response options were assessed on five different scales: "Not effective at all"; "Lowly effective"; "Neutral"; "Effective" and "Very Effective".

Table 5.2 Attitude towards theileriosis control

Variable	Explanation
A	Attitude towards Dipping: The farmer attitude towards effectiveness of the dip tank 1-5 scale
a_1	Attitude towards Hand Spray: Farmers attitude towards use of hand spray to protect against ticks 1-5 scale
a_2	Attitude towards Cutting Tail Brush: Farmers attitude towards effectiveness of cutting the tail brush to reduced spread of ticks 1-5 scale
a_3	Attitude towards Separating sick cattle: Farmers attitude towards separating sick cattle to reduce disease spread in the cattle herd 1-5 scale
a_4	Attitude towards application of tick grease: Farmers attitude towards application of tick grease A thick paste used as alternative to dipping 1-5 scale

Behavior variables shown in table 5.3 were treated as binary with the responses showing either desired behavior or not desired behavior.

Table 5.3 Behavior practice of theileriosis control in cattle

Variable	Explanation
B	Behavior 5-5-4 Dipping cycle: Farmers fully participate in the recommended 5-5-4 dipping cycle 1, if the farmer doesn't practice 0
b_1	Behavior Dip Tank maintenance: Farmer participate in local weekly dip tank maintenance activities 1, farmer doesn't participate 0
b_2	Behavior Encourage Neighbor: Famer encourage neighbor to take cattle for weekly dipping 1, No encouragement to other farmers 0
b_3	Behavior Cutting Tail Brush: Farmer constantly inspecting the cattle and cutting the tail brush 1, Farmer doesn't inspect cattle regularly 0
b_4	Behavior Using Spray Can: Farmer uses the spray can to disinfect cattle when tick infested 1, farmer doesn't use spray can 0

The model specification in this study is a full factor model allowing for an analysis of the strength in relationship between a factor and the observed indicators. In this case the Knowledge, Attitude and Behavior are the Factors and each has 4 indicators and reflected in the description tables above. Thus, the indicators are the y and they vary in their relationship when loaded against the factor hence the term factor loading. The models can be presented as figure 5.2 below:

$$Y_1 = F\lambda_1 + e_1$$

$$Y_2 = F\lambda_2 + e_2$$

$$Y_3 = F\lambda_3 + e_3$$

$$Y_4 = F\lambda_4 + e_4$$

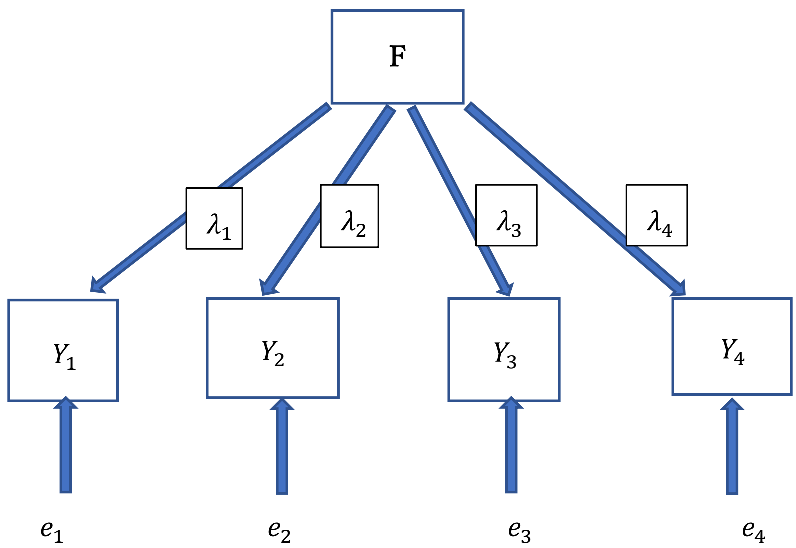

Figure 5.2 CFA model specification

where F is K, A, B; Y is $k_1 - k_4$; $a_1 - a_4$; $b_1 - b_4$: in this case F represent the measured variable Knowledge, Attitude and Behavior, while Y is the latent variable and in this equation factors of the unmeasured variables $k_1 - k_4$; $a_1 - a_4$; $b_1 - b_4$ and $e_1 - e_4$ represent the error associated with the measured variables.

The first phase of data collection was conducted between September 2021 and October 2021 where focus groups of five to seven farmers were conducted to capture the knowledge attitudes and practice towards tick borne diseases and communication with veterinary. Interviewees were selected based on the village system and dip tank locations and this was coordinated by the veterinary extension services. The questions used for the focus groups were open ended and the aim was to establish how farmers can establish knowledge about the disease and the level of awareness and attitude towards the correct method for tick control and the channel used to communicate with veterinary and to identify the current practice of tick control.

Once first phase was completed, the responses gathered were then used to formulate the structured questionnaire for the larger population. The questionnaire covered socio-economic demographics, knowledge of theileriosis. Attitudes towards theileriosis control, practice of theileriosis control and social networks used in gaining knowledge of theileriosis. A five-point Likert scale was used in answering the questions (Likert, 1931) (i.e., 1 ¼ no influence, 2 ¼ low influence, 3 ¼ neutral, 4 ¼ influence, and 5 ¼ strongly influence) and yes/no questions were deployed to examine respondent agreement levels regarding the above issues.

This study used power analysis (Cohen, 1992) to estimate the number of participants needed for a given effect size (significance level P ¼ 0.05, medium effect size f2 ¼ 0.15, statistical power ¼ 0.80). The total farmer population in Mhondoro Ngezi was 6,077, thus, we distributed 360 questionnaires proportionally among the farming systems in the districts in October 2022. All the 360 questionnaires were returned giving a 100% response rate.

After all questionnaires were returned, data cleaning was performed to check if all the questions were answered appropriately and this was done during the first 5 days and it helped in returning back to the farmers and get clarity. The next stage was the data capturing and coding. This coding method examines and compares the connections (i.e., similarities and differences) between codes and semi-structured interview data by breaking the data down into discrete parts (Strauss and Corbin, 1998). The purpose of open coding is to stay open to all possible theoretical directions that reflect researcher interpretations of the semi-structured interview data (Charmaz, 2006).

Quantitative data collected in this survey was for the purpose of statistical analysis and this was done in the following ways: (a) descriptive statistics, variable frequencies summaries, (b) non-parametric tests these include chi-square homogeneity test used to determine whether landholding within the population share same distribution of single category variable like socio-demographic characteristics and knowledge, attitudes and practice of farmers; (c) Mann-Whitney test comparing the mean ranking of farmers knowledge, attitudes and practices in Mhondoro Ngezi and finally (d) Structural Equation modeling was conducted after a probit linear regression detecting determinants of individual livestock husbandry practice.

5.5 Results and Discussion

5.5.1 Descriptive statistics

This data shows that the age range of the farmers is skewed towards the aged population. Most of the farmers that participated in this research had at least primary school education and secondary school education. The source of income of the farmers in this research was varied with more bias towards crop and livestock related activities. Cattle raising system is predominantly free range and the livestock production is dominated by men. In this research the cattle rearing system is all free-range grazing in which the grazing land is common, communal and community shared.

The descriptive statistics show that the number of farmers in Zimbabwe is skewed to the rural areas and their age range more inclined in the aged population. Table 5.1 represents the descriptive statistics of the data collected.

Table 5.4 Summary statistics of the sampled respondents

	N	%
Landholding		
Smallholder	100	28
Rural	260	72
Gender		
Male	295	82
Female	65	18
Education		
No Education	4	0.01
Primary Education	90	0.25
Secondary Education	246	0.68
Tertiary Education	20	0.06
Income Source		
Crop and Livestock	211	59
Off farm income	149	41
Age		
17-25	17	5
26-35	32	9
36-45	77	21
46-55	85	24
56-65	71	19
65>	82	22
Cattle rearing system		
Free range grazing	360	
Stall feeding	0	

Majority of the farmers have reached secondary education but this may not be an indication of agriculture understanding or livestock production the curriculum may not be have much on the real production issues. Data in the above table show that challenges in agriculture development can be more inclined to the aged farmers population as it may be difficult to diffuse new technologies.

The analysis for this research was carried out on a dataset with 360 observations and 15 variables were acceptable for use in this analysis after application of the two-stage selection. Figure 5.3. Structural Equation Model (SEM), results are judged from the curved arrows, which are standardized regression coefficients between Knowledge, Attitude and Behavior factors, ranging from -1 to 1. Factors that have a closer proximity to 1 or -1 indicates a strong positive or negative influence another. Smaller straight arrows indicate standardized factor loading from variables that build the underlying constructs. Standard errors are expressed at each factor and the variables in this research are: ($k_1 - k_4$; $a_1 - a_4$; $b_1 - b_4$).

The knowledge k with sub categories $k_1 - k_4$ is a measure of the farmers knowledge of theileriosis which is measures in the ability to know the cattle affected, identify the spots infested with ticks, know how to mix dipping chemicals and communication with veterinary on animal health issues. The variable k_1 had a p value of 0.031 which was based on the use of media for animal health knowledge had a positive influence on the knowledge of disease, this is supported by various authors and previous chapters on the impact of media in veterinary extension. However, in this research the impact is limited due to the challenge of farmer age and other socio-economic factors. k_3, which is knowledge of part infested by ticks did not have significant relationship when it comes to knowledge of the disease and its signs and symptoms.

Pertaining to Attitude, the variable A_3, which is Attitude of separating sick cows from those that are health had a positive correlation with a positive attitude with a p value of 0.003. This means that the farmers attested to the fact that separating cattle that is showing weak signs and disease symptoms was effective and very effective in controlling the spread of the disease. Other variables $a_1, a_3, and\ a_4$ representing, attitude towards use of hand spray to remove ticks, attitude towards cutting the cattle tail brush and attitude towards use of tick grease to remove ticks respectively.

5.5.2 KAB regression output

CFA results are presented in the figure 5.3. The results for the goodness of Fit indicated that the model for this research had a good fit to the data, this was done with the hypothesis testing as well giving a significance of <0.000. The results from the regression show that knowledge has influence on behavior (0.03), while Knowledge has no direct influence on Attitude neither does Attitude have influence on Behavior. In their study Fabrigar et al (2006), revels that the amount of knowledge did not have a direct effect on attitude – behavior consistency. Thus, in this study the lack of a significant relationship between attitude and behavior is normal while the significance positive relationship of knowledge and behavior is supported by previous researches. To verify the model at hand, the Wald test was also run and the variables that gave a positive result in the CFA, also gave a significant positive result in Wald test.

Table 5.5 CFA regression on KAB

	Knowledge		Attitude		Behavior		Inter Variable	
	Coeff	P> |z|	Coeff	P> |z|	Coeff	P> |z|		
(k_1)	0.510	0.031						
(k_2)	-0.947	0.000						
(k_3)	0.177	0.142						
(k_4)	-1.571	0.000						
(a_1)			7.120	0.004				
(a_2)			13.305	0.003				
(a_3)			12.951	0.003				
(a_4)			14.804	0.004				
(b_1)					0.477	0.054		
(b_2)					0.058	0.193		
(b_3)					0.198	0.069		
(b_4)					-0.041	0.631		
$(K \& B_1)$							0.134	0.059

As for Behavior the variables B_1 *and* B_3, which are Dip tank management an

Cutting the tail brush have a significant positive correlation with the desired behavior practice to reduce and control tick spreading. This shows that farmers who participate in the dip tank management showed the desired behavior practice as well as those that cut the tail brush of each cow.

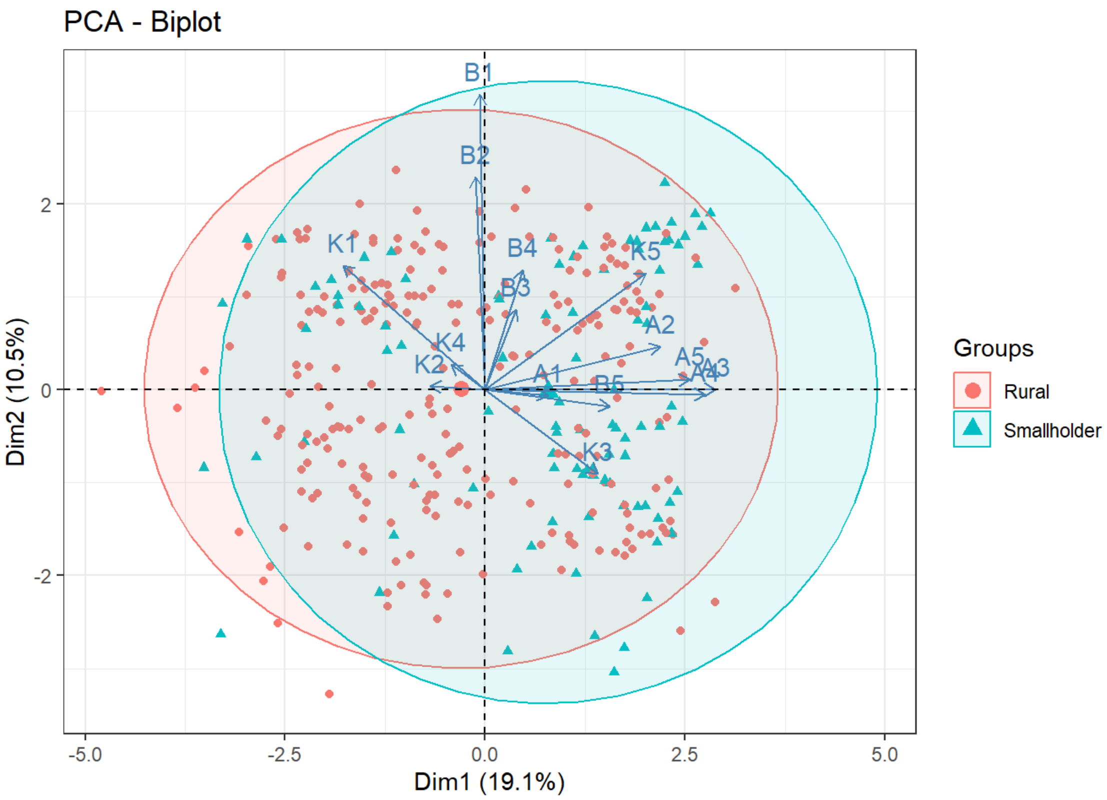

Figure 5.3 Principal Component Analysis on the relationship in KAB

The principal component analysis was done in the light of the landholding and this conforms the theory that the land reform in Zimbabwe had adverse effects on the rural farming at there is limited knowledge.

Probit regression show that only landholding, gender and dead cattle due to theileriosis are the significant socio-economic demographic variables that affect choice and practice of 5-5-4 dipping. The participation of women in livestock production and decision making was studies by Ali 2016 who concluded that the more women are active in livestock will increase household income and animal health. This study was supported by the recommendations of Curry et al, (1996) who suggested that gender issues should be considered in planning and implementing animal disease control. Thus, focus on cattle dipping can be aligned to the findings of the two above mentioned researches and it be concluded that the more women participate in livestock production the higher the chances of more participation in dipping cattle for disease control.

Farmers that can tell the signs of the disease salivating and teary eyes had higher chances to practice 5-5-4 cattle dipping in the correct way. This is supported by Osmani et al (2021) in that famers ability to tell clinical disease signs have higher knowledge of the disease than those that cannot tell. In this study farmers showed more knowledge about the clinical signs like salivation. This shows that the experience of having cattle dying due to theileriosis made farmers to be able to identify theileriosis signs and therefore, be proactive in participating in the weekly cattle dipping services.

The attitude of the farmers is key and this was evaluated using ability to apply tick grease and frequency of local meetings. The farmers who understood the effectiveness of application of tick grease had a tendency of less participation in weekly dipping, which means that the farmers who use tick grease do no frequent cattle dipping as it is an alternative to dipping giving a result of reduced animal deaths. However, farmers that participated in weekly local meetings had a higher tendency of dipping cattle as the meetings are conducted at dip tanks, thus encouraging dipping of cattle.

5.6 Conclusion

The study observed that farmers in rural areas rely mainly on cattle dipping but when it comes to practice their behavior is even below the average. This means that the disease will continue to increase in rural areas as the heard level immunity is difficult to achieve because of high dipping behavior avoidance. DVS should intensify its focus on rural farmers and encourage them to participate in the local weekly meetings which they encourage the dipping practice behavior. DVS should also consider increasing the availability of tick grease as it is a vital substitute for dipping which produces almost the same results while reducing mixing cattle herds and preventing spreading of ticks inter animal.

Farmers weekly meeting at dip tanks encourage 5-5-4 cattle dipping thus the veterinary extension officer should encourage farmers to form dipping committees with rotational leaders to encourage full community member participation.

The Veterinary extension services should consider empowering more women in livestock management as this encourages careful decision making when it comes to dipping cattle this is also highlighted in chapter 2 on women in livestock production in Zimbabwe, which shows that women are active in livestock production but have limited responsibilities and decision-making power on cattle.

The structural equation model with the CFA in this study confirmed that increasing knowledge of farmers will in turn improve on the cattle dipping behavior. Gaps still exist in the understanding of why rural farmers do not practice 5-5-4 as prescribed, which therefore needs to be investigated to further deepen the understanding of theileriosis and farmer behavior.

Chapter 6 General discussion

6.1 General discussion

Theileriosis is an important economic disease in Zimbabwe and because of the effect and impact it has caused in the past few years a study aimed at providing information to DVS and government as the principal on how to manage the relationship with the agent the farmers for a comprehensive approach in the prevention, control and eradication of this in Zimbabwe was necessary. The study tried to explore the socio-economic characteristics of the farmers, the gaps that exist in the communication with veterinary and how the behavior practice of dipping cattle is affected by knowledge and attitudes of theileriosis.

The need to have effective and sustainable ways of controlling and reducing the effect of theileriosis in Africa is an urgent agenda as theileriosis has impacted cattle productivity by weakening cattle and killing as well (Meneghi et al, 2016). Effective control is achieved by a strong relationship between farmers and veterinary extension and this research's purpose was to establish how control, prevention and eradication can be enhanced through the principal-agent relationship.

It was revealed in this research that the relationship between DVS and farmers in this case the principal-agent does not support the main aim of the veterinary which is to eradicate disease or at least prevent and control theileriosis and other tick-borne disease in Zimbabwe. This principal-agency problem in Zimbabwe livestock production has resulted in massive information asymmetry which is characterized by a number of factors which will be discussed below.

Chapter 3 showed that the socio-economic characteristics of the farmers in rural areas in Zimbabwe are in nature and characteristics of an older age, low income and dominated by male livestock farmers, these findings are supported by Manyise et al., (2023) and Nyagadza et al, (2022). The impact of age in this study is negative as it limits the diffusion of knowledge to the aged population and it is the same in many of the studies in Zimbabwe as there is a considerable huge number of aged farmers for which the average age is above 50 years. This has implications on policy as there is need for Zimbabwe to focus on youthful farmers to improve agriculture productivity. Ownership of radio was significant but with a negative influence on both knowledge and source of information. Though a trusted source of information, there may be no running programs conducted by the veterinary to pass information as the focus is now on digital and social media, which means ownership does not influence the level of knowledge a farmer has. However, ownership of phone was positive in increasing knowledge, this may be because the phone enables contact with veterinary and also with other farmers.

In chapter 4, focus was on knowledge of theileriosis and its impact on percentage of dead cattle. Knowledge of theileriosis was negatively affected by communication mediums used by the farmers while information source had a positive relationship with knowledge of theileriosis. Landholding has two farmer groups, small holder farmers and rural farmers that was as a result of land reform. Farmers in the smallholder category had a better chance of communicating with the veterinary than the farmers in the rural category. This is because the farmers in the smallholder were also active in livestock production for economic benefits than the rural who owned mainly for draught power and meat and milk. Thus, the reason for keeping the cattle made the smallholder farmers to be proactive in communicating with veterinary while the rural farmers were not proactive. In this research it shows that the farmers who are active in livestock income production have more knowledge of livestock health and tick-borne diseases Banda and Tanganyika, (2021) supports these findings. There is less participation in cattle dipping among rural farmers which is the main strategy in place to control theileriosis in Zimbabwe. Therefore, communication to the farmers should encourage them to participate in livestock value chain by highlighting the benefits of keeping livestock and controlling diseases.

Chapter 5 evaluated the principal-agent relationship on knowledge, attitude and behavior of 5-5-4 cattle dipping. The Knowledge levels with the farmers in Mhondoro Ngezi were high and the attitude moderate with a medium to low behavior practice. The knowledge, attitudes and behavior were evaluated in terms of the latent factors that measure each variable. Ability to identify the signs of theileriosis and contact with veterinary were the factors that were indicators of the level of theileriosis knowledge. Behavior of cattle dipping was measured in the farmers participation in general dip tank maintenance, which meant the farmers who were active at community level would dip their cattle weekly. Knowledge had a strong relationship with behavior while behavior was not influenced by attitude and knowledge did not impact attitude. Thus, to achieve better and improved behavior of 5-5-4 cattle dipping, there is need to increase the farmers knowledge of the disease and its control strategies. DVS as the principal has a mandate to increase the level of knowledge the farmers have and this can be achieved by decentralizing information flow to be managed through dip tank management committees and other local community leaders like chiefs and herdsman as they are reliable sources of information for the farmers as highlighted in chapter 5 findings.

Veterinary in Zimbabwe is limited to a few methods of communication which are not effective at present hence there is increased principal-agent problem resulting in increased information asymmetry. The government equipped the veterinary extension officers with mobile devises to be delivering services online as highlighted in Chapter 2 on veterinary series in Zimbabwe, but the challenge is the mobile phone access and usage in Mhondoro Ngezi is below 50% which means not many farmers will be accessed due to low income, age and illiteracy chapter 3 section 3.5 discusses this issue. Zimbabwe smartphone penetration is only 53% in the 18-40 years age group, 45% in the 41-75 years age group and only 2% for those above 75 years (Paynow, 2022). This shows that the use of technology as a means of veterinary extension services will not be effective.

This can be dealt with by incorporating increased communication methods and mediums that are engaging to the farmer groups and in the specific locations being served to make it relevant and realistic and practical and chapter 4 proposes use of printed material, in local language. Communication can be done through partnerships with locals and recognized structures such as leadership hierarchies as chiefs and local leaders as well as identifying social groups like sports groups and women's clubs and use of community radios.

The land reform in Zimbabwe had a huge impact on general agriculture productivity and livestock production in a particular way, thus a unique strategy may need to be put in place in Zimbabwe as a novel case because of the challenges created by land reform. The effect of land reform on the livestock production in Zimbabwe has stretched to the level of knowledge about animal health and animal husbandry. The land reform created more challenges for the new livestock farmers which has not been fully addressed, and this is shown in the discord between the resettled farmers who are not active in livestock market and those that have access to livestock production for income. The need to reduce the knowledge gap within the rural and resettled farmer groups is one of the tools that can and should be used to close the disease prevalence challenge that is persistent in Zimbabwe. The aftermath of land reform still impacts today production and disease control.

The government of Zimbabwe is in the process of developing a strategy for the control of theileriosis and other tickborne diseases thus some of the issues raised in this research can be considered for strategy and policy. One of the main findings in this research is that community collective bargaining through dip tank management and maintenance is one of the factors driving farmers to participate in cattle dipping effectively and on a regular basis and that to increase knowledge of the farmers there is need to improve the contact between veterinary and farmers this is highlighted in chapter 5 section 5.5. Community involvement will go a long way in creating a better strategy which maybe unique and applicable to each community than a one in all strategy to be used across the country in different farming regions, this helps participants to tailor make their efforts to their local needs (Moss et al, 2022). Having regional specific community programs is suggested in section 1.2.2 in the definition of proximity under information asymmetry, and this is implemented in section 1.2.6 in Kenya where geographic specific programs are put in place to control ticks.

Contact between veterinary and the farmers has been limited due to the strain in the veterinary caused by the increase of farmers post land reform in Zimbabwe. This is evidenced by the number of farmers according to statistics and also the surge in disease outbreaks. The communication and farmer-veterinary connection gap has to be closed with a pro-poor communication strategy that caters for the farmers with socio-economic status as those identified in this study must be crafted by DVS. This included massive decentralization of information through the recruitment of local leaders as the lead contact people in any community, such as the local chief and herdsman. The government must consider Public Private Partnerships (PPP), such as NGOs, which have many projects in the rural areas and though they may be focusing more on crop production but using them as conduits for livestock health information and such partnerships can expedite and fund the rehabilitation of cattle dipping tanks to improve the dip tanks in the district through corporate social responsibility by the company operating in the Mhondoro Ngezi Area. Researches done in Ghana and Ethiopia suggest that PPPs improve livestock productivity and farmer income (Spilenni, 2023 and N`Guessan et al., 2022). PPPs will improve the market by covering the gaps that the government fail to cover thus increasing market competitiveness. Working with private companies can improve on how the principal (DVS) motivate the agent (farmers) to implement disease control measures.

One of the findings in this research is that education is important in fostering knowledge of the disease and improving the way the farmers manage their cattle. The challenge at hand is that the farmers in Mhondoro are of an older age thus leaving a gap in how education must be used as a tool for the current farmer groups. However, if education is to be used as a tool, the main focus must be on the children of the farmers who in many cases herd the cattle in feeding and dipping. This means that veterinary extension must target having relations with schools and the education ministry to even include animal health management as part of the topics learnt by students of the school going age in the long run but in the short run the veterinary extension must be willing to visit schools and teach kids on how to manage ticks and how to identify the disease.

The improvement of the principal – agent relationship between veterinary and farmer will enhance the national biosecurity in Zimbabwe as it will be easy for the veterinary to monitor the farmers implementing on farm biosecurity. This mean that it is likely to increase the dipping practice in rural areas from 65% shown on figure 5.1 to at least 80%-95% recognized for herd immunity (FAO, 1996), thus reducing disease spread and percentage of animal death.

6.2 Limitations to the study

This study focused on one disease, theileriosis among the body of diseases caused by ticks thus, no focus was given to anaplasmosis, babesiosis and heartwater. The area of focus was Mhondoro Ngezi district among the 56 districts active in agriculture in Zimbabwe, though the epicenter of the disease but not the region with the highest number of cattle. The other limitation was the availability of data pertaining to theileriosis in the government database, as the data for this disease if not yet made available to the public, hence the data used was a bit historical and limited current data, however, there was available information from other sources like newspapers which helped to give some data in bits and pieces, which was useful for the research to draw meaningful information and conclusions for the research to be possible.

This limitation has implications to the reporting in the DVS which shows that there is massive underreporting and this has negative influence on the decisions on how to manage the spread of theileriosis. This challenge of underreporting means that the impact of theileriosis in Zimbabwe will always be underestimated and the number of cattle affected will not be known because only few information will be made available to the public. Government records show that the disease killed about 50,000 cattle between 2018 and 2022, while the media reports show that there were over 500,000 cattle that died due to theileriosis.

Chapter 7 Conclusion

This study aimed at creating a deeper understanding into why there is increased prevalence of theileriosis while the government through DVS is implementing disease control mechanisms. This study focused on solutions that can be used and implemented by the DVS in closing the communication gap between veterinary and farmers while eliminating asymmetry of information and solving the principal-agent problem.

It was revealed that the major cause of the information asymmetry in this study is the principal who due to limited resources is not being able to meet the needs of the increased farmer population and thus the farmers had limited information about theileriosis and ended up relying on other not so original sources thus impacting the cattle dipping especially among rural farmers. Rural farmers who rely on government free and subsidized services needs a functioning veterinary service and this can be achieved by having frequent communication with veterinary officers to strengthen their knowledge of disease and to improve on the behavior of cattle dipping.

Farmer education and awareness must be given priority and focus must be given of the younger generation of farmers as they have the capacity to influence cattle movement as they are the ones that take the cattle to the dip tank. The younger farmers are quick to adopt to the new technologies and may be easy targets for veterinary extension officers to communicate with even using different technologies.

Community participation through dip tank management will be an effective way to group the farmers and communicate with them. The farmers have confidence in DVS but the limited contact and communication results in farmers having limited knowledge of the diseases and thus, do not perform their part in farm biosecurity enforcement.

Special attention should be given to the formulation of strategies that are in line with the different farmer groups that exist in Zimbabwe livestock especially as a result of land reform. Though there are subsidies in crop production, there is need to improve livestock production in the farmer groups that are in the resettled areas but this can be achieved if there is support also in the marketing of livestock products and market access for the smallholder rural farmers and this will stimulate input subsidies such as access to cattle breeds that are tick resistant as indicated in chapter 1 giving better market value.

Eradicating theileriosis, will mean increased cattle productivity, cow milk production, cattle market value, increased national herd and many other benefits including reduced financial burden on the farmer and increased income generation. Private Public Partnerships must be included in livestock policy and strategy making which has the capacity of covering for the gaps left by the government.

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Abstract

Livestock disease are a major setback in livestock production in developing countries and the presence of disease has hampered growth of the livestock industry, reduced the efficiency of farm production making animal health an area of priority. Tickborne diseases affect cattle productivity in Zimbabwe resulting in low cattle productivity, low milk production, low market value and death. The major tickborne disease in Zimbabwe is theileriosis also known as January disease mainly lethal during the peak of the rainy season January. Control of theileriosis is done through cattle dipping to manage external parasites and the department of veterinary services (DVS) monitors the implementation of dipping activities in Zimbabwe. In Zimbabwe the 5-5-4 cattle dipping method is used, which entails that cattle dipping must be done in three times in 14 days with 5-day internals twice and then after 4 days.

DVS is responsible for coordinating livestock disease surveillance and to motivate farmers to be active in prevention, control and eradication of disease. The government of Zimbabwe implemented land reforms in the late 1990 to early 2000s and this resulted in increased farmer population and strained veterinary thus disruption in veterinary extension and disease occurrence increasing. In recent years theileriosis has been increasing on a year by year between 2018 and 2022 at least 500,000 cattle succumbed to the disease and despite the mitigatory measures by the government to reduce the prevalence of the disease the economic cost of the disease huge. DVS has put in a plan to deal with theileriosis but the disease continues to increase thus leaving a gap on the possibility of farmer knowledge, attitudes and behavior towards the theileriosis.

Using the principal-agent theory this research was done to evaluate the veterinary extension and farmer relationship and what factors have contributed to information

asymmetry in livestock production in Zimbabwe. The aim of the research was to outline three specific objectives which are: socio-economic characteristics of the farmers in Mhondoro Ngezi impact the knowledge of theileriosis; communication mediums used by the veterinary influence the level of knowledge for theileriosis prevention and control; and knowledge and attitudes towards theileriosis influence 5-5-4 cattle dipping behavior. This study was done in Mhondoro Ngezi, Zimbabwe, a district in Mashonaland Province. The district was chosen because it has been the epicenter of the theileriosis outbreak in Zimbabwe. Data was collected in two phases between September 2021 and October 2022.

Using the multivariate probit model regression was done to analyze the socio-economic factors that impact knowledge of theileriosis and source of veterinary information. Farmers age, gender, education, ownership of radio, landholding and ownership of mobile phone are the main socio-economic indicators that impact knowledge of theileriosis. There is an aged population of farmers in the rural areas with an average age of 53 years and the age skewed to the right with more farmers in the 50-65 age range. There were more male farmers than females however the female farmers participated more in cattle dipping programs than their male counterparts. Education was a significant indictor to disease knowledge. Further farmers who had mobile phones with access to the internet had more contact with veterinary.

Instrumental Variables method was used to analyze the endogeneity problem on knowledge of theileriosis and its effect on percentage of dead cattle. Communication mediums and source of information were the two exogenous variable that influenced knowledge of theileriosis. knowledge of theileriosis was significant in reducing the percentage of dead cattle per farmer. Farmers who used the right source of information from the veterinary extension and used communication mediums that promoted retention of message such as written documents and recorded material had higher knowledge than the famers who relied on word of mouth. Age of the farmer played a significant role to the knowledge acquisition process as well as the income and veterinary access time.

To evaluate the behavior of farmers towards 5-5-4 cattle dipping, knowledge and attitude analysis was done using a structural equation model. Knowledge of theileriosis was reflected in the ability of farmers to identify the signs of the disease, while the attitude of the farmers was more inclined to separating sick cows. the 5-5-4 behavior of cattle dipping was indicated to be practiced by farmers who were active in dip tank management and those that has a practice of cutting the tail brush. Knowledge and attitude had no significant relationship and attitude had no significant relationship with behavior, however, knowledge and behavior had a significant positive relationship meaning that the higher the farmer knowledge the higher the chances to practice 5-5-4 cattle dipping.

The DVS (principal), had limited contact with the farmer in order to influence or motivate the farmers (agent) to have the desired behavior practice. There is evidence of information asymmetry, which has been as a result of the principal's actions failure to respond to the growing needs of the farmers to motivate and incentivize the farmer to practice the proper biosecurity measures. DVS must consider developing education programs that they use in youth groups and primary and secondary schools to encourage young farmers to be active in livestock production. To attract young and energetic farmers DVS should support agriculture education curriculum on livestock production in primary and secondary schools.

Farmers have challenges to access veterinary services and there is limited direct and indirect communication, thus DVS should consider using radio platforms for the rural farmers who can't use social media platforms as the radio is a trusted source of information. This means that DVS must ensure that there are regional specific strategies that meet with the socio-economic status of the farmers. Farmers generating income from livestock production had increased knowledge of theileriosis because of the need to protect their cattle herd from disease, thus, it is important for DVS to encourage the government to incentivize and motivate rural farmers to participate in livestock value chain and create policies that protect rural and smallholder livestock keepers. The government of Zimbabwe should consider increasing agriculture subsidies that are for livestock production thus improving the farmer understanding of agriculture livestock production.

Land reform had a negative impact on disease control but the introduction of community-based activities like dip tank management which can be done on a rotational basis in the local communities will help improve individual farmer participation in livestock production in rural areas. Though the government is still in the trial phase on the vaccine production, it must be noted that increase in knowledge and improving behavior practice for biosecurity in individual farm is important to achieve success in disease eradication. To remove information asymmetry, Public Private Partnerships and collaboration between principal and the agent must be prioritized to motivate and incentivize farmers.

要旨

家畜疾病は発展途上国における家畜生産の大きな制約要因であり、疾病の存在は畜産業の成長を妨げ、農業生産の効率性を低下させるため、家畜衛生課題への対応が急務である。サブサハラアフリカでは、ダニ媒介性疾病が牛の生産性を大きく低下させている。ジンバブエではダニ媒介性疾病により牛の乳生産量は低下、最後的に家畜は死亡し、その市場価値は失われる。ジンバブエの主なダニ媒介性疾病は、1 月病としても知られるタイレリア症で、主に雨季のピークである 1 月に発生する。タイレリア症の制御は、駆虫剤が入った設備（水槽）に牛を入れる（Cattle Dipping、以下、CD）ことで行われており、獣医サービス局（Department of Veterinary Service、以下、DVS）が CD によるタイレリア症の制御を監視している。ジンバブエでは、14 日間のうちに、5 日間隔で 2 回、その 4 日後にさらに 1 回、計 3 回の CD を行う、5-5-4 CD と呼ばれる方法が推奨されている。

ジンバブエでは農家人口が増加し、農地改革により獣医療サービスは崩壊状態にあり、家畜疾病の発生が増加してきた。近年では、タイレリア症は 2018 年から 2022 年にかけて年々増加しており、この病気で死亡した牛は少なくとも 5 万頭に達した。DVS はタイレリア症に対処する方策を検討しているが、この疾病に関わる農家の知識・態度・行動と現実の対策には大きなギャップが存在する。

この研究の目的は、農家の特徴と家畜衛生対策の知識レベルを評価し、獣医サービスと農家の関係をプリンシパル・エージェント理論から考察し、情報の非対称性の状態にあるジンバブエの畜産生産活動の課題を、知識・態度・行動の視点から解明することにある。調査地域はマスホナランド県モンドロ・ンゲジ地区で、ジンバブエにおいてタイレリア症の被害が最も大きいな地域である。主な研究目的は次の 3 点である。第一は、農家の社会経済的特徴がタイレリア症の知識水準に与える影響を解明することである。第二は、コミュニケーション手段がどのようにタイレリア症の予防と抑制の知識水準に影響を与えているかを明らか

にすることである。第三は、農家のタイレリア症の知識・態度がどのように 5-5-4 CD の実施に影響を与えているかを明らかにすることである。調査データは、2021 年 9 月から 2022 年 10 月までの間に行った 2 回のフィールド調査から収集した。

多変量プロビットモデルにより、タイレリア症の知識水準に影響を与える農家の社会経済的特性について分析を行った。性別、ラジオの所有、農地所有形態、携帯電話の所有等がタイレリア症の知識水準に与える要因であった。女性経営者は、より CD に参加する傾向があった。また、インターネットにアクセスできる携帯電話を持つ農家ほど、獣医師との接触回数も多くなることが明らかとなった。

次に、タイレリア症の知識獲得におけるコミュニケーション手段の利用がどのように、牛の死亡頭数の減少に影響を与えているか、操作変数法の手法から明らかにした。タイレリア症の知識水準は農家の死亡家畜を減少させることが統計的に示された。手書きの資料などで情報を保有する農家ほど、口頭で情報交換する農家より高い知識を持っていた。

また、5-5-4 CD の農家行動に知識と態度がどのような影響を与えているかを構造方程式モデルから明らかにした。タイレリア症の知識は疾病の兆候を見つける能力と関連があった。5-5-4 CD の実施は、CD の水槽管理を行っている農家で頻繁に行われる傾向が確認された。また、農家の知識が高まると、5-5-4 CD を実施している傾向が示された。

DVS（プリンシパル）は農家（エージェント）と限られた接触機会しかなく、獣医師と農家には情報の非対称性の問題があり、プリンシパルがエージェントの要求に十分に対応できていない状況にある。DVS は若い農家が畜産生産の現場で意欲的に活動できるような教育プログラムの開発を考える必要があるだろう。

農家はラジオのような信頼できる情報源がなく、農家は獣医サービスへのアクセスに課題をもつ。よって、DVS は、地方のソーシャルメディアが使えない農家向けに、ラジオ放送の利用を考えるべきである。家畜生産からの収入割合が高い農家は、牛を病気から守る必要性から、タイレリア症の知識水準が高かった。DVS は、地方の小規模農家が畜産バリ

ューチェーンに参加する誘因を政府に与えるよう働きかけることが重要である。

ジンバブエの農地改革は家畜疾病対策に悪影響を及ぼしたが、CD の水槽管理については、地域コミュニティで輪番ベースにより実施できる取組みは、農村での個々の農民参加を促進するであろう。ジンバブエではタイレリア症のワクチン開発は進んでいるが、疾病を根絶させるには、農家個々におけるバイオセキュリティの知識水準向上と農家行動の変革が求められる。情報の非対称性の課題を解消するには、プリンパル（政府）とエージェント（農家）の協力関係が重要である。

Appendices

Section A: Characteristics of farmers

1. **Personal Information**

a) Name:

b) Village:

c) Tel No.:

d) Type of land holding: 1. A1 ☐ 2. A2 ☐ 3. Communal ☐ 4. Resettle ☐

2. **Farmer information**

a) Family	b) Gender	c) Marital Status	d) Age	e) Education	f) Cattle Herder	g) Employment

a) (1) Head of household (2) Spouse (3) Child, (4) Relative (5) Worker b) (1) Male (2) Female

c) (1) Married (2) Single, (3) Divorced (4) Widowed e) (1) None, (2) Primary, (3) Secondary, (4) Tertiary

3. **Livestock**

a) Cattle Breed	① Local	② Purebred	③ Crossbreed
b) Number			
c) Cattle tagging (Yes/No)			
d) Cattle rearing system	① Free range grazing	② Stall feeding	③ Veld and pen feeding
e) Do your cattle graze in common land	① All the times	② Some times	③ Not even

4. **How many cattle did you lose last 2 years?** ______________________________

5. How many cattle did you lose to theileriosis last 2 years? ______________________________

6. Family Income

Household income sources:	(1) Crops	(2) Livestock	(3) Employment	(4) Remittance
Household income from animal products	(1) Milk	(2) Manure	(3) Meat	(4) Skin
Household income from animal sales	(1) Cattle	(2) Goats	(3) Chicken	(4) Sheep
Household income (USD)	Monthly $		Seasonally $	
Household Annual income from Livestock (USD)			$	

7. **Communication device ownership (radio, TV, cellular phone and solar)**

a) Radio	Yes	No
b) Television	Without Satellite	With Satellite
c) Mobile Phone	Simple Phone	Smartphone
d) Solar	Yes	No

8. In relation to the communication assets you own, which communication platform do you favor?

Communication platform of choice	**1** Not effective at all	**2** Lowly effective	3 Neutral	**4** Effective	**5** Very effective
Newspaper					
Radio					
Television					
Phone Call					
Text message					
Facebook					
WhatsApp					

Section B: Theileriosis knowledge

1. Ticks and Tick-borne Diseases (TBDs) in cattle

a) **Have you seen a tick?** 1. Yes 2. No

b) Do you think ticks give diseases to cattle? 1. Yes 2. No

c) Have you heard of tick-borne diseases? 1. Yes 2. No

d) Which of the cattle is mostly infested by ticks? 1. Young calves 2. Heifers 3. Adult cows 4. Don't know

e) Which part of the body of the animal do you commonly find ticks?

1	Head region	2	Neck region
3	Chest and axille	4	Groin and udder
5	Feet	6	Tail
7	Belly and limbs	8	Anus and perianal region

f) What signs did your cattle show that you attribute to TBD?

a) Salivating	b) Teary eyes
c) Ear bleeding	d) Nose bleeding
e) Blindness	f) Bloody dung
g) Lack of appetite	h) Pale or Yellow Gums
i) Weak cow	j) Aborting of pregnant cow
k) Moving always behind the herd	l) Low milk production
m) Staggering	n) Fatigue
o) Shortness of breath	p) Difficult breathing
q) Swollen Lymph nodes	r) Dry dung
s) Red urine	t) Aggressive behavior
u) Cloudiness of eyes	v) Death

g) Have you heard of the theileriosis Vaccine? 1. Yes 2. No

If the responded answered No, jump the next question

h) Where did you hear the information about the vaccine?

1	Veterinary extension officer	2	Friends and Neighbors
3	Veterinary Medicine distributor	4	Media

i) In relation to your knowledge of tick borne how can you rate the influence of the following sources of information to your knowledge of the disease.

Knowledge Source Questions on Likert Scale	**1** No Influence	**2** Low Influence	3 No opinion	**4** Average Influence	**5** Strongly Influence
Veterinary Extension					
Neighbor					
Family members and friends					
Farmer training program					
Village head					
Media (Radio, TV, Social media)					
Church group					
Political group					

Section C: Attitude of the farmers

6) Regarding the tick-borne disease of the following methods of tick control, how can you rate their effectiveness.

Attitude towards Methods Questions on Likert Scale	**1** Not effective at all	**2** Lowly effective	3 Neutral	**4** Effective	**5** Very effective
Dipping					
Hand spray					
Vaccine					
Tick Buster					
Manual removal					
Traditional medicine					
Cutting the tail brush					
Slaughtering the cattle and selling					
Separating the sick animal					

Attitude Questions	1	2	3	4	5
a) Cleaning the cattle kraal is necessary to control the spread of ticks in your					

cattle herd					
b) When a cow dies from theileriosis its necessary to dispose it by burning					
c) A dead cow through disease can be eaten if the meat is properly cooked?					
d) Selling a dead cow will help the farmer recover the value of the cow					
e) When introducing a new cow to the herd, isolating the new cow for some days can help control the spread of ticks					
f) Does regular communication with veterinary increase your knowledge of animal disease					
g) Does ICTs help in the providing solutions to the information gap between you and the veterinary extension					
h) Social media is an effective way of reaching the farmer					
i) Farmers rely on ICT to know about farm management					
j) Livestock experts are not actively using ICT					
k) I am comfortable in Using Social Media for communication with extension officers					
l) I use social media regularly					
m) WhatsApp is quick for communication					
n) WhatsApp has become an important part of my life					
o) Using WhatsApp is costly for me					
p) Sometimes WhatsApp may lead to substantial waste of time for me					
q) Sometime WhatsApp lead to spread of wrong information					
r) Sometimes WhatsApp diverts discussion to unnecessary topics					
s) I am comfortable in Using Facebook for communication with extension officers					
t) I use social Facebook regularly					
u) Facebook is quick for communication					
v) Facebook has become an important part of my life					
w) Using Facebook is costly for me					
x) Sometimes Facebook may lead to substantial waste of time for me					
y) I feel that agriculture-based information cannot be provided through WhatsApp/Facebook					
z) Facebook/WhatsApp tools can lead to spread of incorrect farm-based information					
aa) Through WhatsApp/Facebook it is easy to generate peer to peer discussion about farming practices					

Section D: Farmers' Practice

7) What is the main purpose of keeping cattle at your household?

1	Draught power		2	Income from sale of animals	
3	Storage of Wealth		4	Breeding purposes	
5	Source of meat and milk		6	Ritual Purposes	
7	Income from sale of products like milk and hide		8	Any other	

8) What type of cattle kraal do you have? 1. Open air 2. Shed 3. Other

9) Do you use any bedding materials for the cattle? 1. Yes 2. No

10) Which animal health problems are most common to you herd?

1	Foot and Mouth	2	Mastitis
3	Tick borne disease	4	Bacterial diseases
5	Plant poisoning	6	Other

11) What is your main purpose of calling the veterinary officer?

1	To receive advise on animal health	2	To receive information on livestock production
3	To report sick cattle	4	To get dipping dates
5	For Deworming drugs	6	For general farm advice

Section E: Social Network

12) I would like to ask about the groups or organizations, networks, associations to which you belong. This can be formally or informally.

Type of organization or group	Name of group	Activities that you do	Role that you play 1 – leader 2 – Very Active 3 – Somewhat Active 4 – Does not participate

a) Compared to 5 years ago, do you participate in more or fewer groups 1. More 2. Fewer 3. Same

c) Of all the groups, which two groups are the most important 1.________________2. ______________

d) How does one become a member of the group?

1. Required to join 2. Invited 3. Religious 4. Voluntary Choice

5. Political affiliation 6. Other specify____

e) What is the main benefit of being in this group?

1. Improves access to services 2. Important in time of emergency 3.Enjoyment

4. Spiritual 5. Social status and Self Esteem 6. Others Specify

f) Do the groups help your household to get access to any of the following? 1. Yes 2. No

	Group 1	Groups 2
Education or Training		
Agriculture information and inputs		
Other		

g. Are members of this group same 1. Yes 2. No

	Group 1	Groups 2
Neighborhood		
Religion		
Sex		
Age		
Ethnic or linguistic group		
Education		
Occupation		
Political view point		

f) Where does the groups usually meet? 1. Online 2. Physical place

g) How many times do you communicate with the veterinary extension officer?

1. Daily 2. Weekly 3. Fortnightly 4. Monthly

h) How long does it take to get response from the veterinary extension officers?

1. Less than an Hour 2. 1-4 Hours 3. 5-9 hour 4. 10-12 hours 5. 1 day 6. More than a day

i) What are the three important sources of information about veterinary services?

1. __________________________ 2. ___________________________ 3. ___________________________

13) **Can you name 5 people that have influenced you to use the disease control system you have?**

(1=no influence at all, 2=little influence, 3=average influence, 4= high influence and 5= highest influence)

Person	Name	Occupation	Disease control method	Frequency of communication	Influence				
					1	2	3	4	5
Person 1									
Person 2									
Person 3									
Person 4									
Person 5									

14) **In which farm activity does the following people provide useful information to you?**

(1=no influence at all, 2=little influence, 3=average influence, 4= high influence and 5= highest influence)

Person	Farm Activity			Influence				
	Crop	Livestock	Non-Agric	1	2	3	4	5
Person 1								
Person 2								
Person 3								
Person 4								
Person 5								

15) **Besides agriculture, what is the level of influence that the named 5 people have on the following**

(1=no influence at all, 2=little influence, 3=average influence, 4= high influence and 5= highest influence)

Person	Name	Religious	Political	Social	Influence				
					1	2	3	4	5
Person 1									
Person 2									
Person 3									
Person 4									
Person 5									

Acknowledgements

First and foremost, I would like to thank the Almighty God for the life, strength and opportunity to study and reach this level. I am hugely indebted to the support and guidance of my advisor Professor Hiroichi KONO for his unwavering support, supervision and advise in my quest for knowledge. Professor KONO helped me tap from his rich experience in animal health economics and helped me build a richer understanding in agriculture economics. We had discussion, tips and presentations which improved me in class and infield research approach. I was honored and privileged to be a student under Professor KONO and I heartily thank him for all that he did for me as my advisor for three years six months.

I would like to extend my thank you to Associate Professor Dr. Satoko KUBOTA and Assistant Professor Dr. Masako MORIOKA for their support and critique and assistance in my academic journey.

I would like the thank the Department of veterinary services in Zimbabwe for allowing me to do my research in Mhondoro Ngezi, special mention to Dr Makaya, Dr Jubenkanda, Dr Pasi, Dr Mpezeni, Mr Kampini, Mr Mukosera and the 12 veterinary extension officers that assisted in data collection during the October 2021 and October 2022 data collection periods.

I extend my heartfelt appreciation to all of my lab mates for the support, assistance and encouragements during this journey, I could not have done it without their support. To SU SU Hlaign, Nirukshika, Kato, Makoko, Jin, and all the other foreign students for the support in daily life in Obihiro

Many thanks go to the International Students Office and the Students affair department for the support and assistance with all the paperwork needed to make sure that I study legally, and in peace. I would also like to Thank Professor Marshal Smith for his support and encouragement along this journey as a student.

Lastly, I would to thank JICA for accepting me as a student and for giving me the scholarship to pursue this PHD program as the first SDG student from Zimbabwe to come to Obihiro for a long-term study program. The assistance of Ms Nakakuri will always be remembered and cherished and to Mrs Musuka in JICA Zimbabwe office.

Special mention to Shamiso, Seth, Simone, Nyasha Gore, Dr Thabani Maphosa, Mr. Soloman Manyere and Lovemore Chipindu for their support and media assistance and to all friends and family I thank you for encouraging me.

Dedication

I dedicate this work to:

My Father Richard Nhokwara

For his dream of me becoming a doctorate holder and for the encouragement that I can do it.

My Mother Chipo Nhokwara

For the unconditional love and kindness, from staying up late with me when I was in primary school and encouraging me to take academics seriously.