Adoption dynamics Of Climate Smart Livestock Technologies in Smallholder Farmers (a case of Chegutu District)

A Dissertation Submitted In Partial Fulfilment of the Requirements for the Master of Science Degree in Food Security and Sustainable Agriculture (Policy)

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Declaration

I hereby declare that the research project entitled "**Adoption dynamics Of Climate Smart Livestock Technologies in Smallholder Farmers (a case of Chegutu District)**" submitted to Bindura University of Science Education, Department of Agricultural Economics, Education and Extension is a record of an original work done by me under the guidance and supervision of Dr Mujeyi and this work is submitted in partial fulfilment of the requirements for the award of a Master of Science Degree in Food Security and Sustainable Agriculture. The results embodied in this thesis have not been submitted to any University or Institute for the award of any degree of diploma.

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Dedication

This research is dedicated to everyone that contributed directly and indirectly. But mostly I this to my sons Adrien and Aiden who kept me going in the difficult moments. I hope this paper will be a source of inspiration to them.

ABSTRACT

Climate change is negatively impacting food security and livelihoods of smallholder farmers. The effects of climate change have been evidenced in Zimbabwe in the past decade Zimbabwe has adopted sustainable development goals as part of its national development agenda. SDG1, SDG2 and SDG 13 are vital towards eradicating poverty and food insecurity in the face of a changing climate. Climate-smart agriculture concept offer an opportunity for farmers to improve productivity, resilience and reduce greenhouse gases. Considering Zimbabwe is an agro based economy, the adoption of this concept is key transforming the agriculture sector towards improving productivity, resilience and sustainability. This study focused on smallholder farmers in Chegutu district, Zimbabwe. The main aim was to assess the adoption of climate smart livestock technologies in smallholder farmers. The study employed a mixed methods approach using a household questionnaire and key informant interviews to gather data. The data was collected from 150 randomly selected households. The study used Binary Logistic and Poisson regression models to account for the factors that influenced the adoption of climate smart innovations in the district. Based on descriptive analysis the majority of the farmers were males (58.7%), average age was 51 years and average household size was 7. Most of the farmers lived in old resettlement areas and attained at least secondary education (34, 7%). However 98 % had no access to credits, about 35% of the farmers had received training on CSLT and 62% had not encountered a government veterinary officer in the past 12 months. The study found that adoption rates of climate smart livestock technologies was very low with only 20,5 % of farmers adopting homemade feed and 11% adopting crossed cattle. Education level, farm type, household size and land size were positively significant to the adoption intensity of the technologies. On the other hand, it was noted that age, education level, access to credit, farm size, farm type and household size influenced the probability of a farmer adopting a certain technology. It was also revealed from the study that livestock diseases and lack of extension services were the highlights that are de-incentivizing farmer's decisions to adopt smart technologies. To address these challenges, recommendations included prioritizing trainings and education on CSLT, providing credit facilities as well as increasing farmer contact with extension services. Triggering extension services will improve access of farmers to reliable information about the technologies and their benefits. Furthermore the government need to increase awareness of climate-smart technologies through a multi-disciplinary and inter-sectorial approach to foster behaviour change in farmers towards the uptake of climate smart practices.

LIST OF ABBREVIATIONS AND ACRONYMS

CSLT Climate Smart Livestock Technologies

SDG Sustainable Development Goal

GHG Green House Gases

CSA Climate Smart Agriculture

FAO Food and Agriculture Organisation

FEWS Net Feminine Early Warning Systems Network

NGO Non-Governmental Organization

SADC Southern Africa Development Committee

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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The livestock sector is a significant part of an economy due to its contributions to agriculture, employment, and food security. It provides income and employment to an estimated 1.3 billion people in the world (Herero et al. 2016). The sector also contributes to the world's GDP and serves as a buffer against economic shocks by providing diversified income. The Regional Livestock Policy Framework COMESA (2015) states that an average of 40% of agricultural gross domestic product in Africa is represented by livestock. Around 68% of households in developing countries keep livestock as an essential source of income (Banda and Tanganyika, 2021). In addition, they serve many social, cultural, and financial roles in different societies (Herero et al., 2012). Livestock-derived products such as meat, milk eggs are crucial for a balanced diet. Animal-source foods provide vital nutrients including protein energy and minerals thereby contributing to good nutritional outcomes for a household. Additionally, it plays an important role in wealth accumulation (Murphy and Allen, 2003) and economic security through employment, particularly in rural communities where agriculture is the primary source of livelihood. Despite its vast potential to significantly contribute to poverty reduction, economic growth, social well-being, and food and nutrition security, the sector has been greatly affected by climate change and variability (Thornton et al., 2009). In Zimbabwe, this is evidenced by an array of extreme weather events such as droughts heat waves, and flash floods in recent years. According to the Government of Zimbabwe (2015b), there has been an overall decline of nearly 5% in rainfall in the last century. Furthermore, projections up to 2070 by the IPCC indicate average temperatures in Zimbabwe are expected to increase by 2.5% while rainfall is expected to decrease by 5% (Collins et al. 2013). This implies Zimbabwe may become hotter and drier which will have huge implications on crop and livestock sectors. The Meteorological Services of Zimbabwe went on to explain that there has been an increased number of years with below-normal rainfall and an increase in the intensity of mid-season dry spells. Droughts and floods have increased in frequency since 1990, often occurring back-to-back with a flood year immediately following a drought year (Mupangwa et al., 2011). In the livestock sector, devastating news has been recorded. Agriculture and Rural Development Advisory Service in 2023 through FEWS Net report (2024) disclosed that Zimbabwe had a cumulative cattle poverty death of 7643. A USAID FEWS Net 2024 report went more to state that more than 1.4 million cattle are at risk of death due to drought conditions and lack of pasture and over

9000 drought-related cattle deaths have been reported since the start of the El Nino induced drought in the 2023 - 2024 agricultural year. Incidences of diseases have increased as recorded by the government of Zimbabwe 2021 report which states over the past five years tick borne diseases have increased calming over 500 000 cattle with Theilerioses termed January disease being top of the list. This leaves climate adaptation and mitigation the only way to combat the devastating effects induced by climate change and variability. Climate smart livestock technologies have emerged as a promising approach in response to climatic challenges and to transform agro-food systems towards resilience and increase productivity and enhancing adaptation (FAO, 2010). This is new form of concept is anchored on three pillars which are to enhance productivity in a sustainable and resilient way, mitigates greenhouse gases, and improves household food security (FAO, 2010; FAO, 2013). The potential of climate-smart agriculture to boost food security and resilience has gained considerable appreciation in developing countries such as Zimbabwe where rain-fed agriculture is the backbone of the livelihoods of smallholder farmers (Mekonnen et al., 2021). This is pertinent to Zimbabwe where agriculture is mostly done by smallholder farmers and temperature and rainfall are the major drivers of crop production and food security. According to the Government of Zimbabwe (2022), approximately 70% of the Zimbabwean population depends on climate-sensitive rain-fed agriculture. This high dependence on natural resources renders livelihoods vulnerable to the negative impacts of climate change.

1.2 Problem statement

Climate change is a threat to agricultural production systems and is one of the biggest challenges in the 21st century worldwide (FAO, 2013). 80% of livestock farmers are smallholder farmers who rely on rain-fed agriculture making them more vulnerable to climate fluctuation (World Bank, 2020). Zimbabwe is amongst the 10 countries worldwide most exposed to the effects of climate change (IEP, 2021). Noticeable increases in temperature and changes in the pattern of rainfall have started to be experienced lately. Droughts and floods have increased in frequency, occurring back-to-back with a flood year immediately following a drought year. UNDP (2017) reports that during the 2015-16 drought, 27 percent of the reported cattle deaths were drought-related due to poor grazing and lack of water. Rurinda (2014) states that climate variability creates a conducive condition that favours the increased incidence and range of livestock pests and diseases such as Newcastle, theilerioses, anthrax, and foot-and-mouth disease. Some of these diseases lead to the deaths of livestock, of which communities rely on these livestock for their livelihoods. The Government of Zimbabwe recognised the need to reconcile its policies with smallholder agriculture so as to adapt and mitigate the predicted impacts of climate change. Several policies and strategies relevant to climate change have been enacted including the National Climate Change Response Strategy which promotes adoption of climate-smart technologies for sustainable agriculture. Technologies in climate smart livestock production offers potential benefits to improve production, increase resilience as well as improve livelihoods of small holder farmers (Aggarwal et al 2018, Bazzana et al. 2022). Regardless of the potential benefits of addressing climate change challenges, adoption rates have been poor, especially among smallholder farmers who are more vulnerable (Mujeyi et al. 2021, Henry et al., 2014, Mekoneen et al 2021). Furthermore majority of studies on adoption of climate smart technologies have been biased towards crop production for food security purposes not recognising the contribution made by livestock to livelihoods and income generation of smallholder farmers. Therefore, this paper aims to assess the adoption of climate-smart technologies in the livestock sector and determine the factors that affect their adoption.

1.3 Objectives of the study

1.3.1 Main objective

The main aim of the study was to assess the adoption dynamics of climate smart livestock technologies in smallholder farmers of Chegutu District.

1.3.2 Specific objectives

1. To identify the climate-smart livestock technologies being used by farmers.
2. To determine the factors that influence the adoption of climate-smart livestock technologies.
3. To determine the challenges and barriers hindering adoption of climate smart livestock technologies by farmers.

1.4 Research questions

1. What are the climate-smart livestock technologies currently being used by farmers?
2. What are the factors that influence the adoption of various climate-smart livestock technologies?
3. What are the major challenges and barriers hindering adoption of climate smart livestock technologies by farmers?

1.5 Significance of the study

The Government of Zimbabwe has promoted several technologies to improve livestock production as well as the farmer's livelihoods. This study will enable the Government through the Ministry of Lands Agriculture Fisheries Water and Rural Development to determine areas where more effort is needed to enhance the uptake of climate smart innovations. Findings from this study will act as evidence of where the ministry stands and lag behind in terms of promoting climate smart livestock technologies and make informed, necessary corrective actions which are in line with government policies. Therefore, assessing the different factors that affecting their adoption is a step towards identifying factors influencing adoption so as to inform strategies to promote their use among smallholder farmers and to tailor-make technologies that are specific and appropriate to each area to enhance wider adoption.

The study will add to the existing literature and offers baseline data on the efforts towards improving uptake of climate smart livestock innovations as well as further research on improving adaptation and resilience amongst Zimbabwean smallholder farmers.

1.6 Limitations of the study

The study concentrated on Chegutu District therefore the findings cannot be generalised to other districts in the country due to differences in agro-ecological zones. Limited resources constrained the validation of initial findings through follow-up data collection.

1.7 Outline of thesis

The study was organized into 5 chapters. Chapter 1 (introduction), it comprised of the background of the study, problem statement, objectives of study as well as limitations of the study. Chapter 2 (literature review), it is a summary of all related literature on climate smart technologies. Chapter 3 (methodology) this outlines the research design, sampling techniques as well as data analysis techniques used. Chapter 4 (results), it indicates findings of the research as well as discussions on the findings. Chapter 5 summarizes the study as well as outlines recommendations.

1.8 Definition of terms

Climate change - a change in the mean characteristics of climate over a long period of time (IPCC, 2007b)

Resilience - FAO (2013) described resilience can be described as the capacity of systems, communities, households or individuals to prevent, mitigate, or cope with risk and recover from shocks the ability of small-scale farmers to recover from shocks resulting from extreme weather events due to knowledge and skills on climate information and smart technology-based farming operations.

Adaptation – This is a process through which societies increase their ability to cope with an uncertain future, which involves taking appropriate action and making adjustments and changes to reduce the negative impacts of climate change. It can also be defined as an adjustment in human and natural systems in response to actual or expected climatic variation, with a view to moderating harm or exploiting beneficial opportunities" (IPCC, 2001)

Mitigation –IPCC (2007) defined climate mitigation as anthropogenic interventions to reduce the sources or enhance the sinks of greenhouse gases from the atmosphere.

Climate-smart livestock technologies –FAO (2017) states that these are practices that works towards sustainable livestock production systems to support climate change adaptation and mitigation activities, food security sustainable incomes, and animal welfare. These are the strategies and interventions applied to improve livestock productivity especially under resource-limited systems while enhancing climate change resilience and reduce greenhouse gases. CSA is about moving agriculture from its present state to one where productivity is higher, the risk to farmers and the food system is lower, and agricultural activities make smaller contributions to factors that exacerbate climate change.

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CHAPTER 2: LITERATURE REVIEW

2.1 Introduction.

Climate change is negatively impacting food security and the livelihoods of smallholder farmers. Zimbabwe has adopted sustainable development goals as part of its national development agenda. SDG1, SDG2, and SDG 13 are some of the vital development goals the government is working towards to eradicate poverty and food insecurity in the face of a changing climate. Climate-smart technologies offer an opportunity for farmers to improve productivity and resilience and reduce greenhouse gases. Considering Zimbabwe is an agro-based economy agriculture is a key instrument in achieving these SDGs. This chapter will review the literature on climate change and its impact on the livestock sector as well as the climate-smart technology concept being promoted for sustainability.

2.2 Livestock production

Livestock and livestock products contribute significantly to the country's GDP, accounting for about 35% of the GDP (Government of Zimbabwe, 2021). In Zimbabwe, livestock production is primarily driven by smallholder farmers in mixed crop-livestock systems. Cattle are the most valued animal followed by goats (Tavirimirwa *et al.*, 2013). Mayiki (2010) estimated that up to 60% of rural households own cattle, 90% own goats, and over 80% own chickens. However, livestock populations and densities of cattle and goats differ across districts due to different agroecological zones (Herrero *et al.*, 2012). Maburutse (2012) further explain that integrated crop-livestock farming is the predominant system of production in smallholder farmers often characterised by low-input and low-output systems. This type of system tends to be less efficient and is associated with high mortality and low productivity. Livestock play various roles in smallholder farmer's livelihoods and food security. They provide meat, milk, eggs, hides and skins, draught power, and manure (Banda & Tanganyika, 2021). Additionally, livestock acts as a strategic household investment. Phiri *et al*., (2020) states that goats, sheep and poultry act as safety nets as they are easily disposable for cash in events of extreme conditions such as droughts. Furthermore, Eneyew and Abddisa, (2015) states that in response to shocks such as floods and droughts, households owning livestock are able to cope than those that rely on producing crops only. This is because livestock tends to be more resilient than crops when disasters strike. Livestock are also sources of wealth and social status of a household. According to Mayala et al., (2017), cattle also serve many sociocultural functions such as funerals, rituals, bride wealth, and fines. Moreover, livestock production contributes significantly to household income. Income can be derived from hiring out animals for draught power and the sale of products such as meat, milk, eggs, and manure (Swanepoel *et al.*, 2010).

Table 2- 1: Benefits and functions of livestock (Swanepoel et al., 2010)

Function	Products
Food	Milk, meat, eggs, blood; fish, honey, processed products
Clothes	Wool, hides, skins, leather
Work	Draught power cultivation, transport of goods and people, threshing
Social	Lobola/Roora, ceremonial, companionship, recreational, status, rituals
Monetary	Capital wealth, investment, income from: hiring working animals, sale of products, and sale of animals.
Manure	Fertilizer; fuel; flooring; plastering
Other benefits	bone meal; soap production

In Zimbabwe, smallholders own 90% of the national cattle herd and 97% of the goat stock (Tavirimirwa et al., 2013; Ndlovu et al., 2020). This is consistent with a study by Mutambara et al (2013) which revealed the smallholder farming system now owns 92% of the national herd after the land reform program. This is worth noting as a larger portion of livestock in the country is owned by small-scale farmers. Therefore, livestock production has the potential of improving household food security and address poverty alleviation in rural Zimbabwean farmers (Melesse *et al.*, 2023). Indigenous breeds constitute the larger portion due to their unique genetic traits towards high disease tolerance and low feed requirement (Mpofu, 2002). Herding of cattle is the most common method of cattle rearing in Zimbabwe which is characterised by the use of native grass and crop residues as the common feed poor quality feed from the open grazing lands. This type of animal-rearing practice is often characterised by poor-quality feed which limits productivity (Tavirimirwa *et al.*, 2019).

2.3 Constraints to Livestock Production

Livestock productivity in smallholder farmers in Zimbabwe faces numerous challenges that differ with agroecological zones (Tavirimirwa *et al.*, 2019). The main constraints include a high prevalence of diseases and parasites (Mavedzenge et al 2006) and poor management (Motoko et al 2007), which cause poor livestock production.

Diseases and parasites are major constraints to small holder livestock production and are endemic in most Zimbabwe communal areas. Poor control of diseases has negative financial and productivity implications (Chawatama *et al.,* 2005). The Government of Zimbabwe (2021) states diseases remain the major cause of cattle mortalities followed by drought-related deaths accounting for 69% and 21% respectively. It further stated that a cattle herd mortality of 4.2% was recorded in the year 2020. These high mortality rates affect greatly the lives of the rural smallholder farmers who depend on these livestock for draught power, food and income. Thus exacerbating the already compounded poverty status. The most common diseases reported by farmers are blackleg, heart-water, babesiosis, anthrax, and anaplasmolisis (Masikati 2010; Mavedzenge *et al*., 2006). The situation is worsened by the unavailability and high cost of drugs (Ndebele *et al*., 2007) and inadequate veterinary officials (Chawatama et al., 2005). For example, a survey by Motoko et al. (2006) has shown that most cattle farmers have poor access to veterinary extension services except during dipping days.

Seasonal deficiency in feed quality and quantity particularly during the dry season is another major constraint to communal livestock production (Masikati 2010; Dube and Ndlovu 1994). In a study by Pen *et al.* (2009) in Cambodia farmers rated feed availability as the most important constraint to livestock production. The principal causes of the feed challenges emanate from a combination of the following factors: (i) Communal use of grazing land and fallow fields (Gupta, 2019), (ii) Poor quality of grazing due to the poor soils, low rainfall, and forage species characterising communal rangelands (Kumalo and Manyani, 2023) (iii) Insufficient and inefficient use of crop residue (Thierfelder *et al.*, 2024) (iv) Recurrent droughts which affect veld forage temporal quantity, (v) Pressure on land as farmers expand their crop fields and clear more land,(vi) veld fires. Tavirimirwa et al (2012)

2.4 Impact of climate change on livestock production

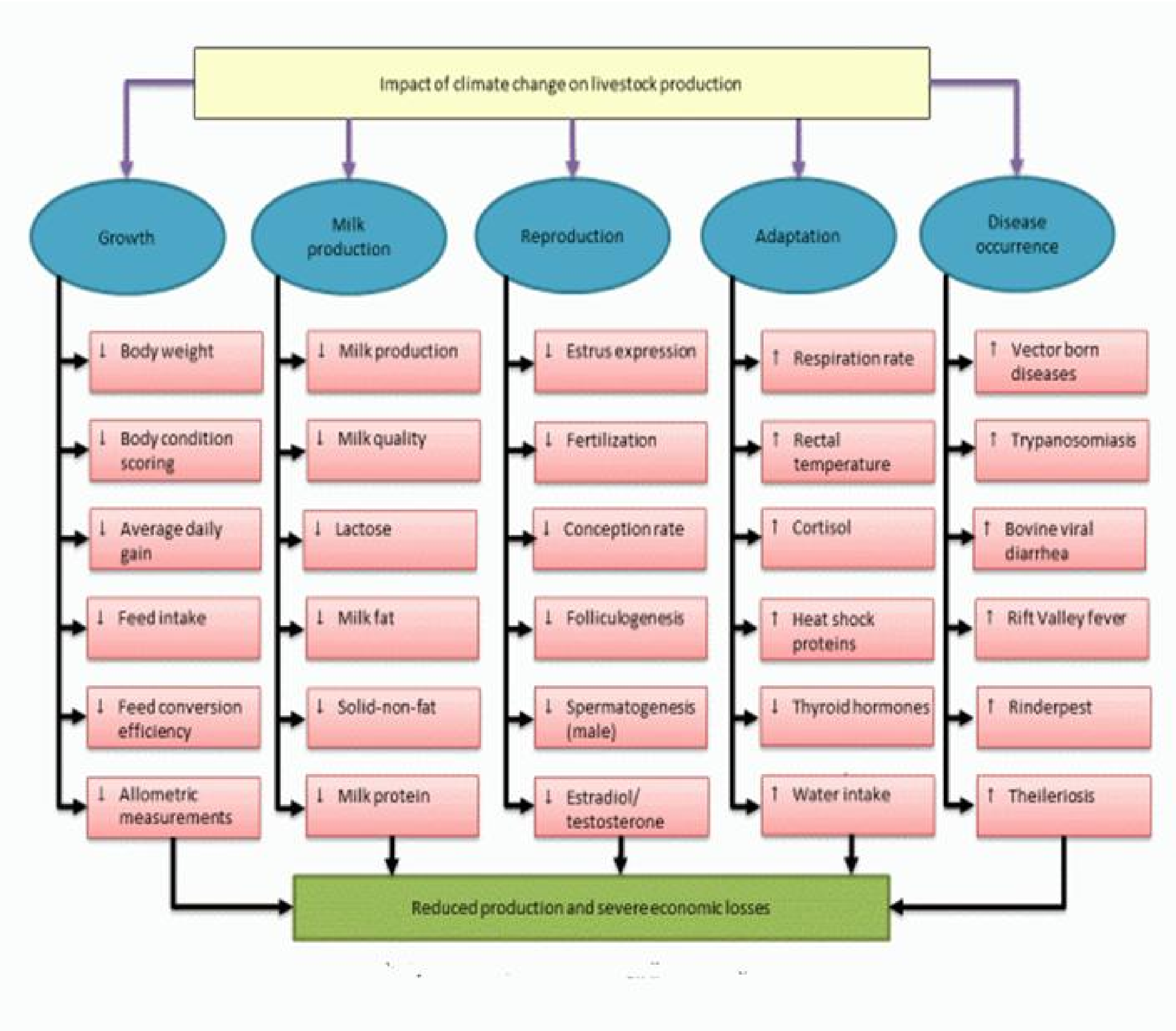

Figure 2- 1: Impact of climate change on livestock production (adapted from Sejian et al. (2022))

Heat stress

Temperature increase due to global warming can cause heat stress in livestock, affecting their health, reproduction and productivity (Sai Prasanna, 2021). Animals respond to heat stress through reducing feed intake which then has a direct impact on performance. For example, reductions in milk yield, milk quality, egg production, and fertility rates thus impacting the overall profitability of the livestock sector (Summer *et al.*, 2018). According to Sejian *et al.* (2022), heat stress on birds will reduce body weight gain, carcass weight, and reproduction efficiency and consequently egg production because of reduced feed intake and interruption of ovulation. In addition, heat stress responses have an effect on dairy animals resulting in thus reduction in milk production, and birth rates, and under extreme conditions there may also be an increase in mortality rates (Habeeb *et al.*, 2018). All of these changes lead to economic loss for a farmer

Disease patterns

Climate change-induced shocks often disrupt the natural ecosystems by providing new and optimum environments for infectious diseases (Burgiel and Muir, 2010). In addition, climate change can alter the distribution and prevalence of diseases affecting livestock that are restricted by seasonal weather patterns (Bett *et al.*, 2016). IAEA, (2010) shows that there is evidence that the increasing occurrence of tropical infectious diseases in the mid-latitudes is linked to global warming. Furthermore, ecological changes such as variations in rainfall and temperature could significantly alter the range, seasonality, and incidence of many zoonotic diseases (CDC, 2008). (FAO, 2012). For example, Trypanosomiasis an insect-borne disease is now present in temperate areas where the vector insects were non-existent in the past. The climate change-induced increase in the incidence of food-borne zoonosis and animal pests will result in increased use of veterinary drugs (FAO, 2012). Consequently, there may be higher and even unacceptable levels of veterinary drugs in the food chains.

Water scarcity

Water availability issues due to climate change will influence the livestock sector, which uses water for animal drinking, feed crops, and product processes (Thornton et al., 2009). The livestock sector accounts for about 8 % of global human water use (Schlink *et al.*, 2010). Reduced rainfall and changing precipitation patterns contribute to water scarcity affecting water supply and availability of drinking water (Ayanlade *et al.*, 2022). Periods of excessive precipitation and drought can influence both the availability and the microbiological quality of water (Wright *et al.*, 2014).

Forage availability

Climate change affects the growth and quality of pastures and forage crops leading to reduced availability of fodder for livestock (Kandalam and Samireddypalle, 2015). The quality of feed crops and forage may be affected by increased temperatures and dry conditions due to an increase in lignin and cell wall components in plants which reduce digestibility and degradation rates (Moyo and Nsahlai, 2021). This in turn leads to a decrease in nutrient availability for livestock. This will increase the cost of production for livestock farmers.

Table 2- 2: Impact of climate change on animal production system (FAO 2013)

Grazing system	Non grazing system
increased frequency of extreme weather events	increased frequency of extreme weather events
increased frequency and magnitude of droughts and floods	disease epidemics
productivity losses (physiological stress) due to temperature increase	change in water availability (may increase or decrease, according to region)
change in water availability (may increase or decrease according to region)	increased resource prices (e.g. feed, water a
alteration in fodder quality and quantity	increased cost of animal housing (e.g. cooling
change in host-pathogen interaction resulting in an increased incidence of emerging diseases	

2.5 Impact of the livestock sector on climate change

Agriculture is the third largest source of anthropogenic greenhouse gases in the SADC region (Nhemachena *et al.*, 2020). Livestock contribute both directly and indirectly to climate change through the emissions of greenhouse gases such as carbon dioxide, methane, and nitrous oxide (Sejian *et al.*, 2016). Globally, the sector contributes 18 per cent of global greenhouse gas emissions (IPCC 2007). There are three main direct livestock emissions sources: which are:

1. Enteric fermentation is a digestive process in ruminant animals (i.e., cattle, sheep, and goats) that breaks down carbohydrates into simple, digestible molecules for absorption. Methane is produced as a by-product of enteric fermentation and contributes about 55% of livestock emissions and the bigger proportion is mostly from cattle (Svinurai *et al.*, 2017).
2. Manure management, Animal wastes contain organic compounds such as carbohydrates and proteins. During the decomposition of livestock waste, the

anaerobic bacteria transform the carbon and nitrogen compound skeleton to methane and nitrous oxide respectively which is emitted to the atmosphere (Sejian *et al.*, 2015).

3. The livestock industry. The use of manure and synthetic fertilizers for forage and feed crop production, processing of feed, and transport of feed are the most important contributors to GHG emissions related to the livestock sector (IFAD, 2010). These make up 45% of global livestock anthropogenic GHG emissions (Gerber et al., 2013). These emissions are not normally considered part of livestock GHG emissions, but can significantly contribute to the overall carbon footprint of livestock production

2.6 Climate-smart livestock technologies

Climate-smart livestock technologies are practices that work towards sustainable livestock production systems to support climate change adaptation and mitigation activities, food security, sustainable incomes, and animal welfare (FAO 2017). Climate smart technologies are linked to three pillars which are increasing production, adaptation, and mitigation. Climate smart technologies are a set of practices therefore one practice alone cannot achieve these 3 goals, farmers are encouraged to adopt more than one technology to benefit fully from these technologies. For example, the use of silage can help farmers improve productivity in times when grasslands are depleted as well as reduce greenhouse gases. Similarly, artificial insemination can improve production. Therefore, it should be noted that no technology alone will offer all three benefits associated with climate-smart innovations. According to Safdar et al. (2024), the adoption of CSLT poses several advantages which include the following

1. Resilience - they enhance the resilience of argic systems to climate variability by incorporating drought tolerant livestock breeds so farmers can better withstand the impacts of drought and heatwaves floods
2. Sustainability- CSLT promotes sustainable agricultural practices that mitigate greenhouse emissions and reduce environmental degradation.
3. Increased productivity- they boost agricultural productivity by optimising resource use

Improved feeding practices:

In Africa, animals are fed to fill their rumen without considering the quality of the feed through the use of native grasses and crop residues which are vulnerable to seasonal patterns (Amole *et al.*, 2021). The use of good quality feed supports the maintenance of the intestinal barrier in animals, enhance consistent nutrient utilization thus reducing methane emissions and improves and strengthens the animal immune system (Binder, 2019). Feed lower in protein is linked to improved feed conversion efficiency and in the process, reduces excess nitrogen production. Feeding cattle with at least 55% forage decreases methane production and significantly increases their digestibility, thereby improving the production efficiency of livestock and decreasing methane emissions (Tamminga *et al.*, 2007). Moreover, having multiple sources of livestock feed through fodder source diversification helps improve livestock system resilience. For example, studies on farmers in Africa have shown the use of various improved fodder crops to help diversify the fodder source (Franzel *et al.*, 2014) and also helps stabilize ecosystem services (Martin *et al.*, 2020), improving the soil's ability to retain water (Paul *et al.*, 2020), thereby be more resilient to dry periods. However, quality feeds are not affordable and available to smallholder farmers in developing countries.

The following practices can be used to improve feeding practices

a) The use of good quality feed**:** Forage legumes such as velvet bean (*Mucuna pruriens*), lablab (*Lablab purpureus*), lucerne (*Medicago sativa*), Leucaena (*Leucaena leucocephala*), thornless acacia (*Acacia angustissima*), and sesbania (*Sesbania sesban*) as protein sources to improve feed-conversion efficiency, thus decreasing enteric methane emissions by about 25-33%.

b) Intercropping suitable legumes like groundnuts rotated with staple crops, mainly cereal grains. The legume tops can be fed to livestock as protein-providing crop residues.

c) Fodder conservation: Excess fodder produced during the rainy season can be conserved in the form of silage or hay and it can be fed to animals during the lean season to meet the requirements. Silage being a semi-fermented feed, is easily digestible and produces relatively lesser quantities of GHGs in the rumen.

Manure management

These are technologies for capturing and utilizing methane from livestock manure such as composting, anaerobic digesters, and biogas systems to generate renewable energy for household use anaerobic digesters such as biogas systems can increase farm profits by 10 to 20 percent (Kumar Pramanik *et al.*, 2019) and help reduce the environmental impact of livestock production. They are recommended as a mitigation strategy for methane to generate renewable energy (FAO 2013).

Breeding for climate resilience

Breeding management is a key strategy to increase livestock productivity by improving traits such as live weight gain and milk yield or fertility (Chawala *et al.*, 2021). The objective of animal breed improvement is to enhance the efficiency of production and the quality of the product through planned genetic change. Breeding can be accomplished through the following ways:

a) Artificial insemination can be an option to increase the genetic potential of animals (FAO, 2017a). Though requiring a lot of expensive resources, innovative arrangements can be made at the community level, where farmers benefit from social capital.
b) Cross-breeding programs. This involve identifying and strengthening indigenous breeds that are adapted to local climatic stress and feed sources. It is a strategy in which animal breeds that are adaptable to climate change effects such as heat tolerance, disease resistance, fitness and reproductive traits can be developed (Woldeyohannes *et al.*, 2024). Ultimately, this has the possibility to deliver simultaneous adaptation, food security and mitigation benefits. Crossbreeding of indigenous species with imported breeds is done to combine the high productivity of exotic breeds with the adaptive attributes of indigenous breeds in smallholder farmers (Scholtz and Theunissen, 2010). For example, Muchenje et al (2007) reported that there was an increase in milk production from Jersey × Nguni and Jersey × Tuli crossbred cows in Matopos There is always a challenge of introducing relatively higher-producing cattle breeds in environments they are not well adapted to as they face constant risks of survival

Grazing management

FAO (2012) states that the biggest threat to livestock production is the shortage of fodder during the dry season. Preventing more degradation and re-establishing degraded grasslands can be done through rotational grazing management, reforestation and promoting carbon sequestration. According to FAO (2007) well-managed grassland stores up to 260 tons of carbon. By restoring degraded grassland, these measures can also enhance soil health and water retention, which increases the resilience of the grazing system to climate variability (Rolfe, 2010). Improved grazing management could lead to greater forage production, improved soil health more efficient use of land resources, enhanced profitability and rehabilitation of degraded lands and the restoration of ecosystem services (Papanastasis, 2009). This enhances the quality and digestibility of the forage, improves the productivity of the system and reduces methane emissions (FAO, 2012)

Water harvesting techniques

Ndlovu et.al (2020) notes that water harvesting is one of the adaptation strategies that can be adopted by some smallholder farmers in drought-prone regions. Lasage and Verburg (2015) add that water harvesting improve water availability for domestic and agricultural use in semi-arid regions. Moreover, Grum et.al (2016) are of the view that water harvesting techniques improve the availability of water, which is essential for livestock production.

2.7 Factors influencing the adoption of climate-smart livestock technology

The adoption of technologies has been shown to depend upon a myriad of factors. These factors include age, gender, level of education, asset ownership, farm size income levels and farming experience. The age of the household head influences the adoption of technologies differently. Some studies have shown that age has a positive effect on adoption as older farmers have enough experience and have been exposed to the different dynamics in agriculture and the benefits associated with the adoption of technologies (Aduwo *et al.*, 2019). On the other hand, studies have found that age negatively affects adoption (Olum *et al.*, 2019). Youth is alleged to be more technology-oriented than older farmers. The number of people living in a household can influence the adoption of innovations (Dissanayake *et al.*, 2022). The household size is mostly used as a proxy for labour. According to Orser and Riding (2018), a household with few members may be discouraged from adopting labour-intensive technologies. While gender, males have been found to have a higher probability of adopting technologies than female counterparts (Namonje-Kapembwa and Chapoto, 2016). This may be due to the patriarchal societies where males are mainly land owners therefore, they influence decision-making on technology adoption. Most farmers depend on extension workers as their source of reliable information on various livestock production methods and practices including technologies (Mupawaenda *et al.*, 2009). Hence farmers with increased access to extension services are more likely to adopt technologies. In Zimbabwe extension services have been found to positively influence adoption (Mujeyi et al., 2021). These findings are similar to studies done by Makate and Makate, 2018 which concluded that lack of extension services denies farmers information about the use and benefits associated with technology. There are also findings that show that having formal employment or an off-farm income source decreased the likelihood of adopting more climate smat practices (Justin et al., 2017, Abegunde et al., 2019, Kassa and Abdi, 2022). Farmers who have off-farm jobs may be unable to commit their time to agricultural activities. This can make it more difficult to adopt climate smart technologies as farming activities require additional time and attention. Moreover, being less dependent on farm income can reduce the probability of uptake and use of these innovations. A higher farm income increases the likelihood of adopting smart farming practices. (Kassa and Abdi, 2022; Negera *et al*., 2022). Farmer that has more financial resources are likely to invest in new equipment and technology. Assets and wealth endowments such as income, savings access to credit, and insurance are considered to have a significant influence on the adoption of technologies by farmers (Mohamed and Temu, 2008). This is because they act as a safety net in times of crisis, enabling farmers to innovate and take risks which supports long-term sustainable adaptation (Jones *et al*., 2010). Correspondingly, technology adoption in some cases requires heavy initial capital investment, which in most cases is out of reach to the majority of rural farmers. This implies that farmers with higher resource endowments are more likely to adopt climate-smart practices compared to the less-endowed farmers (Deressa *et al*., 2009). Other factors that have been shown to influence the adoption of new practices include the size of land a farmer owns tends to influence adoption. Conflicting findings have been found by various researchers. Some studies have shown that farm size negatively affects adoption (Idrisa *et al.,* 2010). This means those with smaller land sizes are quicker to adopt technologies than those with bigger portions of land. In contrast, positive relationships have been recorded with farmers with bigger portions of land and the likelihood of technology adoption (Brown *et al*., 2020). Institutions also play a critical role in the adoption of agricultural practices (Djurfeldt *et al*., 2011). Jones et al. (2010) affirm that the effective adoption of climate-smart practices requires the involvement of institutions at all levels. For instance, local collective and civil society institutions play a significant role in terms of asset building, access to information, resource mobilization, capacity and skills development, and creating linkages necessary for the adoption of adaptive strategies (Agrawal, 2008).

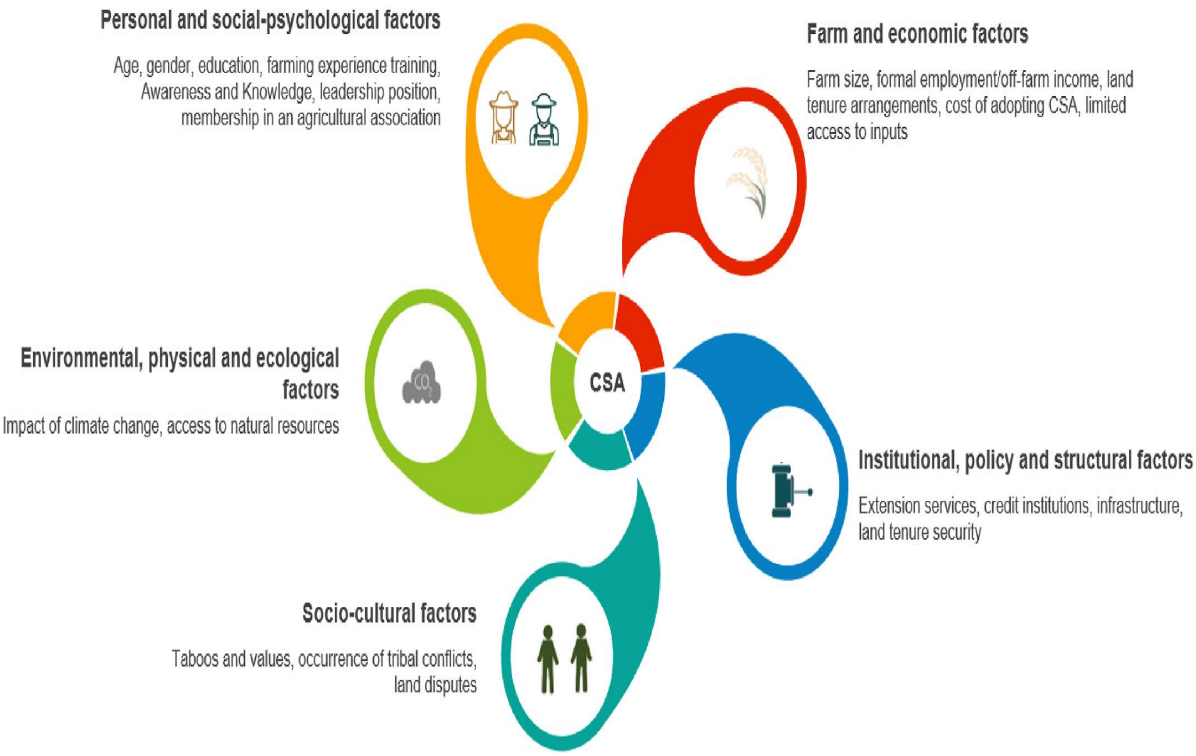

Figure 2- 2: Factors that influence the adoption of climate-smart agricultural practices (Ogisi and Begho, 2023)

2.8 Challenges and barriers in the use of climate-smart livestock technologies

Adoption of scientific and technological innovations in the agricultural sector has received considerable attention given their contribution to improved productivity and incomes (Branca et al., 2012), particularly in developing countries, where agriculture plays a pivotal role in terms of eradicating poverty, hunger and supporting livelihoods of the majority small scale farmers (World Bank, 2008). In spite of these efforts, the adoption of new technologies at the farm level remains a challenging and dynamic issue. This is affirmed by several studies conducted in countries such as Kenya, Ethiopia and Nigeria (Deressa et al., 2009; Dulal et al., 2010, Ogada et al., 2014, Mugwe et al., 2009). Access to inputs such as machinery and equipment hinders the use of climate-smart livestock practices and requires the use of certain machinery or equipment, for instance, breeding services and artificial insemination. These inputs are often expensive and out of reach for many smallholder farmers who are already crippled by poverty. Surveys have also shown that when inputs are readily available and accessible in the local marketplace, adoption of technologies becomes easier (Ogada *et al.,* 2014; Agrawal, 2008). Most smallholder farmers are situated in rural areas characterised by poor infrastructure. The lack of infrastructure in rural areas is considered one of the most important barriers to the development of the agricultural sector. Poor infrastructure has ripple effects for the entire value chain. It often results ini high cost of inputs, post-harvest losses, and higher prices for consumers (Munyanyi, 2013). Lack of training of training and awareness of farmers on climate-smart livestock practices is also a barrier to adoption of these innovations. Limited training and funding on climate change of extension workers compounds the situation and limits their ability to cascade climate smart information (Zuma-Netshiukhwi, 2023). In mixed crop-livestock systems, small farm sizes and diversified activities can make investments in improved technologies or practices economically inviable (Bastos Lima, 2014). Finance provides opportunities as well as barriers to the adoption of climate-smart livestock practices. Adoption of new technologies is associated with high initial costs to establish and implement the practices. Many farmers lack access to financial resources and are unable or unwilling to seek credit to finance otherwise profitable investments. Investing financial, labour and natural resources in new technologies and practices always implies risks, which are often too significant for resource-poor producers (Langyintuo, 2020). Livestock sector policies in the region both provide support to and constrain development opportunities for livestock keepers.

2.9 Impact of Climate Smart Livestock Technology Adoption

CSLTs are promoted and adopted with the potential to increase productivity and reduce poverty. Studies have shown that the adoption of technologies improves overall household welfare (Mujeyi et al., 2021 Manda et al., 2016, Khonje 2015). After studying the impacts of climate-smart technologies on household production. Findings have shown that adoption has the potential to improve household food and nutrition status. Farmers who use smart technologies consume more diverse foods. Adoption of improved livestock breeds showed a 38% improvement in the dietary diversity score compared to those who did not. Furthermore, the adoption of resilient livestock breeds reduced periods of food insufficiency by 4 to 6 months per year than non-adopters. This revealed a 90 % reduction in household food insufficiency. These findings were consistent with Tecklewold et al (2019) who showed adoption of climate-smart technologies increases dietary diversity and improves calorie and protein intake at the household level. Climate-smart technologies have the potential to improve household income (Lipper et al 2014). An increase in productivity means farmers can sell surpluses and gain extra income. The positive impact on farm output shows that technologies have the potential to reduce poverty rates in developing countries. Findings indicate households that adopted climate-smart technologies had 20, 3% higher average annual farm income than non-adopters (Mekonnen *et al.*, 2023). Pampori and Sheikh, (2023) presented that livestock smart innovations improve livestock products such as milk and eggs which can be sold to bridge the hunger gap and add to the household income. A Study in Burkina Faso showed feeding cows with silage resulted in a tenfold increase in milk production and ewes on silage-maintained milk yield throughout the year. This is consistent with Mujeyi et al 2021 who went on to say adoption of climate-smart practices can result in sufficient food for households and a surplus which can be sold to generate more income. Adopters of livestock breeds sold significantly large quantities of animal-sourced foods which could be used in lean seasons to purchase food. Ogada et al (2020) showed adoption of livestock technologies led to household asset accumulation. It is consistent with the literature which states that livestock is a wealth store (Banda and Tanganyika, 2022). These livestock especially cattle and goats can be sold off during seasons of weather shocks and food insufficiency to purchase food. Farmers in West Africa successfully managed to feed their livestock during the dry season and also started income generation through silage sales. This enhanced their income as well as animal production. Overally, adoption of climate livestock technology improves household welfare by increasing food security and income through the production of own food (Mujeyi et al 2021, Wekesa 2018, and Siziba et al 2019 Ogada et al 2020). Increase in food supply enhances food availability in markets which is an indirect effect of climate-smart agricultural technologies. Altogether climate-smart innovations have a positive effect on the food availability, access and utilization pillars of food security. There by strengthening the 4 pillars of food security and attainment of sustainable development 2 SDG 2 Zero hunger. The positive impacts of adoption show that technologies have the potential to reduce poverty rates and adaptive capacity to climate risks in developing countries (Zakaria *et al.*, 2020).

2.10 Summary

The literature highlighted that CSLT offers a potential to reduce food insecurity and poverty levels, increase farm income as well as reduce greenhouse gases. However farmers should adopt a range of technologies to attain optimum benefits offered by climate smart technologies.

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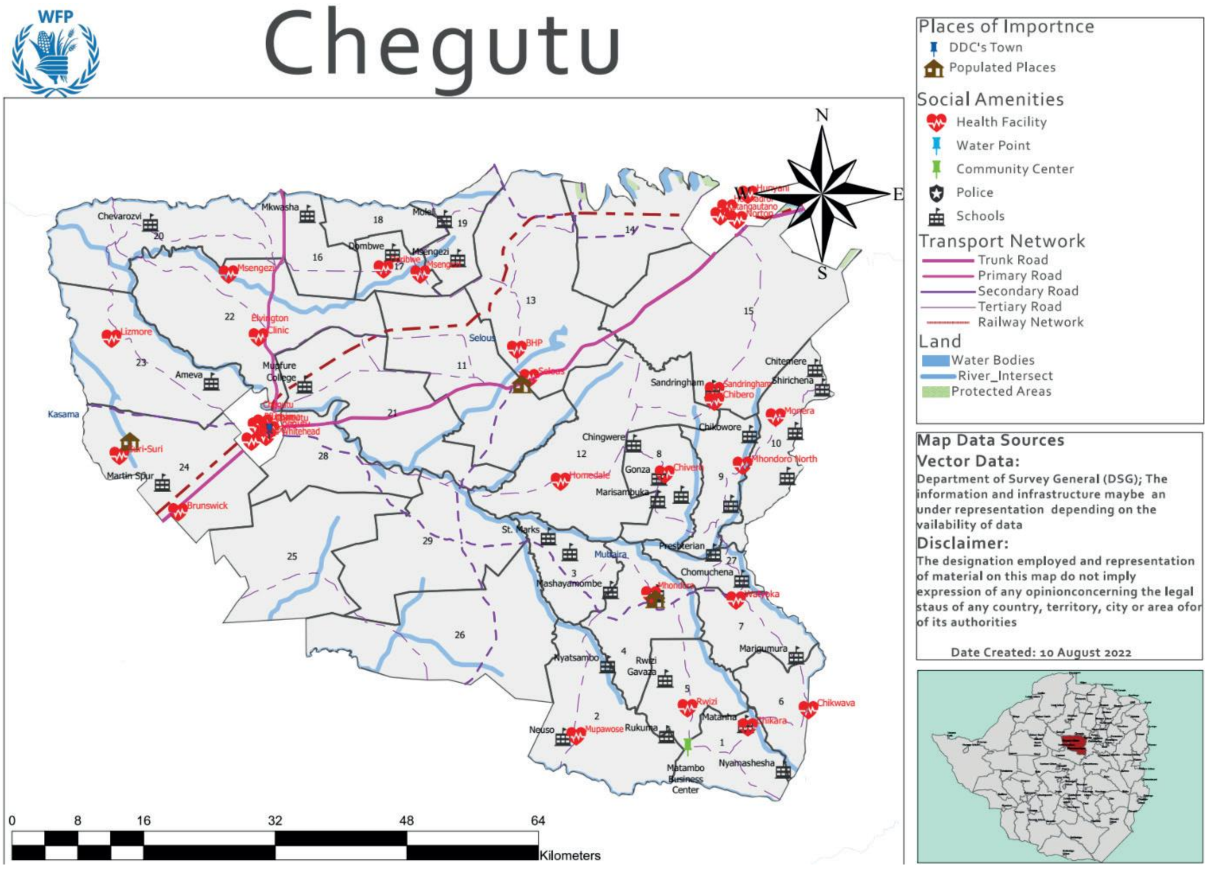
CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the study area, study design, study population, sampling method, sample size, data collection methods, data collected and data analysis.

3.2 Study Area



The study was carried out in Chegutu district. The district is located in Mashonaland West province of Zimbabwe and boarders with Seke district to the North, Sanyati to the South, Mhondoro-Ngezi to the East and Zvimba to the West. There is also a small shared boundary with Makonde district. There are 29 rural administrative wards under the authority of Chegutu Rural Development Council (Sango and Nhamo, 2015). The estimated total rural population is 178, 906 with 50.1% being males and 49.9% females (ZIMSTAT, 2022). The district covers approximately 436, 200 hectares and of these 99, 877 hectares (22.91 %) is arable, 45, 000 hectares (10, 31%) under forestry, 291 323 hectares (66, 78%) is grazing land (FNC, 2016). The average annual cropping area for the district is 31, 307 hectares representing 7% of the total district area. The district falls into three main agro ecological regions 2A 2B and 3 this makes the district an intense agricultural area. The main sectors in the districts are mainly communal and resettlement areas. The Food and Nutrition Security Profile (2022) states that the main livelihood sources in the district are mainly based on agriculture mainly livestock and crop production, horticulture production and mining.

3.3 Research design

Explanatory research was applied in this study. The regression model was used to quantify and determine intensity of the relationship between the dependent variable and independent variables. Quantitative and qualitative research approaches were used using a cross-sectional survey. The quantitative data was collected using a pre tested household questionnaire while qualitative data was collected using key informant interviews. The target population was 150 smallholder farmers who practiced livestock production in Chegutu district

3.4 Sampling technique

A multistage-stage sampling technique was carried out to select respondent households. In the first stage, the study district was selected purposefully based on its potential for the climate-smart agriculture practices. In the second stage, random sampling was used to choose 150 households who practised livestock production. The population was divided into their respective wards. The respondents were randomly sampled from lists of farmerswho has been assigned numbers in each ward. They were drawn from all the wards to come up with a total of 150 respondents. Simple random sampling enables participants to be chosen in a fair, unbiased manner and gives a full representation of farmers from diverse household characteristics. Noor et al (2022) states that random sampling enables generalizability of results in similar contexts.

Purposive sampling was on the other hand, used in identifying key informants' participants. In this study key informant interviewees were individuals who had competence and knowledge in the area of livestock production and application of climate smart livestock technologies. They were mainly extension officers in the ministry of agriculture under the livestock production department.

3.5 Data collection

A questionnaire was used to gather primary data from the households. The questionnaires were administered individually through face-to-face interviews to obtain information on household demographics. The questionnaire was pre tested to provide room to make correction and modification.

The questionnaire collected mostly quantitative on household characteristics as well to establish the factors influencing adoption of climate smart practices. The quantitative data collected included age, gender, educational level, and farm size, access to credit, membership and benefits drawn from farmer organizations. The climate smart practices which were examined in the study included practices that had been promoted by the ministry of agriculture in Chegutu district. The key informant interviews were conducted to the ministry of agriculture staff under the livestock production division. The key informant interviews gave an in-depth understanding of the technologies that were being promoted in the district as well as challenges and barriers the farmers were experiencing on adopting various technologies the interviews were also aimed at determining the technical and institutional capacity of the department to adoption of climate smart innovations in response to changing climate. During the study, seven key informants were interviewed.

3.6 Data analysis

Both descriptive statistics and econometric analysis models were used to address the study objectives. Descriptive statistics in form of percentages and frequencies were used to describe demographics and the types of climate smart technologies which are adopted by various farmers. To test statistical significance of the findings, that is the relationship between the independent variables and dependent variable, binary logistic regression for the factors influencing the adoption of each climate smart technology and Poisson regression for the adoption intensity of farmers (counts). The poison regression model was used to quantify factors that influenced adoption of the climate smart livestock technologies. Cramer (2002) states that Poisson is used to analyse count data and estimate the relationship between a count variable and one or more independent variables. The number of technologies adopted by each farmer were counted and summed up to derive the dependent variable. Statistical Package Social Sciences (SPSS) Version 20 was used to analyse quantitative data

3.7 Poisson regression

It is recommended that farmers adopt more than one climate smart practice to enjoy the impact and maximum benefits associated with them and adoption (Negera *et al.*, 2022). Most studies have used econometric models such as the probit and logit models to estimate the factors that influence adoption of climate smart practices. These models are relatively simpler and easy to administer (Al-Karablieh *et al.*, 2009). However, these models require the dependent variable to be binary or dichotomous (Ali, 2021). That is the dependent variable will either be 1 = adoption of a certain technology or 0 = non adoption. However binary models only predict whether a farmer will adopt a certain technology. They do not provide information on farmer who adopted more than one technology at a time. To address this challenge of using binary models this study adopted the Poisson regression model. The poison model provides a better insight beyond binary indicator and allows quantification of relationship between factors influencing adoption of more than one technology of adoption of one technology (Ajayi and Jera, 2008). The Poisson regression model is used to model instances when the outcome variable is a count data. This model is a type of generalised linear model uses the assumption that the outcome variable follows a Poisson distribution (Yang and Berdine, 2015). The mean and variance in a Poisson distribution are equal. If the variance is lower than mean under dispersion is observed and if variance is greater than mean over dispersion is observed (Ajayi and Jera, 2008). The Poisson regression equation is presented as follows

$$\log(\mu) = \beta_{\circ} + \beta_{1\circ}X_1 + \beta_2X_2 + \ldots + \beta_kX_K$$

Where

μ is the expected value of the Poisson distribution

$\beta_{\circ}$ is intercept

$\beta_{1\circ}, \beta_2$ are rhe coefficients for the predictor variables

X_1, X_2 are the predictor variables

k = is the number of predictor variables

log is the natural logarithm

3.8 Binary logistic regression

Binary logistic regression is a prognostic model that is used when dependent variable is dichotomous or binary (Harris, 2021). Like in this research where the researcher is interested in whether there is adoption of a technology by a farmer or not. One advantage of logistic regression is that it is not dependent on stringent assumptions to be met compared to linear regression. (Rona et al 2010). The binary regression quantifies the relationship between the binary dependent variable and predictors using the odd ratios (Schreiber-Gregory and Bader, 2018). Odds ratios is the probability that the event will occur divided by the probability that the event will not happen (Cramer, 2002). In this study odds ratio is the probability that the farmer will adopt a technology divided by the probability that farmer will not adopt.

$$\text{Odds} = \frac{\text{p(adoption of technology)}}{\text{p(no adoptin)}}$$

$= \frac{\pi(x)}{1-\pi(x)}$

where $\pi(x)$is the probability of adoption and 1-$\pi(x)$is the probability of not adopting. Therefore, the regression model equation will be as follows

logit y =$\beta_\circ + \beta_1 X_1 + ... + \beta_K X_K$

logit y is the natural logarithm of the odds of outcome

$\beta_\circ$ is intercept

$\beta_{1\circ}, \beta_2$ are rhe coefficients for the predictor variables

$X_1, X_2$are the predictor variables

k = is the number of predictor variables

3.9 Variable description

Dependent variable for multilinear model

Each technology was treated as a dependent variable on which its adoption will be affected by various hypothesized independent variables.

Dependent variable explanation for the Poisson model

A total of ten technologies were used for this study. Counts on the number of technologies adopted by each farmer was the dependent variable. A total of ten technologies were used to calculate the counts. All the technologies a household adopted were summed up to obtain total number of technologies

Independent variable

A total of 10 independent variables were postulated to affect the adoption of various technologies by farmers in Chegutu district. The variables were chosen based on review of related literature

Figure 4- 1: Summary of Variables Used In Econometric Analysis

Variable	Description	Measurement
Age	Age in years of household head	Continuous
Sex	Gender of household head	Dummy

Education	Highest educational level attained	Categorical
Farm type	The type of their farm	Categorical
Landholding	Land size in ha a household owns	Continuous
Household size	Number of household members in the household	Continuous
Access to credit	Access to credit such as loans	Dummy(categorical)
Affiliation to farmer association	If farmer belong to any livestock association	Dummy
Access to extension services	If farmer had contact with extension service(veterinary officer) for the past 12 months	Dummy

3.10 Ethical considerations

The study sought verbal consent from the participants for both household questionnaire and key informant interviews. In addition, the information that was gathered was used only for the purpose of this study. To ensure anonymity the study did not gather any names of the respondents.

3.11 Summary

The chapter gives full details of Chegutu district and on how data was gathered from the respondents which were sampled using random and purposive sampling methods. The qualitative data which was obtained was analysed using the binary logistic and Poisson regression models.

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CHAPTER 4: DATA PRESENTATION AND DISCUSSION

4.1 Introduction

This chapter presents the study findings that were obtained from the study. The chapter is structured in two sections. The first section presents the descriptive statistics of the study and the second section presents and discusses findings according to the stated objectives

4.2 Descriptive statistics

The study sought demographic information from the study. The demographic information included the age and sex of the respondents, education, years in agriculture, household size and farm type land size trainings access to credit.

Gender

The majority of respondents were household heads. 58.7% of them were males and 41.3% were females. These results show that males have greater access to land which is the most important asset in agriculture than females.

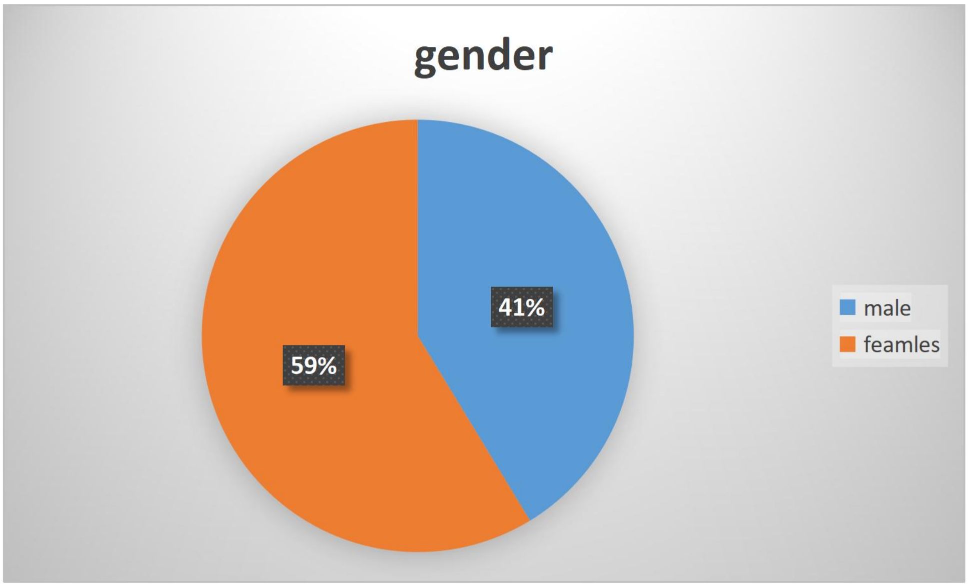

Figure 4- 1: Gender of respondents

Age

The findings showed that the average age of respondents was 51 years representing relatively middle-aged household heads. This shows that most of the farmers are in their productive ages and hence have the potential to adopt new farming techniques.

Farm type

The survey results also showed that most of the farmers lived in old resettlement 31.3% and communal farms. Least of the farmers lived in large scaleA2 farmlands. The findings showed that most of the farmers had bigger farmlands as only 28 percent lived in communal lands which are characterised by small portions of land

Table 4- 1: Type of Farmland of the Households

Farm type	Frequency	Valid Percent
Communal	28	18.7
old resettlement	47	31.3
A1	35	23.3
A2	16	10.7
large scale commercial	24	16.0
Total	150	100.0

Education

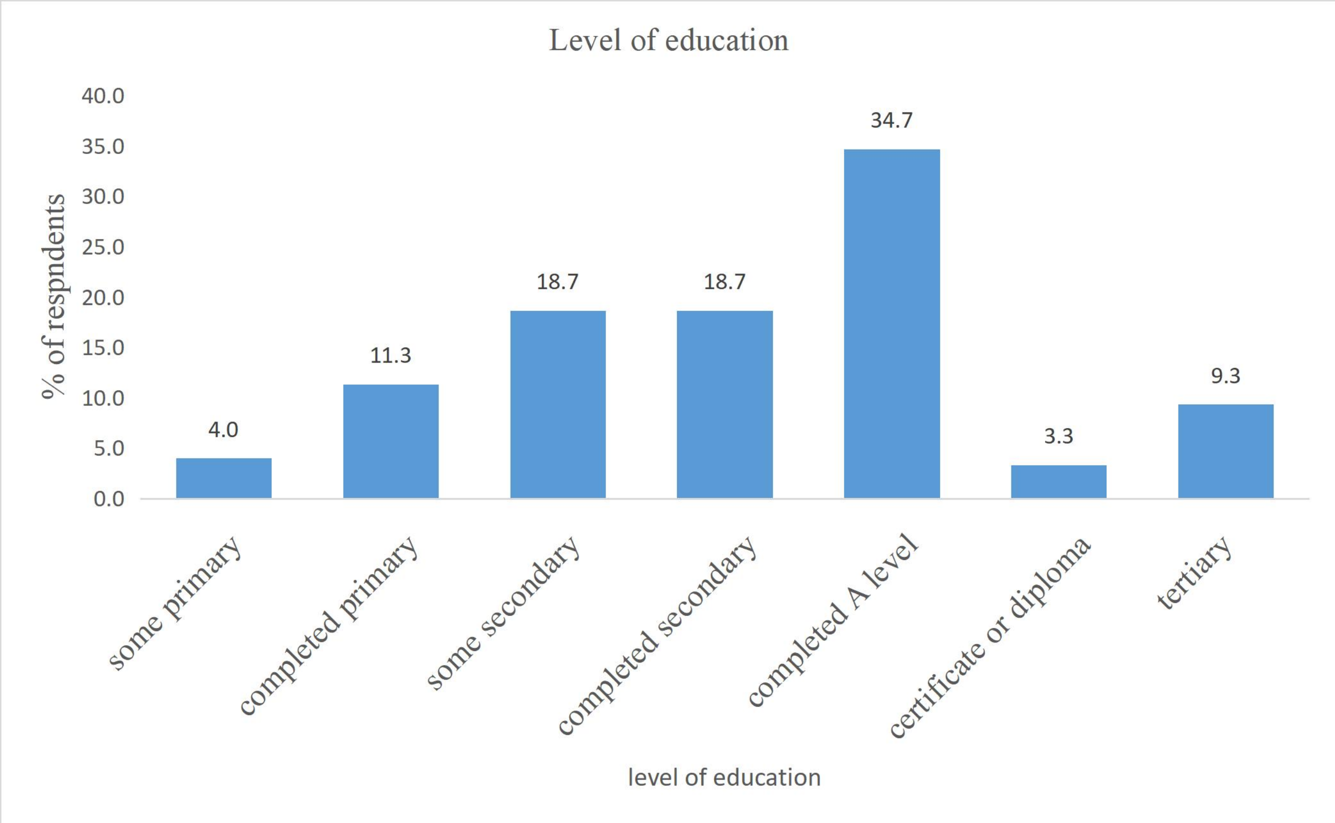

Figure 4- 2: Education Level of the Participants

From the figure 4.2 above the study reveals that the largest number of the farmers (34.7%) had completed their secondary education. The study also showed that 4 % were illiterate. The study indicates that most of the respondents received formal education. Findings further revealed that 66 % had completed secondary education which is considered a standard in the Zimbabwean educational system. Attainment of formal education enables a farmer to understand, comprehend and interpret information that helps in decision making. Therefore, education is a precursor to the adoption of a farming method. According to a study by Manda et al. (2016), the probability of adopting a technology increased as the level of education of a farmer increased.

Household size

On average the household size was 7. Household size is a proxy indicator for the availability of labour. This implies that a larger household is more likely to adopt technologies that are labour intensive or those that may require more human capital.

Access to credit

The majority (98%, n=144) of farmers in the study area had no access to credit. Only 2% (n=3) of the respondents indicated they had applied and used credit in their farming activities (Figure 4.4). Credit is considered vital in supplementing the meagre resources that farmers have, to meet the costly financial requirements in their farming activities (Jones et al., 2013). With limited access to credit, farmers will be constrained in terms of investing in farming activities including adopting innovations, such as climate-smart practices.

Affiliation to Farmer Association

Only one farmer belonged to a livestock association, majority of respondents (99.3%, n=150) did not belong to a farmer organization. Association with a farmer group is linked to high awareness and a good understanding of the benefits of climate-smart technologies. Key informant interviews indicated that farmer groups were mainly characterised by small-scale and commercial farmers who took livestock production as a business. They also attributed to a lack of awareness of the benefits of being a member of a farming association, lack of exposure and contact with these associations as they were located in urban areas and that associations required subscriptions which is an expense to an already poor farmers

Access to extension services

Table 4- 2: Number 0f Farmers Who Accessed Extension Services in Past 12 Months

Number of farmers who accessed extension services in past 12 months	Response	Frequency (%)
	No	62.0
	yes	35.3

62% of the farmers stated in the past 12 months they had not encountered a government vet officer. In other words, only 35 % had done training on CSLT. These results reflect that not much has been done to promote uptake through awareness and enhancing knowledge on CSLT by the Government of Zimbabwe through the Veterinary Department. Frequent visits and follow ups help to establish relationships and trust between farmer and extension worker which in turn increases likelihood of adoption of climate smart practices Low accessibility to extension services implies that farmers had poor access to veterinary services which are critical for access to information on climate smart technologies as well as technical advice on animal production. Contact with extension services help to influence perceptions of farmers about climate change. Based on the innovation diffusion theory farmers who have frequent contact with extension services tend to be more productive and receptive to new technologies. These results are in concurrence with other studies done in Africa. A study in Ethiopia showed only 12 % were trained in climate-smart practices (Wekesa *et al.*, 2021).

Landholding

The mean was 15 hectares. A farmer had a minimum of 1 hectare and a maximum of 87 hectares. This amount of land was where both crop and livestock production were done. Bigger land size leads to a higher probability of adopting climate-smart innovations that demand more land.

4.3 The climate-smart livestock technologies being used by farmers

The ten climate-smart livestock production technologies that have been promoted by the Government of Zimbabwe were bag silage, silage pit, Mucuna, Lablab, Home feed, Earth Pond, Artificial insemination, Leucanea, crossed cattle and Crossed breed for goats and sheep. Silage making is used to store fermented forage crops which are usually cut into pieces. Use of silage allows farmers to conserve excess forage during periods of abundance and use them during the dry seasons. The fermentation process in silage making improve digestibility of forage leading to efficient digestion and reduced enteric fermentation (Nyairo *et al.*, 2021). Earthponds is a water havesting technique where water is stored during wet seasons. The stored water can be used to irrigate fodder or act as a consistent source of water for luvestock especially in areas where water sources are unreliable or dry out (Mwenge Kahinda *et al.*, 2007). Lab lab, mucuna and leucanea are fodder crops that are rich in protein which are mainly used for rumminants such as cattle sheep and goats (George *et al.*, 2013). Lab lab and mucuna are from the legume family hence have an ability to fix nitrogen from atmosphere. This is beneficial for agroforestry and soil conservation practices. Furthermore, foder crops have a dense root system which helps to prevent soil erosion hence contribute to land management. Homemade is a practice where farmers are able to formulate their own feeds using locally available resources and waste (Muschler, 2016). This reduces reliance on commercially produced products. Locally available ingredients such as grasses, forages, waste products crop residues are used. Homemade feeds reduce transportation costs. Expenses associated with purchases of feed which lowers carbon foot print. Cross breeding of cattle goats and sheep and artificial insemination are methods that's involve identifying and strengthening indigenous breeds that are adapted to local climatic stress and feed sources. It is a strategy in which animal breeds that are adaptable to climate change effects such as heat tolerance, disease resistance, fitness and reproductive traits can be developed. This can be doe in vivo (crossbreeding) or in vitro (artificial insemination).

The figure 4.3 below illustrates the widely adopted practices

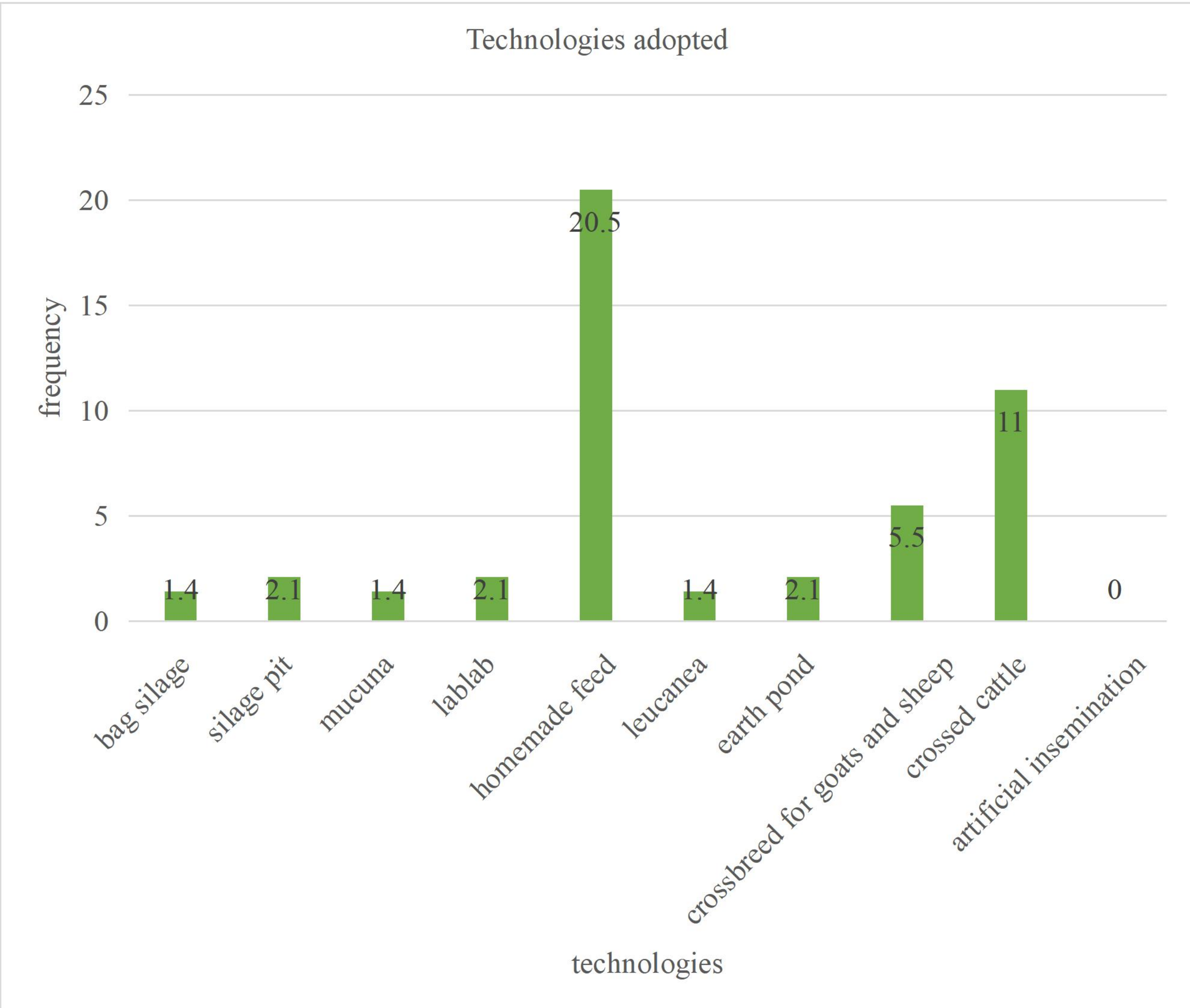

Figure 4- 3 : Percentage of Adopted Technologies by Farmers

Homemade feed (20.5 %) and crossed cattle (11%) and Mucuna (1.4%) bag silage (1.4%) and Leucanea (1.4%) were the least adopted technologies while none adopted artificial insemination (0%) despite over 5 % being trained on the technology. Low levels of adoption shows that the farmers are yet to adopt the CSLT. These results affirm with other studies that have highlighted slow uptake and adoption of CSLT despite the efforts being done by the government to prepare farmers in terms of adaptation and mitigation. Adoption of CST is low in Sub Sahara less than 7% of farmers have adopted improved maize cultivars (Uaiene *et.al* 2009, Ogada *et al.,* 2014). Key informant interviews underlined that the smallholder farmers view climate-smart technologies as practices that are only applied by commercial farmers for example artificial insemination. It is viewed as a practice that is done for the commercial production of cattle. Lack of land was one of the challenges highlighted, limiting farmers to adopt the growing of fodder crops and trees as there is competition between growing fodder and food crops. Farmers tend to commit much of their land to growing food crops rather than growing fodder for livestock. It was highlighted from key informant interviews that most of the households are food insecure therefore it is a tough decision to commit a piece of land to grow fodder that will not contribute to household silos. Considerable adoption was recorded with homemade feed this was due to the fact that some of the raw materials the farmers had readily available at their disposal especially for chickens as each household was capable of mixing various grains to feed their chickens. Several studies in West Africa have shown that farmers are aware of the contributions of forage legumes to their livestock production but their integration is relatively slow (Amole and Ayatunde, 2016). According to Kebede *et al.*, (2016) the use of forage legumes is limited because they do not contribute directly to the human food supply. Growing feeds is a new concept for most farmers as they are used to collect natural forages from fields, weeding crops, fallow lands or forests. Some farmers also mention the fear that forages can become weeds. Poor adoption of artificial insemination was recorded due to a lack of cold chains to preserve the semen as most of the farmers lived in rural areas where electricity may be a problem. Key informants indicated that most used of improved crossbreed bulls from commercial farms as a method to improve breeds

4.4 The factors that influence adoption of CSLT

Table 4- 3: *Factors influencing adoption of CSLT (binary logistic regression results)*

	lablab		fodder		silage bag		silage pit		home feed		earth ponds		l breeds fo goat r		crossed cattle		lucaenea	
	coeff	p value	coeff	p value	coeff	p value	coeff	p value	coeff	p value	coeff	p value	coeff	p value	coeff	p value	coeff	p value
variable																		
sex	-0.32	0.148	-0.004	0.789	0.018	0.734	0.008	0.382	0.066	0.389	-0.017	0.779	0.011	0.786	0.045	0.451	-0.005	0.27
age	0.001	0.311	0.001	0.22	0,00	0.264	0.001	0.016	0,00	0.873	0,000	0.304	-0	0.55	0.001	0.718	0.001	0.744
farm type	0.06	0.689	0.001	0.01	0.006	0.569	0,00	0.45	0,00	0.985	0,000	0.794	0,00	0.545	-0.001	0.593	0.009	0.132
education	0.012	0.138	0.01	0.078	0.001	0.826	0.002	0.695	-0.001	0.728	-0.003	0.765	0.021	0.171	0.003	0.896	0.012	0.267
hh size	0.004	0.138	0.002	0.378	0,00	0.333	-0.004	0.032	0.01	0.691	0.001	0.593	0.011	0.019	0.012	0.084	-0.002	0.054
land size	0,00	0.933	0,000	0.663	0.004	0.745	0,00	,0000	0.003	0.145	0,000	0.714	0,000	0,020	0,00	0.053	0,00	0.392
access to cre	-0.003	0.965	0.006	0.905	0.004	0.942	0.232	0,00	0.0122	0.64	0.002	0.988	-0.18	0.2	-0.68	0.736	0.021	0.75
access to ext	-0.024	0.279	0.015	0.34	0.012	0.469	0.005	0.77	0.045	0.51	-0.012	0.447	-0.01	0.831	0.024	0.687	0.017	0.705
affiliation tc	0.014	0.616	-0.008	0.683	0.01	0.643	0.015	0.466	0.167	0.99	-0.013	0.529	0.093	0.087	0.04	0.608	-0.013	0.815

Age

From the study results, there was no statistical significance of age on the intensity of adoption of CSLT by farmers. On the other hand, the age of the household head had a positive significant effect on the adoption of silage pits (p=0.016). This concurs with the results from a study by Deressa (2009), which showed a positive relationship between age of household head and adaptation to climate-smart technologies

Education

Higher education leads to the adoption of more CSL technologies. From the study, there was a positive correlation between the level of education and adoption of leucanea (p=0.054) and the results were statistically significant. This implies that the probability of more educated farmers being aware of the use of leucanea in livestock production is higher than that of less educated farmers.in addition, education was found to be statistically significant to the adoption intensity of climate-smart technologies. As the education level of a household increases the probability of adopting more than one technology increases. According to Muzamhindo and Jiri (2015), education affects farmer's perception of technologies, its diffusion, and sustainability. An educated household head can read educational pamphlets that are often given to farmers to educate them on new innovations and technologies by agriculture extension officers and NGOs. Thus, this can help improve the productivity of households and help reduce vulnerability to food insecurity. In addition, this can be supported by Weir (1999) who highlighted that there is a positive correlation between the level of education of farmers and the speed with which they pick an innovation This means that farmers who are learned, that is, those who can read, understand and analyse issues and are more capable of adopting a technology. This incurs with a study by Beshir and Wegary (2014) that showed an additional level of formal education increased the likelihood of technology adoption

Access to credit

Access to credit had a positive significant effect on the adoption of silage pit. Researches on the influence of access to credit has shown mixed results, with some studies showing no influence and others showing positive or negative influence. Studies conducted on the determinants of adaptation show a positive relationship between adaptation and credit (Below *et al*., 2010; Hassan and Nhemachena 2008; Deressa, 2009). With access to credit, farmers are able to purchase agricultural inputs as well as incorporate technologies that require initial capital for instance artificial insemination. Stated that lack of credit impedes famer's ability to adopt new technologies even if the famer is willing to do so. Therefore, access to credit is a very important factor in determining whether a household should adopt climate change mitigation and adaptation technologies.

Farm size

The farm size had a positive significant effect on the adoption of silage pits, crossed breeds for goat and sheep and crossed cattle. The study findings showed that a bigger land size is related to the adoption of crossed cattle and crossed goats which may require a large portion of land compared to other technologies. This is consistent with other studies done that showed the larger the land size the more likely the farmer is to adopt technology. This may be due to the fact that land is a vital source to technologies that require space. Large land sizes allow farmers to diversify their livestock options, apply different climate-smart livestock technologies and also make larger investments (Farad *et al*., 2015, Muraoka *et al*., 2018). Fodder production in most cases requires relatively secured land tenure to ensure that farmers who invest effort in cultivating the fodder species retain the right to exclude others from harvesting it. As obvious as this may sound, it is a major constraint to forage development in many livestock systems and one of the most difficult obstacles to overcome due to communal grazing.

Farm type

Interestingly the type of farm had a mixed effect on the adoption of CSLT. It had positive significant effects on the adoption of fodder production but negative significant on the adoption intensity of the farmers. Poisson results indicated that farm type was inversely and significantly correlated with a number of technologies adopted by a farmer. This suggested that communal are more responsive and quicker to adopt more innovations than large-scale farmers. Idrisa *et al*., (2010) investigated the factors affecting the likelihood of technology adoption among farmers. They reported similar results that showed that farm size negatively affected the adoption of improved technologies. This is in line with a study by Deressa *et al*., (2011) that estimated a negative effect of farm size on climate adaptation.

Household size

In most smallholder farmers family members are the sources of labour for agricultural activities. Hence a bigger family size have opportunities for much more family labour involved in trying out new technologies. The size of the household had a positive significant effect on the adoption of silage pits (0.032) and crossed breeds of goad and sheep. This is consistent with the conclusions from a study by Mudzonga (2012) where, households with large families are able to take up labour intensive adaptive measures than smaller households Poisson's results further indicated a positive correlation between household size and technology adoption. (0,085 P=0.008) For a unit increase in household size, the probability of a household to adopt more technologies that farmers are expected to rise by a factor of 8, 5%. The result shows that a higher number of adults in a household significantly increases the intensity of innovations. A household with a larger size had a higher odd of adopting more technologies. This implies that the bigger the family size the higher the probability of adapting to climate change.

A statistically insignificant relationship was found between adoption of CSLT by farmers and affiliation to association, sex and access to extension services

Table 4- 4: The factors influencing the adoption intensity of farmers (Poisson estimates)

			95% Wald Confidence Interval		Hypothesis Test		
Parameter	B	Std. Error	Lower	Upper	Wald Chi-Square	Sig.	Exp(B)
(Intercept)	-3.669	1.6741	-6.950	-.387	4.802	.028	.026
Sex	.322	.3043	-.274	.918	1.121	.290	1.380
[farm type]	-3.719	1.5048	-6.668	-.769	6.107	.013	.024
[education]	2.753	1.3963	.016	5.490	3.888	.049	15.690
Access to credit	-.006	.7897	-1.553	1.542	.000	.994	.994
Extensions services	.090	.3026	-.503	.683	.089	.765	1.095
Agri serv association	-.330	.3434	-1.003	.343	.925	.336	.719
Age	.001	.0126	-.023	.026	.014	.906	1.001
Hh size	.085	.0320	.023	.148	7.101	.008	1.089
Land size	.005	.0015	.002	.008	10.458	.001	1.005

4.5 Challenges and barriers hindering adoption of CSLT by farmers

Climate-smart agricultural technology adopter smallholder farmers are facing multiple challenges in the study area. The major challenges that prohibited these smallholder farmers from adopting the practices were identified and presented in Table 4.5

Table 4.5: challenges faced by farmers in selecting CSLT

Challenge/Barrier	Frequency
Lack of training in technology	85
Poor access to credit or loans	37
Lack of resources	82
Lack of governmental support(extension)	62
Diseases	100
Land	57
Veld fires	3

The main challenges highlighted were the following lack of training, lack of resources and financial constraints. Smallholders lack access to information and livestock inputs, veterinary services, feeds, and breeds (Dube et al., 2014) Lack of finance was major highlighted as one of the majors limiting the adoption of artificial insemination and uptake of crossed goats and cattle. These technologies require a strong financial background and most of the farmers are communal and which may not be able to afford cross-breeds. Lack of training from both extension officers and implementing partners was one of the challenges noted. Trainings increase farmers knowledge, skills, builds confidence and enhances collaboration among farmers thus help in overcoming barriers to adoption (Zeinu 2019, Ogis and Begho, 2023)

Shortage of extension workers with a ratio of 1: 100 households in a community. Therefore, education on Celt will be low as each extension worker covers a wider area with a bigger workload as they will be involved in disease surveillance and attending to farmers' problems a survey by Motoko et al (2007) has shown that most of the cattle farmers have poor access to veterinary extension services except for contact with the dip attendants during dipping days Fodder production is viewed as for those who are into commercial production and those with bigger pieces of land. During a key informant interview, the extension workers raised concern that most communal farmers had a limited portion of land therefore they will be faced with a tough decision to commit land they were supposed to grow food crops for consumption to grow fodder for livestock consumption. Most households are not food secure therefore a few of them will grow fodder as most will grow food for their households. Furthermore, it was noted that most of the households are poor and most of them cannot afford to buy the fodder seed to grow. In addition, the lack of specific grazing land for a household makes it difficult for a household to grow fodder as most of the grazing lands a community grazing lands owned by the community as a whole therefore it will be difficult to grow fodder crops as well as control them in a no man's land.

Diseases

Table 4- 6: Livestock Challenge of diseases outbreak

Livestock disease challenge	Frequency	Valid Percent
No	33	22.4
Yes	114	77.6
Total	147	100

All the research participants stated an increase in the prevalence of diseases affecting their livestock especially cattle as shown by table 4.6. The farmers stated that they experienced diseases such as Newcastle, January disease and lump skin virus which reduced their herds and flocks. Loss of livestock demotivates to adoption of technologies as diseases tend will wipe out their flocks even if they practice the technologies. Figure 4.4 shows that January disease was the most prevalent disease amongst livestock farmers and it affected mainly cattle.

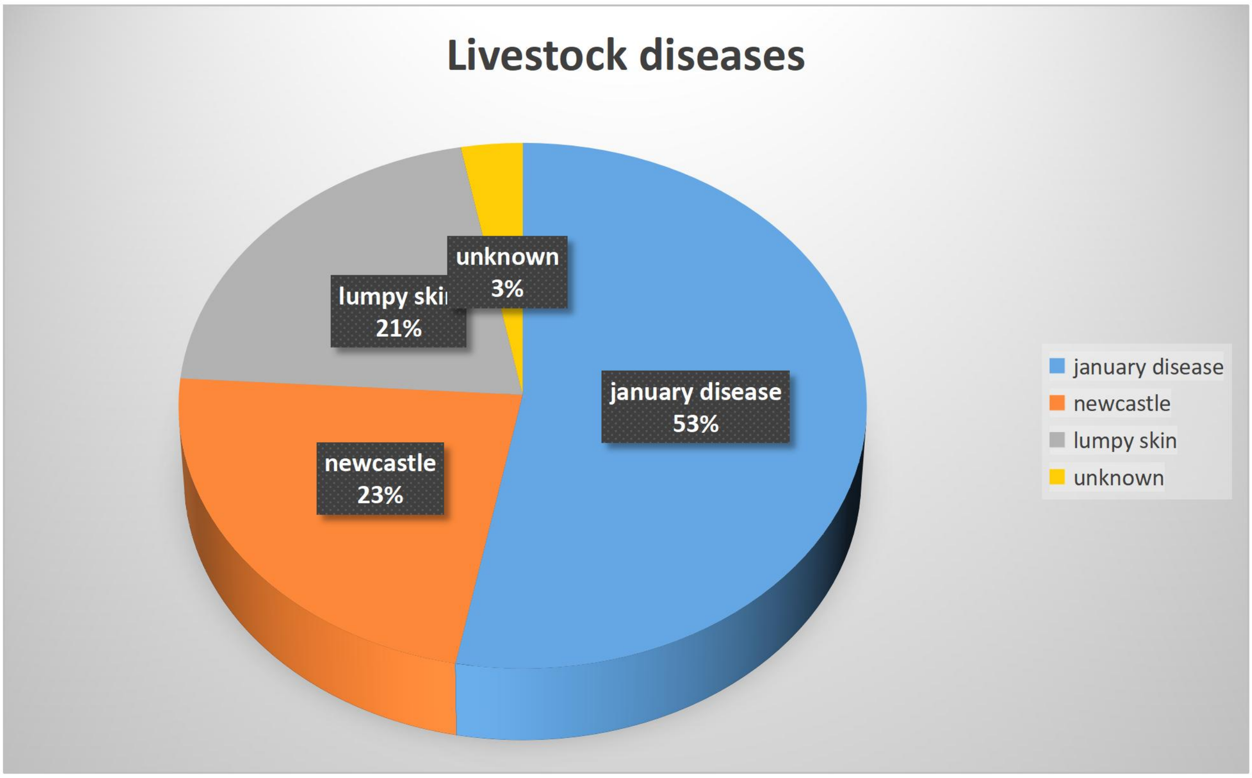

Figure 4- 4: Prevalence of Diseases

Access to credit or loans enhances the financial capacity of a farmer to implement climate-smart agricultural practices According to Malefiya (2017), farmers' access to credit simplifies cash constraints and allows them to purchase agricultural inputs such as improved seed, fertilizer, chemicals, livestock feed and farm equipment. Iftikhar and Mahmood (2017) stated that households that obtained finance from either formal or informal credit sources could fulfil economic obligations. The majority of the respondents had no access to credit or loans. 2.3% indicated to have accessed loans in their production systems.

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CHAPTER 5: CONCLUSIONS AND RECCOMENDATIONS

5.1 Introduction

Based on findings from the study, a summary of the study are highlighted in this chapter as well as recommendations that were derived from the research.

5.2 Recommendations

Accordingly, the following recommendations were made.

Education. To address the problem of low adoption there is need to properly educate the farmers on the advantages the technologies have to offer in terms of their production and livelihoods and demystify that technologies are only meant for commercial production. The education should be provided through a multi-disciplinary and inter sectorial approach where NGOs, community based organizations and farmer organization offer extension services rather than extension services offered by the veterinary officer and Paravets only.

Farmers should be encouraged to incorporate and try these new technologies rather than sticking to the old native ways of livestock rearing which is not sustainable in this era of changing climate.

Improving and strengthening contact with agricultural extension agents, there is need for information to be availed to the farmers and options regarding technologies that they can use to reduce vulnerability to climate change and improve their livelihoods. The research findings showed extension officer to farmer ratio is too high therefore more human capital in terms of extension workers need to be increased so as to reduce work load to the officer as well increase contact between farmer and extension services.

Revamping and capacity building of agriculture extension and research related institutions. Agricultural extension officers are principal stakeholders for engaging farmers and guiding them on approaches to increase productivity, especially during unforeseen events as a result of climate change. Therefore training extension workers to enhance their knowledge and awareness on climate change science, its impacts and adaptation and mitigation strategies and to communicate adaptation and resilience building strategies to the farmers.

There is need to increase direct financial support on smallholder livestock production with a focus on climate adaptation and mitigation. The government need to increase its budget allocation to climate smart technology through incentives and subsidies to enhance adoption

Government and other implementing partners need to work in collaboration in strengthening the existing initiatives to alleviate the identified challenges faced by smallholder farmers in adopting the climate smart livestock production practices. In addition Zimbabwe has excellent polices in place towards mitigating and adapting the climate change but lack of financing is hindering progress. Therefore synergies between government and development practitioners such as NGOs need to be strengthened so that the little resources are utilised to full potential and directed to farmers

Strengthening collaboration within the Ministry of lands agriculture fisheries water and rural development. There should be synergy between crop production officer and veterinary officer in terms of disseminating climate smart information as these officers are all under one arm which is the Ministry of lands agriculture fisheries water and rural development which has the mandate to oversee and champion the adoption of climate smart agriculture technologies. Their synergy and collaboration will enhance knowledge and skills in farmers which will increase probability of adoption as these farmers practice mixed farming where they are both crop and livestock farmers.

Participatory extension approach should be adopted to deliver climate smart agriculture innovations so that they can be more accepted by farmers which will enhance probability of adoption and farmers will be able to select technologies which will be appropriate to their household setup

Government should embark on climate smart education on all sectors of the economy rather than on agriculture only so as to promote behavior change this will enhance adoption of various technologies as well as reduce its carbon footprint.

Further research should be done on the barriers that are hindering the adoption of capital intensive technologies such as artificial insemination which could inform necessary interventions to promote the usage of these technologies

Credit facilities should be availed to smallholder farmers to enable them purchase inputs and implement climate smart technologies

The government should establish livestock insuarance schemes to protect farmers from loses due to diseases and climate related shocks.

5.3 Conclusion

Adoption of climate smart technologies was found to be quite low (5, 2%, n=150). The descriptive statistics showed that the adoption of homemade feed is higher than that of the other technologies. The low levels of adoption shows that majority of the farmers are yet to adopt climate smart practices in Chegutu district. These findings resonated well with several studies (McCarthy *et al.,* 2011; Ogada *et al.,* 2014, Mujeyi et al., 2020) that had shown slow pace of adoption of various climate smart practices particularly in sub-Saharan Africa. This is further supported by study by Uaiene *et al.* (2009) in Mozambique who found that less than (7%) of farmers adopted improved cultivars of Maize, in spite of the efforts the government had put in over a decade.

The results indicated that the demand for climate smart livestock technologies was influenced by education, land size, farm type, household size sex and age had significant effect on adoption.

The study results clearly justify the need for intensifying the delivery of extension services by the Ministry of lands agriculture fisheries water and rural development to promote the adoption of climate smart agriculture. The model results showed that farm type, education household size and land size influenced the intensity of adoption of CSLT technologies. This research implies that encouraging smallholder farmers with training in CSA technologies can significantly boost their adoption. To help smallholder farmers adapt to climate change effective action must be taken to reduce obstacles to the adoption of CSA technology. Policy and practice must also take these adoption factors into account. In addition, the ministry of agriculture and other relevant organizations should work to resolve the problems that hinder the use of climate smart technologies in the study area.

5.4 Area for further research

More research should be done on the impacts of climate smart livestock technologies on the livelihoods of smallholder farmers. In addition this stufy should be conducted in other districts as factors that influence adoption vary with geographical area as well as socioeconocmic factors.

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APPENDIX

HOUSEHOLD QUESTIONAIRE

Vimbai Musaka is a student with the Bindura University of Science Education (BUSE). She is doing a research project entitled "adoption dynamics of climate smart livestock technologies by smallholder farmers". We have randomly selected 150 households from in the district. The information generated in this study will be kept in a secure place and will be used only for the purposes of this research. Answers will be kept confidential, and analysis will not involve individual names. There is no way anyone will be able to identify you

By what you have said in this interview. Thank you for your willingness to participate in this study. You have the right to terminate this interview at any time, and you have the right to refuse to answer any question you might not want to respond to. (If household does not consent to interview, thank them and get replacement from supervisor. If Household consent to interview, proceed with interview).

PART 0: INTERVIEW BACKGROUND

1	Date of interview		6	Respondent name	
2	Enumerator name		7	Respondent Sex **0=male 1= female**	
			8	Respondent Age	
4	Ward number		9	Farmer type **1=communal 2=old resettlement** **3=A1 4=A2** **5=large scale commercial**	
5	Village name				

PART A. HOUSEHOLD DEMOGRAPHIC DATA

A2	Household head Age		A7	Main Principal Economic	

					Activity **0=none 1= farming 2= non-agriculture**	
A4	Number of people in the HH (staying at the homestead in the last three months, include newly married, children in boarding school)			A8	Livestock Experience (years)	
A5	Land holding					
A6	Grazing land owned (acres)					

SECTION B: LIVESTOCK OWNERSHIP

Livestock Ownership

	Livestock	**# owned**		**Livestock**	**# owned**
B1	Cow		B9	Kids	
B2	Bull		B10	Pigs	
B3	Steer		B11	Piglets	
B4	Heifer		B12	Exotic Chicken	
B5	Calves		B13	Indigenous chicken	
B6	Adult goats		B14	Donkeys	
B7	Kids		B15	Draft animals	
B8	Adult sheep				

SECTION C: LIVESTOCK PRODUCTION AND MARKETING

C1. Which livestock do you specifically rear for the market? (Rank according to importance) code……………………………………………………………………………….

For the top three market livestock, indicated the total variable costs incurred by that enterprise during the 2023/124 agriculture season

		Livestock 1		Livestock 2		Livestock 3	
		Amount	Source	Amount	Source	Amount	Source
C1	Livestock (specify)						
C2	Number of livestock						
C3	Fodder						
C4	Bought feed						
C5	Veterinary care						
C6	Crop residues						
C7	Artificial insemination						
C8	Labour						
C9	Transport						
C10	Salt						
C11	Kraal repairs and maintenance						
C12	Others						
	Code Source 1= local agro dealer 2= dealer from town 3 =DVS 99= other (specify) **Livestock Codes** 1 = Cattle 2= Goats 3 = Sheep 4=Donkeys 5=Pigs 6=Broilers 7 =Layers 8= Indigenous Chickens 9= Rabbits 99= Other specify						

C16	Did you get any loans for your livestock value chains during the 2018/19 season? 1= yes 0=no	
C17	If yes how much	$
C18	If yes, Source of loan 1= bank 2= micro finance institutions 3=ISALS 4=relatives, friends and neighbors 99= Others (specify)	
C19	What are the current challenges that you face in production of livestock? **(code)**	
Production challenges: 1=high costs of drugs 2= inadequate grazing 3= diseases outbreak 4= limited technical knowhow 5=water scarcity 6= limited access to extension 99=other (specify)		

	Livestock	
C21	Three main Problem pests according to severity	1. 2. 3
C22	Control measures pests	1. 2. 3
C23	Three main Problem Diseases according to severity	1. 2. 3
C24	Control measures Diseases	1. 2. 3

SECTION D FARMER LIVESTOCK TECHNOLOGY ADOPTION

	Technology	**Have you received training on….? 1=yes 0=no**	Source training **Code**	**Ever used** *1=yes 0=no*	**Still using** *1=yes 0=no*	**Years using**	**Acres 2023/24season**	What do you think needs to be improved on the technology)
D1	Bag silage							
D2	Silage pit							
D3	Fodder - Velvet bean (mucuna)							
D4	Fodder-lablab							
D5	Home-made feed							
D6	Leucaena							
D7	Earth ponds							

	construction							
D8	Crossed breeds for goats/ sheep							
D9	Crossed Cattle							
D10	Artificial Insemination							
	Training Source: 1=government extension 2= NGOs 3=research 4= fellow farmer, friends, neighbour 99= other (specify)							

SECTION E: ACCESS VARIOUS AGRICULTURE SERVICES (Markets, Research, Education & Extension, credit) and SOCIAL CAPITAL

	Value Chain Support Services	**Frequency of interaction in the last 12 months**	**Three main Methods of delivery code**	**Effectiveness of service out of 10**	**Satisfaction levels** 1= Very Dissatisfied 2= Dissatisfied 3= Neutral 4=Satisfied 5=Very Satisfied	**Enterprise covered** **code**
E1	Government Veterinary					
E2	NGO extension					
E3	Private sector extension					
E4	Agriculture Research (MRI, ICRISAT etc.)					
E5	Para vets/Lead farmer					
E6	**Methods of delivery** :1=demonstrations 2=field day 3=tours 4= printed media 5 electronic media including radio and TV 6=cell phone 7 =workshops 8 =shows 99= other (specify) **Enterprise**: 1=maize 2=small grains 3 =legumes 4=livestock 5=horticulture 99=other (specify)					
E7	What are the three main challenges to accessing extension? **1=illiterate 2= not involved/ not invited 3= long**					

	distance to training centre/ venue 4= no time to participate due to overwhelming chores 5= Extension do not reach us 99= other (specify)		
E8			
E9	What is your most preferred extension delivery method (1 only) **1=demonstrations 2=field day 3=tours 4= printed media (e.g. leaflets & manuals) 5= electronic media including radio and TV 6=cell phone 7 =workshops 8 =shows 9=group meetings 10= one on one extension**		
E10	Indicate Distance to the nearest agricultural extension office (km)		
E11	Specify affiliation to farming related associations **1=none 2= ZFU 3=livestock association 4= Zimbabwe Association of Dairy Farmers (ZADF)99= others specify**		

SECTION F: SHOCK EXPOSURE

	Shock	Frequency of occurrence in the last 10 years	Rank severity of shock(1=most important)	Rank 3 Important copping strategies: separate answer by :	% reduction in production of livestock	Which livestock is most susceptible?
	Climate shocks					
F1	Floods					
F2	Drought					
F3	Crop pests and diseases					
F4	Hail storm and Extreme winds					
F5	Livestock diseases					

THANK YOU SO MUCH FOR YOUR TIME!

KEY INFORMANT INERVIEW

1. Are the smallholder farmers aware of climate smart practices for livestock?
2. Do the farmers have knowledge of applying the technologies?
3. Do farmers know the benefits associated with adoption of climate smart technologies?
4. From your experience what are the challenges and barriers that are being faced by framerate adopt climate smart technologies
5. Are the extension officers equipped with knowledge and skills on climate technologies?
6. Do extension officers disseminate information on climate technologies? If yes how and which methods are used to convey the messaging.
7. What other organisations are complementing your efforts in cascading these technologies to small holder farmers.