CONSTRAINTS AND OPPORTUNITIES FOR INCREASED LIVESTOCK PRODUCTION IN THE COMMUNAL AREAS OF LEJWELEPUTSWA DISTRICT, FREE STATE

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DECLARATION

I, Lerato Mary Molieleng, identity number ________ and student number ________ , do hereby declare that this research project submitted to the Central University of Technology, Free State for the degree MASTER OF AGRICULTURE is my own independent work; and complies with the Code of Academic Integrity, as well as other relevant policies, procedures, rules and regulations of the Central University of Technology, Free State; and has not been submitted before to any institution by myself or any other person in fulfilment (or partial fulfilment) of the requirements for the attainment of any qualification.

Signature ____________________ Date 14/11/2022

DEDICATION

This dissertation is dedicated to Abongile my nephew, my mother Anna Molieleng, my sister Relebohile Molieleng, and my whole family. Their unwavering love, support, and encouragement sustained me throughout the course of this study.

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LIST OF ABBREVIATIONS

FAO - Food and Agriculture Organization of the United Nations

USAID - United States Agency for International Development

STATS SA- Statistics South Africa

ARC - Agricultural Research Council

CA - Conservation Agriculture

CCSP - Climate Change Sector Plan

CH_4 - Methane Gas Emissions

CLF - Communal Livestock Farmers

CSA - Climate Smart Agriculture

CT - Conservation Tilling

DAFF - Department of Agriculture Forestry and Fisheries

DARD - Department of Agriculture and Rural Development

DDM - District Development Model.

DoA - Department of Agriculture

ECRMP - Eastern Cape Red Meat Project

FSP: DEDTEA - Free State Province: Department of Economic Development, Tourism, and Environmental Affairs.

GDP- Gross Domestic Product

GHG - Greenhouse Gas emissions

IDP - Integrated Development Plan

IZRDS - Integrated Sustainable Rural Development Strategy

MICCA - Mitigation of Climate Change in Agriculture Program

NDA - National Department of Agriculture

NWGA - National Wool Growers Association

RPO - Read Meat Organisation

THI - Temperature-Humidity Index

WWF - SA -South African Wildlife Foundation

ABSTRACT

The purpose of this study was to investigate the constraints and current status of livestock production in the communal areas in the Lejweleputswa district in the Free State province of South Africa, and to provide possible opportunities to alleviate these problems. The survey was conducted in three (3) municipalities (Tswelopele, Matjhabeng and Masilo) in the communal areas of the Lejweleputswa district. A total of sixty (60) communal livestock farmers from these municipalities were randomly selected as respondents for the study, but only fifty-three (53) questionnaires were selected for statistical analysis because of the reliability of the answers. The findings indicated that all respondents were African farmers, with the majority being between the ages of 50-70 years (57%) and were predominantly males (83%). This shows a lack of participation in livestock farming from the youth and women. The low female participation rate can be attributed to the fact that most women stay at home and perform domestic chores, while others work full-time in other fields of life. Semi-intensive (66%) farming system was the most recorded practice. De-horning (78%), castration (90%), and de-worming (100%) were the most frequently conducted livestock management practices on the farms. Most farm infrastructures (55%) were in reasonably good condition (broken but repairable) and only 20% were in a poor state. This means that farmers in the study areas face limited infrastructural constraints. Access to land is a barrier to communal livestock farming in the study area. The farmers lack title deeds and the financial capacity to lease land or obtain loans. Small grazing land, overstocking, and overgrazing are the primary (17.5%) factors affecting livestock grazing. The results showed that the communal livestock farmers in the study area were facing feed shortages, the majority were able to provide lick supplements to their animals, with salt being the most frequently provided, and the animals relied heavily on the natural veldt. A number of respondents had access to extension services, which invariably had an impact on production. Farm records were not mostly kept (67.9%), and this negated the knowledge of farm profitability for most farmers. It was also concluded that farmers' low educational level may have contributed to record keeping failures. Lumpy skin disease (23.4%), heartwater and bluetongue (12.7%) were the most prevalent livestock diseases in the study area. Pour-ons (87.2%) were used to combat external parasites. The communal livestock farmers practiced the natural method of breeding. Breeding season recorded a significant positive correlation ($r = 0.16$, $p < 0.05$) with farmers' educational levels. Thus, the more educated farmers are, the more likely they are to adhere to breeding seasons. Current technological innovations (96.2%) especially information sharing, up-to-date training (42.3%), lack of animal health service (84.9%) and livestock breeding management (93.3%) were amongst the most prevalent constraints expressed. Communal livestock farmers faced significant challenges in pursuing sustainable and profitable agriculture due to a lack of transportation, low market prices and access to relevant market information. Farmers' poor livestock conditions and high transport costs forced them to sell their animals on the black market. Despite this, some farmers did not market their animals because were either still young, in poor condition, or they were very few. The results of the study support the hypothesis that increased production can be achieved by training and introducing new technologies and advanced agricultural methods to the farmers. The study concludes that communal livestock farmers should receive regular training on relevant topics such as animal nutrition, animal health, breeding and selection, and producing to market specifications in order to obtain higher market prices.

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CHAPTER 1

1.0 GENERAL INTRODUCTION

1.1 Background

South African agriculture is divided into two sectors: the developed commercial sector, comprising of approximately 41 122 commercial farmers and accounts for 86% of agricultural land; and the small-scale communal farming sector, which accounts for the remaining 14% of farmland (NDA, 2005; Stats SA, 2020). Agriculture dominates the landscape in the Free State province, covering an area of 12 9458 million hectares. There are 3.2 million hectares of arable land and around 8.7 million hectares of natural veld and grazing area. The province is home to over 30,000 farms and produces more than 70% of the country's grain (DARD, 2018).

The Free State is known as South Africa's "bread basket," with agriculture covering 90% of its land area. Approximately 57% of the land area is dedicated to livestock farming, such as beef, dairy, and sheep, while 33% is dedicated to crop farming, such as maize, wheat, sorghum, potatoes, groundnuts, and sunflowers. The province produces 45% of the country's sunflower crop, 34% of total maize, 37% of wheat, 53% of sorghum, 33% of potatoes, and 90% of cherries (FSP: DEDTEA, 2014).

Communal livestock farming is an agricultural unit in which livestock farmers or villages work together and run their holdings as joint enterprises, some operating on state-owned lands. Traditionally, the term "communal" referred to a system of livestock management and land tenure in which privately-owned cattle graze together with other herds on communally owned land (Queenan et al., 2020). Communal livestock farming is one of the oldest farming systems and it is still used in many parts of South Africa (Mmbengwa et al., 2015). This system has been linked to increased household food security in poverty-stricken areas of South Africa.

Livestock can be described as domesticated animals especially sheep, goats, cattle, poultry and pigs, which are intentionally reared for food, fibre, manure, raw materials or breeding purposes (Ntshepe, 2011). These animals play a major role in the South African livestock industry (Meissner et al., 2013). Beef cattle account for approximately 80% of the national herd with dairy accounting for 20% (DAFF, 2019). Even though the contribution of sheep farming is modest in monetary terms, the industry is of major importance in the regional context and of strategic importance in the rural parts of the country (Cloete and Olivier, 2010). Likewise, the majority (approximately 63%) of South African goats consist of unimproved indigenous veld goats in the non-commercialized agricultural sector and are kept under small scale conditions (Visser and Koester, 2017).

Cattle are used in *lobola* (payment of bride price) negotiations, in wedding and cultural ceremonies and as a store of wealth. Sheep and goats, on the other hand, are utilized for mohair/wool production, milk production, tombstone unveilings, family gatherings, and ancestral ceremonies. Poultry produces eggs, meat, and feathers, as well as manure. Though livestock production plays a big role in the economy of our country, these animals remain vulnerable to diseases and pest attacks.

Agricultural development is one of the most powerful tools to end severe poverty in communal households, rural communities, and across the country, boosting shared wealth, and feeding a projected population of 9.7 billion people by 2050. (IZRDS, 2004; and Coetzee et al. 2004; World Bank, 2020). However, several bottlenecks militate against agricultural productivity, especially amongst rural communal farmers.

Musemwa et al. (2008) and Mutibvu et al. (2012) stated that the constraints faced by communal farmers include amongst others, poor breeding knowledge, lack of feed, lack of medication and poor management practices. Inadequate knowledge, or lack thereof, exhibited by these communal farmers on techniques and improved farm management practices to tackle these constraints exacerbates the problem. Similar constraints were reported in developing countries like Ethiopia in the Ginchi watershed area, were the most important problem of livestock production perceived by the farmers was feed shortage (100%). Animal feeds are not readily available and where they are they are not easily affordable for an average farmer (Belay et al., 2013). Water is one of the limiting resources for livestock farming in Senegal and determines the mobility of herders in addition to pasture. Lack of transport, infrastructure, cold storage, and processing facilities are among the marketing constraints found in that area (Umutoni et al., 2014). Furthermore, in Nigeria, Endemic animal diseases such as helminthosis, Contagious Bovine Pleuropneumonia (CBPP), brucellosis, mastitis, Peste des Petits Ruminants (PPR), and many others have devastating impacts on the animal industry leading to losses in hundreds of millions of dollars every year (Bamaiyi, 2013).

In South Africa, there is limited reliable information about the performance levels, constraints and opportunities for livestock farmers in communal areas. This makes it difficult to design and implement development programmes that will benefit communal farmers. It is therefore imperative to understand the current status of livestock production in the study area, the constraints faced by these communal farmers and to provide possible opportunities to alleviate their problems.

1.2 Problem statement

The communal farmers in the Lejweleputswa district of the Free State are confounded with numerous constraints, these include animal diseases, lack of marketing opportunities and poor technology adoption amongst others. These constraints expose farmers, their households and communities to a high risk of food insecurity, poverty, and very few livelihood improvement options. Furthermore, it is evident that during disease out-breaks, many communal farmers are left uninformed on what to do to curtail these out-breaks. Likewise, despite the advances in assisted reproductive technologies (ARTs) like artificial insemination (AI), oestrus synchronisation (OS), multiple ovulation embryo transfer (MOET) technology etc. which have been proven to improve livestock efficiency and productivity, these farmers are still unable to obtain and efficiently utilize these technologies. The results of these incidences increase food insecurity which further impoverishes the farmer and ultimately the community at large. Farming needs to be profitable, farmers must have access to domestic supply networks, market signals, local value-adding, and post-harvest storage. This will create jobs and increase income earning capacity, which is essential for ensuring households' food security (Bjornlund et al., 2022).

A deeper understanding of the unique reasons impeding communal livestock farmers' development is critical for developing successful policies, development strategies, programs, and models targeted at supporting and enhancing communal farmers' transition to commercial farmers. At present, there is insufficient reliable information that focuses on the reasons behind communal farmers' low livestock productivity in the Lejweleputswa district, hence this study.

1.3 Motivation

Livestock production is one of the major components of agricultural activity and productivity in South Africa and other developing countries (Herrero et al., 2013). Almost 80% of the 122.3 million hectares of the land surface in South Africa is suitable for raising livestock, particularly cattle, sheep, goats and equines (NDA, 2003; Hajdu et al., 2020). Despite abundant agricultural land, communal livestock farmers are still plagued with constraints to profitable production such as a lack of education, a lack of livestock feed, poor breeding methods, poor animal health management, high cost of medication, and poor management of natural resources, amongst others. Mpinyane and Terblanche (2005) discovered that the rate at which farmers adopt new technologies is directly connected to their degree of knowledge and information-seeking behaviour. It is a well-known fact that the majority of farmers are illiterate, which creates a barrier to technology adoption (Kunene and Fossey, 2006). Therefore, the appropriate use of technology can contribute to the growth and development of the agriculture sector (Ayim et al., 2022).

There is a dearth of studies on the possible causes of low livestock productivity and the opportunities available to promote and assist communal farmers in increasing productivity.

1.4 Scientific contribution

According to the FAO (2012), livestock is a strategic asset for a majority of poor households, worth promoting to address their poverty. This study elucidates the current challenges faced by communal livestock farmers in the study region. The findings will aid in the development of pertinent farmer-focused programs and a strategic framework which when implemented, promises to assist communal farmers to penetrate the national market, get better returns for their products, improve their farming efficiency and ultimately improve the national and household food security. This will facilitate the engineering of global competition to provide profitable and sustainable agriculture.

1.5 Hypotheses

1.5.1 This study hypothesized that:

i. Illiteracy, inadequate market support structures, poor infrastructure, livestock health issues, and low technological input contribute mostly to the low livestock productivity of farmers living in communal areas in the Lejweleputswa district.
ii. Training communal farmers and introducing new technologies and advanced agricultural methods will increase production.

1.6 Aim of the research

This study aimed to investigate the constraints and current status of livestock production in communal areas in the Lejweleputswa district of the Free State province and provide possible opportunities to alleviate these problems.

1.6.1 Objectives

The specific objectives of this study are as follows:

i. To determine the current status of livestock production by communal farmers in the study area;
ii. To assess the role of technology adoption and adaptation in alleviating poor livestock productivity;
iii. To gain insight into the communal farmer’s knowledge and attitudes towards animal health care and breeding programmes;
iv. To assess the marketing strategies available to communal livestock farmers in the study region;
v. To present opportunities that can be utilised by communal livestock farmers to increase productivity; and

vi. To provide recommendations on how communal farmers can overcome their challenges.

1.6.2 Research questions

The following research questions will be addressed in this study:

i. What species of livestock are predominantly reared in the communal farms of the Lejweleputswa district?
ii. What are prevalent management systems practiced by communal farmers in this district?
iii. What challenges do communal farmers encounter with regard to feeding their livestock?
iv. How do communal farmers in the Lejweleputswa district deal with disease outbreaks?
v. Do communal farmers know how to improve the reproductive efficiency of their animals?
vi. Do they understand the interplay of genetics, management system and productivity?
vii. Which market support facilities are available to communal farmers in this district?
viii. Will training, provision of efficient support services and information technology (IT) improve farm activity?

1.7 Limitations to study

I conducted this study using questionnaires and the survey relied on the respondent's subjective reports. Issues relating to language use, truthful answers, biases, insufficient time to fill in the questionnaires, respondents' expectations from the researcher, and distance to farming communities, amongst others were perceived to limit the study objectives.

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CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Overview of animal agriculture

Agriculture is the foundation of developing economies. However, the health of the agricultural sector depends on the sustainability of farming methods. Farming practices must therefore not only protect the long-term productivity of the land but must also ensure profitable yields and the well-being of farmers and farm workers (Goldblatt et al., 2015). In South Africa, there is a need to ensure a healthy agricultural industry that contributes to the country's gross domestic product (GDP), food security, social welfare, job creation and eco-tourism, while adding value to raw materials (Goldblatt et al., 2015).

The term "Animal Agriculture" refers to animal farming, it refers to the breeding, growing, and slaughter of animals for products intended for human consumption, as well as crops used to feed farmed animals (Mishler, 2022). Livestock production in developing countries and in South Africa provides stable food sources, jobs, and opportunities for increased income. Sehlobo (2022) in an article published in Agribiz mentioned that Industry surveys conservatively estimate that black farmers are responsible for 34% of South African commercial beef production, 13% of mohair, and 11% of wool. Furthermore, the estimated calving percentage of beef cattle is 62% in the commercial sector of South Africa, with farmers' average weaning age for calves being 7 to 8 months (Mahlobo, 2016).

The current status of livestock production in developing countries reveals that COVID-19 pandemic had a negative impact on animal production. With production especially evoked by the restrictions on human mobility, leading to a lack of access to animal feed, fuel, vaccinations and shortages in farm labour and subsequently causing unequalled challenges to transportation, processing, retailing and other logistics, and momentous shifts in consumer demand (FAO, 2020). Additionally, Pu and Zhong (2020) mentioned that these restrictions undermined the production capacity of livestock commodities, decreased livestock production cycles and hindered farmers' access to production inputs.

In many parts of South Africa and the world, communal farmers keep cattle, sheep, goats and pigs for multiple purposes. Many people in rural areas depend on these enterprises for milk, meat, asset savings and income (Chimonyo et al., 2006; Moyo et al., 2010). Unfortunately, Devendra et al. (2000) stated that livestock production is declining due to the high prevalence of diseases and parasites. Even though Agricultural Extension Services are offered free of cost by the government to communal and emerging farmers, many farmers in rural communities do not have adequate knowledge about the causes, symptoms of specific diseases and parasites, and available treatment for their livestock (Jaja & Wanga-Ungeviwa, 2022). In a study by Mugwabana et al. (2018), they stated that a lack of proper nutrition and feeding practices, unimproved breeding management strategies and poor marketing structures play an important role in the declining productivity and profitability of these communal farms.

Livestock production in the communal areas of sub-Saharan Africa is constrained by a couple of issues, which include: dry season feed shortages, a decline in forage quality and quantity, susceptibility to pests and diseases due to reduced immunity and other environmental stressors. In 2010, Masikati stated that these constraints constitute the greatest limitation to profitable livestock production in this region. Conversely, cattle and other livestock meet the multiple objectives which are desired by our resource-poor farmers. These objectives include the provision of drought power, manure, cash sales, and socio-economic functions amongst others.

2.2 Constraints experienced by communal livestock farmers

2.2.1 The Effect of climatic conditions on communal areas

The spatial-temporal effects of climate variability and coping mechanisms vary across human communities (Dhliwayo et al., 2022). The extreme temperatures that livestock farmers are experiencing as a result of climate change pose significant challenges to livestock production. When animals are exposed to extreme heat or cold, their physiology is altered in terms of behaviour, chemical imbalance, physical and nutritional difficulties, and metabolic impairments as the body strives to maintain cell integrity for survival (Kadzere, 2018). Agriculture in eastern and southern Africa has to cope with unpredictable seasons, gradual loss of soil fertility, soil degradation, increasing pressures by human and livestock populations, and the restricted resources (cash, labour, and drought) of many farm households (Goldblatt et al., 2010). Ash et al. (2007) are of the opinion that one of the major challenges facing farmers is to make appropriate management decisions in the face of this climate variability.

The vast majority (69%) of South Africa's land surface is suited for grazing, and livestock production is by far the largest agricultural sector in the country (Gbetibouo & Ringler, 2009). Climate change has resulted in low and variable rainfall, droughts, veld fires, and bush encroachment. Rainfall is critical for livestock production; however, the erratic and unpredictable nature of rainfall creates difficulties for communal farmers (McPeak, 2003; Leweri et al., 2021). McPeak (2003) also averred that biophysical and socioeconomic models that incorporate policy considerations affecting rangeland productivity could be used to predict the effects of fluctuations in herd sizes, rainfall, and land tenure

Most of South Africa's grazing land is stocked beyond its long-term carrying capacity, however, overstocking is most evident in the Limpopo, KwaZulu-Natal and the Eastern Cape communal rangelands. This land supports support more than half of South Africa's cattle production (Gbetibouo & Ringler, 2009). This leads to reduced productivity, reduced soil fertility and increased soil erosion.

In 2015, South Africa experienced drought throughout the country. According to the report by Agri SA (2016), the country received below-normal rainfall and this almost depleted natural grazing resources. With limited grazing capacity, farmers have been attempting to keep nucleus herds alive amidst escalating feed prices. This report also mentioned that the Red Meat Producers estimated that over 40 000 cattle had died as a result of the drought in Kwazulu-Natal only. There were also cases of veld fires in the Free State, Limpopo and Northern Cape, Mpumalanga, North West and Western Cape provinces, and significant livestock mortalities were reported in some provinces. In 2015, the MEC of Agriculture in the Free State province launched a drought plan for the province, which included the following:

1. The distribution of fodder in the form of protein-based pallets to all targeted smallholder and subsistence livestock farmers.
2. The provision of infrastructural support from stock water reticulation support to 132 smallholder subsistence farmers.
3. Provision of veterinary medication and feed supplements to all qualified farmers in need.

The models, databases, and monitoring equipment required to make weather forecasts based on climate data are available at the South African Weather Services offices in Bloemfontein. Normally, on farmers' days, South African weather services advise farmers to contact them and inquire about specific forecasts for the areas in which their farms are located (Farmer's weekly article, 2019).

2.2.2 Water and feed constraints

Southern Africa is one of the regions in the world to be confronted with a debilitating water deficit. This is based principally on physical descriptors like climatic conditions and escalating water demands (Mnisi, 2020). Within the region, South Africa stands out as one of the most water-scarce countries (Goldblatt et al., 2010).

The unavailability of water is a common factor in communal areas. In some areas, the available water is poor in quality and cannot support the healthy growth, development and performance of livestock. The water points are sometimes limited and a large number of animals use the same points leading to an easy spread of diseases and accelerated land degradation (Mthi & Nyangiwe., 2018). This harmonizes with the statement made by Lukuyu et al. (2009) who reported that a lack of water results in a reduction in feed intake, imposing a limit on milk yield and growth rate. Since South Africa has no surplus water, all future development will be constrained by this fact. Farmers will double their use of water by 2050 if they are to meet growing food demands (Goldblatt et al., 2010). Also, South Africa will need a better understanding of the elements affecting water management and agricultural growth in order to design more sustainable ways for planning approaches to water management and agricultural development (Nyam et al., 2020). To avoid a water crisis while maintaining current farming methods, the water supply must be increased and water usage efficiency raised.

In most communal grazing areas, the natural veld is the major source of feed for livestock (Mapiye et al., 2009). The problem of feed availability also presents a problem of how much labour is used on a farm. According to Pen et al. (2009), farmers use more labour hours to take livestock to the grazing land which is further away from where they live. This results in farmers using approximately 4.5 hours of labour per day on feeding. Pen et al. (2009) further mentioned that farmers who plant their forage spend on average 2.5 hours of labour per day cutting it and feeding the animals.

During prolonged dry seasons, livestock in communal grazing areas rely on low-quality roughages to meet their nutritional requirements (Becholie et al., 2005). There are different causes to feed problems in all areas of the world. One of the causes mentioned by Mutibvu et al. (2012) is that there is more planted land for agricultural production at the expense of grazing fields, as farmers attempt to meet some of the pressures of urbanization, but this compromises land for grazing.

A questionnaire study that was conducted by Bath et al. (2016) in the Eastern Cape province, stressed that the farming communities that responded to the questionnaire did not perceive nutrition as a major problem, but it was rated very highly by all three technical groups (veterinarians, advisors and extension officers), who understood that malnutrition was most likely an important contributor to most, if not all the disease problems experienced. Similarly, McPeak (2003) also indicated that nutritional inadequacy is a severe seasonal constraint in dry areas, and the most feasible solution to improve livestock productivity in dry areas involves integrated applications of current knowledge rather than new technologies.

Furthermore, Sebina & Duvel (1999), and Katikati & Fourie (2019) concluded that fencing of communal grazing areas and the establishment of ranches can potentially, given the correct management, curb the degradation of natural rangelands. This implies that the adoption of fencing the veld and good management practices is fundamental (Bath et al., 2016).

2.2.3 Breeding and selection

Livestock farms that are not divided into camps are prone to uncontrolled breeding, the easy spread of diseases and undesirable bull-to-cow ratios (Sekwadi et al. 2016). Camps (fencing) in a farming environment are also beneficial because they help in reducing labour expenses. Lack of controlled breeding in smaller areas results in inbreeding, which then causes poor growth and various disabilities in livestock.

The case study that was conducted by Mutibvu et al. (2012) in Simbe, Zimbabwe stated that many communal farmers in that area are aware of and possess some knowledge of the selection of animals for breeding purposes. Some of the farmers indicated that they practised the selection of individual animals like goats, cattle, sheep and chickens to breed. The selection of breeding animals was influenced by the performance of the parents, which shows that farmers are not totally ignorant of the laws of genetic inheritance. Furthermore, Petrus et al. (2011) explained that the use of improved breeds in developing countries presents farmers with a major challenge as they require intensive management for them to realize their full production potential.

According to Musemwa et al. (2008), the use of globally adapted breeds and/or the cross-breeding of more genetically superior animals with indigenous breeds may help in overcoming most of the constraints faced by these communal farmers.

Increasing livestock production in communal areas has always been a difficult challenge despite the benefits of “free land” and “free water”. Because of the setting of many communal areas in South Africa, there are usually no clear guidelines on reproductive management procedures, therefore, different ineffective practices are employed which makes it difficult to combat diseases, overgrazing, inbreeding and other problems (Mashala, 2010). Moreso, indigenous African breeds thrive with minimum input costs, in contrast to imported breeds. They are pivotal in climate-smart livestock production, especially in communal and small-scale farming systems (Kadzere, 2018).

Efficient livestock development practices can be a sustainable way to improve the livelihood of the communal society in terms of food security and a better life for under-resourced farmers.

2.2.4 Diseases

Improving the health of animals can have a substantial impact on the livelihoods of farmers, especially communal farmers who rely on animals for labour, food and additional income (NRC, 2009). The study that was carried out at the University of Limpopo by Mugwabana et al. (2018), reported that most communally reared livestock are challenged by tick-borne diseases such as heartwater and redwater diseases, lumpy skin and other diseases like foot and mouth disease which is caused by a virus. This report is similar to the findings of other authors like Rajput et al. (2006); Mapiye et al. (2009) and Swai et al. (2010), who stated that tick-borne diseases are the main cause of substantial losses in livestock production due to reduced productivity, a decline in fertility and often death. Some diseases that affect sheep, goats and cattle include foot-rot, gastrointestinal parasitism, and hypocalcaemia. Many deaths that are caused by diseases result from a lack of diagnosis, and the unavailability/unaffordability of drugs and treatment programmes (Ndebele et al., 2007).

Furthermore, Katikati and Fourie (2019) mentioned that in their study, many farmers had access to vaccines and medicines but were not informed about their use and therefore, often use them inappropriately or incorrectly. They also recommended that ways to improve veterinary service delivery to communal farmers need to be explored with the help of pharmaceutical companies and other private sector veterinary service providers.

Their findings further revealed that the majority of farmers had no idea when vaccination was required, how often to vaccinate, or which animals to target. Similarly, the drugs used by farmers were frequently incorrect or ineffective. To correct these errors, training and education are required.

In the study that was conducted by Goni et al. (2018), in the Eastern Cape, the results showed that diseases and lack of effective livestock management strategies were the challenges reported to be hindering the development of communal livestock farming by most farmers. This harmonises with the results of a study that was conducted by Bath et al. (2016) also in the Eastern Cape province, which stated that parasites (both internal and external) and malnutrition emerged as important disease categories. In addition, these authors revealed that diseases were a significant constraint in small-ruminant farming, with farmers giving it a ten-out-of-ten rating. Sheep scabs, heartwater, clostridial diseases (especially pulpy kidney), endoparasites, bluetongue, and ectoparasites emerged as the top six diseases or conditions. The farmers additionally identified pasteurellosis, coenurosis and black quarter as among the most important diseases. Veterinarians considered malnutrition to be an important underlying factor for most disease conditions.

A prerequisite for communal farmers to succeed is that herd or flock health must be promoted because animal diseases in the broadest sense if left undiagnosed and unchecked will negate all efforts to improve livestock farming for the communities (Masiko and Mafu, 2004; McCrindle and Webb, 2004; Chimonyo and Dzama, 2009).

In line with the recommendations made by Katikati and Fourie (2019), below are some of the tips from Shane Brody in a *Farmers Weekly* article (2018), stating the important medicinal products that communal farmers need to have in their medicine chests always.

2.2.4.1 Antibiotics

Antibiotics can be used to treat persistent conditions like septic sores and coughing (which may denote a chest condition such as pneumonia). These, unlike white penicillin, do not need to be refrigerated. Farmers should always have an adequate supply of oxytetracycline antibiotics.

2.2.4.2 Dips and doses

Dips should be used during a change of season or at times of high parasitic prevalence. They can be pour-on, sprays or plunge dips. Different types of dips should not be mixed because they might cause harm to the animals. When the seasons change or if tell-tale symptoms appear, broad-spectrum doses should be used. Mucus in the nose, pot bellies, anaemic or pale inner eyelids, or swelling under the mouth area (bottle jaw) can all signify worm infestation. A dose gun makes it much easier to administer medication, therefore it should be used.

2.2.4.3 Antiparasitic injectables

These can be used to treat dangerous tick-borne diseases. Many injectables are also effective against internal parasites.

2.2.4.4 Healing oils and sprays

These should be applied directly to sores or wounds as they help to heal the injury as well as prevent nuisance insects such as flies from pestering the injured animal. Some sprays contain oxytetracycline antibiotics, which also assist in combating secondary infections.

2.2.4.5 Eye powder

This usually contains antibiotics that act against the organisms causing sore eyes. It should be used before infections become severe; severe eye infections can result in permanent blindness if left untreated. The powder should be continuously applied until the infection is healed.

2.2.4.6 Afterbirth pessaries

If an animal has experienced difficulty in birthing (dystocia), pieces of the afterbirth may be left behind, and it can lead to an infection. To prevent this from happening, a pessary is carefully inserted into the birth canal; this will assist in expelling any afterbirth tissue left behind. These pessaries come in small sizes for sheep and goats, and larger sizes for cattle.

2.2.4.7 Vaccinations

All adult animals should be vaccinated at least once a year. Lambs, kids and calves can be vaccinated against prevalent diseases at about six weeks of age (with a booster dose later on). Farmers should try to use vaccines which cover seven of the most prevalent diseases in that geographical region.

2.2.4.8 Other necessities

In addition to medication, farmers should keep the following in their livestock medicine chest:

- Clean measuring containers in which to pour dips and doses.
- Disinfectants, as well as soap, for washing hands before and after treating animals.
- Sterile injection needles and syringes. Needles for both small stock and large livestock should be kept. Using thick cattle needles on young lambs, for example, can cause injury. Livestock medicines can be dangerous to humans or other animals such as pets, so they should always be kept in a safe place.
- Always store vaccines in the refrigerator;
- And never use expired vaccines (Brody, 2018).

2.2.5 Infrastructural constraints

In South Africa, the most prominent infrastructural challenge for communal farmers is transport and holding facilities (Gwala, 2013). Lack of facilities like crush pens, paddocks, dams and high costs of transportation from farms to sale points or abattoirs are some of the struggles experienced by smallholder farmers. In areas where amenities are available, there are either in a poor state (broken) or non-functional due to lack of maintenance. Long distances and poor road networks in communal areas affect the ability of farmers to attract many buyers. This is so, given that livestock is an inflation-free form of banking resource for communal farmers, hence, it can be sold to meet their daily, weekly and monthly expenses like school fees, medical bills and household expenses (Dovie et al., 2006; Simela et al., 2006).

Coetzee et al. (2005) agree with Gwala, (2013) that, the problem of infrastructure in communal areas also includes both the institutional infrastructure (market information, security and animal disease control) and physical infrastructure (communication, transport, and roads). Communal farmers are mostly found in areas remote from market places, where there is a serious lack of the aforementioned facilities (BATAT, 2004; Mthembu, 2008). Remote locations with a poor state of roads result in high costs of moving livestock to markets and hinder marketing efficiency (Mendelsohn, 2006). The results from the study go along with the findings of D'Hease and Kirsten (2003), Makhura et al. (2001) and Pienaar and Traub (2015) who reported that the smallholder farmers have been neglected in terms of infrastructure support, distribution of economic assets, support services, market access, and income by the past government. The effective participation of livestock farmers in markets may be influenced by investments in high-quality infrastructure (Mthembu, 2008).

2.2.6 Marketing constraints

The purpose of marketing in agriculture, according to Rathore et al. (2019), is to enable the transfer of product ownership from producers to consumers while ensuring that farmers or producers make a sufficient profit while conveniently meeting the consumer's needs. Turner and Williams (2002) stated that communal farmers do not keep livestock solely for marketing purposes, but also as a means of storing wealth which is converted into cash during times of need. This makes livestock, particularly cattle, to be the most valued assets in rural communities.

In 2005, South Africa embarked on the Red Meat Development Programme as an initiative to increase the participation of communal farmers in the formal market. This initiative was driven by ComMark as the Eastern Cape Red Meat Project (ECRMP). Despite this great initiative, Fitter et al. (2001), Mahabile et al. (2002) and Kapimbi & Teweldemedhin (2012) pointed out that the main problems encountered with livestock marketing in communal areas are a lack of competition from buyers, lack of marketing facilities like sale pens, lack of understanding and knowledge about prices and market economics, lack of capacity building in binding to the buyers' quality criteria and understanding of the marketing system in general.

Amongst many other marketing constraints faced by communal farmers, Mushendami et al. *(*2008), NDA (2005) and NERPO (2004), supported the above statement by mentioning that low purchasing power of buyers, bad roads, long distances to markets, transport logistics and the high cost of moving livestock to markets have been identified as some of the constraints to livestock marketing by small-scale farmers. Makhura et al. (2001) and Nkhori (2004) noted that even if emerging farmers are in areas with good road linkages, the distance from the formal markets tends to influence transaction costs. As it is a statutory requirement that when purchasing or selling cattle, producers and consumers must have a valid identification certificate and transporting permits (NDA, 2005). Hence, farmers incur extra transport costs to obtain transporting and selling permits from the police station and veterinary offices, respectively. These restrict farmers' participation in distant markets.

Although the lack of buyers is frequently given as a reason why communal livestock farmers are unable to access the market, the fact is that when such buyers do wish to buy from communal livestock farmers, the poor condition of communally raised livestock results in lower prices, especially during dry seasons. This statement is supported by livestock auctioneers and speculators that often raise concerns that they cannot pay competitive prices for animals that are in poor condition or not ready for the market. Nkhori (2004) also indicated that although the poor condition of livestock is important, the age of animals (too old) equally contributes to poor prices when farmers do sell. The poor condition of livestock is also attributable to inadequate grazing and the extreme degradation of natural resources.

Furthermore, the large numbers of cattle kept in villages lead to overstocking and severe overgrazing, especially in winter. This results not only in inadequate feed but also in poorer quality pastures each year. Since supplementary feeding is hardly provided due to the costs involved, insufficient nutrients subsequently result in a high loss of the animal’s body weight (Soun et al., 2006). Despite these problems, some small-scale farmers have managed to produce food for their own consumption and for the market (Ortmann & King, 2006).

Communal farmers need to stop undermining the value of collective action. As a result, they often sell small and varying numbers of livestock individually and directly to the buyers without linking to other market actors (World Bank, 2005; Coetzee et al., 2005). Smallholder farmers lack collective action in markets, and this weakens their bargaining positions and often exposes them to price exploitation by traders.

Marketing should play an important role in the process of transforming small-scale farmers into commercial producers. According to Coetzee et al. (2005), the market is the institution that should provide the necessary incentives for farmers to increase their income. However, according to the study that was done in Cambodia by Pen et al. (2009), farmers do not view marketing as the major constraint to the development of livestock. Farmers ranked marketing as the least important constraint to livestock development.

2.2.7 Market information

The importance of having access to information in the supply chain cannot be over-emphasised. Yuen (2009) reported that information sharing and trust between and among stakeholders is an essential element for any successful supply chain. If the information is available but cannot be shared by the supply chain members, its value degrades exponentially (Kwon & Suh, 2005). By making information available about the prevailing market conditions, type of product in demand, quality, quantity, price and market opportunities will greatly benefit stakeholders in the supply chain to work as a unit and help them to better understand the needs of the end customers and enable them to timely respond to market changes (Coetzee et al., 2004).

2.2.8 Adoption and adaptation to technology

The importance of adopting modern technology in agriculture, especially in a changing climate, cannot be underestimated in Africa. Since 1960, agricultural production has more than doubled as a result of improved farm management and the adoption of modern technology

(NDA, 2010). Kijima et al. (2011) previously concluded that agricultural modernisation enhances production. Janvry and Saudolet (2002) also noted that agricultural technology can contribute to poverty reduction through direct and indirect effects.

Slow and poor adoption of improved agricultural technologies among smallholders often frustrates technology development and promotion efforts in the developing world (Yigezu et al., 2018). Mphinyane and Terblanche (2005), reported that the rate of adoption and adaptation to technology by communal farmers is very low. This is due to the level of education and information-seeking behaviour of these farmers. The high illiteracy level of most of the communal farmers is a stumbling block to the adaptation of new technology (Kunene and Possey, 2006).

Farm size can affect technology adaptation by communal farmers (Lavison 2013). Some technologies are termed 'scale-dependant' because of the great importance of farm size in their adoption (Bonabana-Wabbi 2002). The cost of adopting agricultural technology is a constraint to technology adoption. The adoption process involves an interrelated series of personal, cultural, social and institutional factors. Also, the five stages of awareness, further information and knowledge, evaluation, trial, and adoption are included. Furthermore, characteristics of a particular technology, such as simplicity, visibility of results, usefulness towards meeting an existing need and low capital investment promote its eventual adoption and should be considered when transferring any technology (Bonabana-Wabbi 2002).

2.2.9 Lack of information

Lack of information and training for farmers is a major category of concern that can easily be addressed by a sustained, coordinated programme, based on the training material provided. This was addressed in a full report submitted to the Wellcome Foundation in 2013 by G.F. Bath (unpublished report). This agrees with the results of Fourie et al. (2018) who showed that most respondents suffered from a lack of market information owing to a lack of communication, tools, and support services from the government and extension officers. According to the authors, the majority of the farmers relied on word of mouth, family, and their own research for information regarding product prices, which in most cases was biased, inaccurate, and/or outdated.

Farmers with no access to market information often make poor decisions. Agricultural production methods in particular are dynamic and require farmers to have access to information and be able to interpret information. Poor transfer of knowledge, skills and information is further manifested by limited interaction of the farmers with extension officers because of poor road networks and resources (Coetzee et al., 2005).

Fourie et al. (2018) further made recommendations that the government should host planned workshops for all farmers in order to equip them with knowledge. Some agricultural bodies, such as the Red Meat Producers Organisation (RPO), the National Wool Growers Association (NWGA) and breeders' societies can play a meaningful role in the training of these farmers.

2.2.10 Financial constraints

In 2009, the National Department of Agriculture indicated that agriculture contributes around 6.5% to total export earnings. Farmers in communal areas would also like to make a profit, generate income, increase well-being, and improve food security and sustainability of environmental resources (Masiteng et al., 2003). Zwane (2012) and Zander et al. (2013) mentioned credit financing is another constraint in livestock growth in developing areas. It is difficult for communal farmers to get credit because they rarely meet the requirements and conditions set by financial institutions (Jacobs, 2003). Communal Farmers need financing for purchasing inputs, however, it can be difficult for them to receive such financing due to a lack of access to assets for security.

Access to credit is regarded as one of the key elements in raising agricultural productivity (DBSA, 2005). But in South Africa, Spio (2002) pointed out that financial intermediaries have not been able to accommodate small-scale rural farmers because it is risky, costly and a difficult task associated with high transaction costs. This agrees with the 2005 Development Report which stated that black farmers have no access to credit, no access to financial services, and no access to grants other than those available for land reform beneficiaries by the Land Bank which was charged with the responsibility of supplying the financial services required to develop the smallholder agriculture. Unfortunately, this bank now concentrates on lending to established commercial farmers (DBSA, 2005).

Although the government has made some advances in broadening access to credit, most communal livestock farmers and emerging farmers still do not have access to affordable credit for investment in the technology necessary for expanding and intensifying agricultural production or diversification of production into high-value crops and livestock (Vink, 2003).

2.2.11 Government services

Extension services provide an effective link between agricultural research and farmers in enhancing inputs as well as flows of information that can improve farmers' and other rural people's welfare (Zivkoc, 2009). Interestingly, Veterinarians and Extension Officers are assigned to every district in the agriculture sector where they provide expertise to the farmers in South Africa. Nonetheless, Gwala (2013) reported on the poor quality of work done by the extension services provided by the government in order to help communal farmers. Liebansberg (2015) also stated that eight out of 10 Extension Officers in South Africa are insufficiently qualified to carry out their responsibilities. Despite this challenge, the Extension Officers will remain a major source of information and knowledge for rural farmers.

Peeling and Holdern (2004) pointed out that the failure of the government to provide sufficient veterinary health services contributes a challenge to the productivity of communal farmers, coupled with other constraints like poor housing or structures for livestock, low soil fertility for forage production and weak market chains for livestock and livestock products. According to Jenjezwa and Seethal (2014), there is also a shortage of support staff which reduces the efficiency of service delivery, especially during vaccinations and testing programs which seem to take longer to complete. They further mentioned that the animal health technicians are not able to cater for all the needs of the stock farmers due to these shortages.

An investigation by Belay et al. (2013) in Ethiopia, indicated that a lack of veterinary services has led to farmers using traditional medicines and these were reported to be functioning poorly. But this is not the case in Kenya as Kiptot et al. (2015) also noted that farmers mentioned that they received information about feeding practices from community extension service providers, volunteer farmer trainers, and other service providers. In Kenyan agricultural development, Cuellar et al. (2006) cited that agricultural extension services play a role in enhancing farmer, staff and stakeholder knowledge and skills. They support the establishment of forums and institutions that promote the participation of private service providers in the agricultural sector which promote and strengthen farmer institutions.

The study that was conducted by Fourie et al. (2018) made some meaningful recommendations such as Extension Officers and farmers can be empowered by attending workshops as well as agricultural shows (for example NAMPO); forming group discussions, and attending short courses that are offered by universities. In addition, there is a need for Extension Officers to get information from researchers on veterinary services that can be rendered to communal farmers (Kimaro et al., 2010). This, (Musemwa et al., 2010) opined will improve service delivery and accelerate agricultural development. Also, Alfaro (2004) earlier observed that education from Extension Officers can help rural farmers to change their standard of living and bring sustainable development.

The study conducted by Mugwabana et al. (2018) about the challenges that are experienced in communal areas revealed that some of the limitations faced by farmers include, but are not limited to:

Human interference

- Dispute by stakeholders
- Stock theft

- Delayed government services
- Overstocking
- Lack of services by the state veterinarians
- Inbreeding depression
- Poor livestock management
- Fire outbreaks
- Labour regulations
- Age of animals

Lack of resources

- Inability to supplement animal feeds
- Inadequate infrastructure
- Lack of medication
- Lack of access to market
- Shortage of grazing lands
- Lack of proper breeding practices
- Lack of transportation
- Insufficient government services
- Disproportionate bull-to-cow ratio

Natural causes

- Drought and dry season
- Diseases
- Sores and injuries due to horns and thorns
- Predators
- Global warming
- Dystocia and repeated incidents of abortion

The challenges above are the results from the study that was carried out in the four provinces in South Africa, which included the Free State, KwaZulu-Natal, Limpopo and Mpumalanga provinces. Furthermore, Mugwabana et al. (2018) stated that in the farmer's opinion, it is the responsibility of the government to assist them to overcome these challenges.

2.2.12 Good practices

According to the article published in *Agriculture facts and trends South* Africa, written by Goldblatt et al. (2010), below are some of the good practices for livestock management that may be practised by communal farmers.

- Ensure stocking rates are within the land's carrying capacity, based on the commercial stocking rates for a given area and the present veld condition.
- Monitor and manage veld conditions for optimal productivity with minimal environmental damage.
- Maintain or improve veld condition and the health of the soil by ensuring appropriate rest periods after relevant grazing and/or fire events.
- Prevent overgrazing, trampling and soil erosion.
- Rehabilitate degraded veld.
- Ensure that veld improvement techniques are well understood and well managed to avoid environmental damage and a long-term decrease in productivity.

In the study that was conducted by Masiteng et al. (2003) in the Free State province, the authors revealed that some of the communal farmers' short and long-term needs and aspirations regarding commonage projects vary significantly between the different farming categories. Even though this study was done a long time ago, several studies (Fourie et al., 2018; Gwala, 2013; Zwane, 2012) have shown that these needs are still important and relevant to this date. Listed below is a list of needs that have been noted by communal farmers as reported by Masiteng et al. (2003).

2.2.12.1 Communal farmers' immediate needs or aspirations:

- Government financial assistance: to buy a farm.
- Fencing, access to roads and water points enable expansion and save money.
- Infrastructure development.
- Support services, training and farming knowledge and skills.
- Generate income.
- Herd health programme and training on disease control and management.
- Veld management skills and knowledge.
- Large numbers of livestock.
- Prevention of veld fires.

2.2.12.2 The commonage farmers' future major long-term needs or aspirations:

As reported by Masiteng et al. (2003), some of the major long-term needs of communal farmers are as follows:

- Security of tenure.
- To be developed, known, successful, recognised and organised.
- Improved linkages with other service providers and farmers.

- Own a farm and farm commercially.
- Co-operation among farmers grazing on communal land.
- Improved support services from the Department of Agriculture.
- Farm with quality livestock breeds.

These authors further made the recommendations that farmers on commonage land need an extremely diverse range of training to facilitate the development of managerial and technical skills.

2.2.13 Overcoming challenges: The way forward

Early findings by the Food and Agriculture Organization (2010) stated that farmers need to retrace their steps, assess their management strategies and consider what went wrong. Adoption and adaptation to newer and more efficient methods of production and technology implementation will help communal farmers overcome most of these challenges. Efficient management strategies such as the selection of locally adapted breeds, the use of group marketing, and the availability of information, support services and technology for farmers must be easily accessible and user-friendly for them. During the drought season in 2015, the Department of Agriculture in the Free State made a meaningful contribution to farmers. Moreso, during this time of the COVID-19 pandemic, the Department of Agriculture at the national level, has introduced several relief grants for farmers. According to the researcher, engagement and development of agro-processing facilities and training opportunities for communal farmers in the processing of livestock products and value addition deserve immediate attention. It is assumed that this will assist in alleviating these constraints militating against profitable livestock production experienced by communal farmers.

2.3 Conclusion

Livestock communal farmers are faced with many constraints which include unfavourable climatic conditions, lack of infrastructure, high disease prevalence and poor marketing management. Others include a lack of feed and water, poor breeding practices, lack of financial service, lack of information and low adoption and adaptation to technology, and a shortage of extension and veterinary services. Given the constraints that have been reported, there is still a need for further research to elucidate the opportunities that can be beneficial to communal farmers. With all these mentioned constraints, there is still a need for more current data which will reveal the issue at hand, to be used in order to develop effective farmer development programmes, especially in the research area. Recommendations from the literature review about every discussed constraint need to be taken into account when developing these programmes.

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CHAPTER 3

3.0 RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

The study aimed to investigate the current status of livestock production and constraints faced by communal livestock farmers in the Lejweleputswa district of the Free State province. The research objectives are as follows: To determine the current status of livestock production by communal farmers in the study area; To assess the role of technology adoption and adaptation in alleviating poor livestock productivity; To gain insight into the communal farmer's knowledge and attitudes towards animal health care and breeding programmes; To assess the marketing strategies available to communal livestock farmers in the study region; To present opportunities that can be utilised by communal livestock farmers to increase productivity; and To provide recommendations on how communal farmers can overcome their challenges. Secondly, to look at the available opportunities that can be introduced to assist the communal livestock farmers to increase their production. In this chapter, the study location, sampling of communal areas, structuring of the questionnaire and data analysis will be discussed.

3.2 Study location

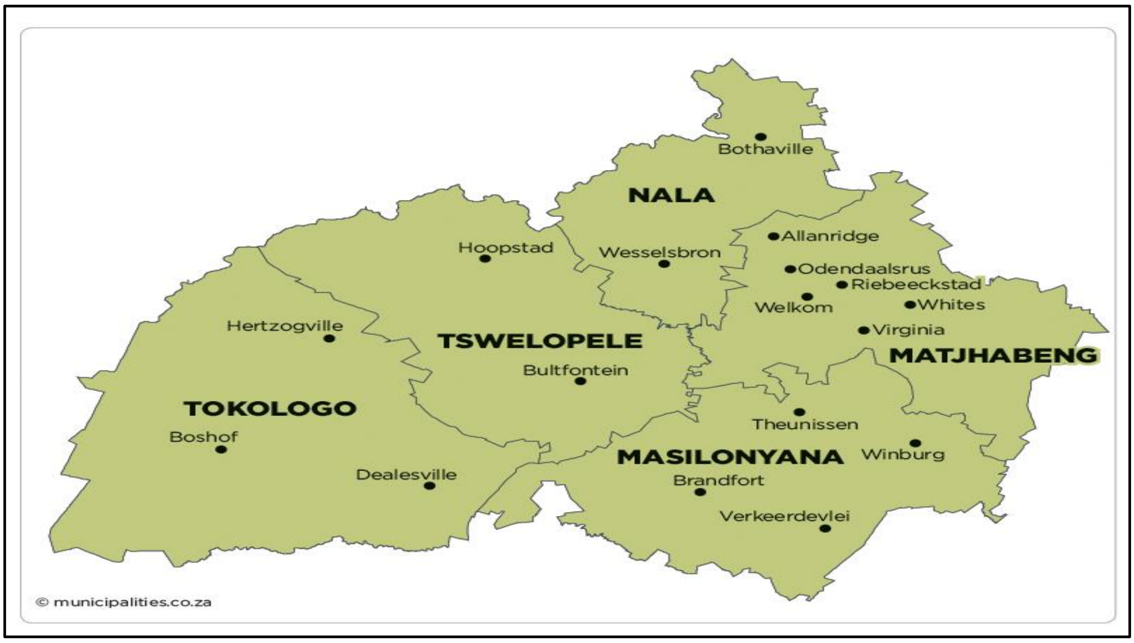

Figure 1: Map of Lejweleputswa district municipality showing the different study locations. Source: Municipalities of South Africa. https://municipalities.co.za/map/108/lejweleputswa-district-municipality

3.3 Description of the study area

The study was conducted in the Lejweleputswa district municipality of the Free State province. This is a category C municipality situated in the north-western part of the Free State province sharing its borders with the Northern Cape, North West and Gauteng provinces. According to the spatial planning for Lejweleputswa, the district has 3 190 855 hectares of land area, which constitutes approximately 26.4% of the total provincial land area of about 12 969 028 hectares (IDP, 2009). As a category C municipality, Lejweleputswa district municipality has jurisdiction over the following five municipalities: Masilonyana, Tokologo, Tswelopele, Matjhabeng, and Nala. The district is commonly referred to as the Free State Goldfields which forms a part of the larger Witwatersrand basin (DDM, 2021). The district contributes to the Free State Gross Domestic Product (GDP) and is also an important agricultural area. The main agricultural produce in the area is maize.

Agriculture and mining are the district's primary industries which have contributed 28.6% of the district's economy (PAM, DDM, 2020). The local municipalities of Tswelopele and Nala contributed 39.9% and 25.7% of the district's total agricultural production respectively. Bloemfontein Karroid Shrubland, Central Free State Grassland, Highveld Alluvial Vegetation, Highveld Salt Pans, Vaal-Vet Sandy Grassland, Western Free State Clay Grassland, and Winburg Grassy Shrubland are some of the vegetation types found in the Lejweleputswa district (DDM, 2020).

The common grass species in the area are *Hyparrhenia hirta, Themada triandra* and *Sporobolus pyramidalis* (IDP, 2012). The average midday temperatures in the area range from 17℃ in June to 29℃ in January. The region is the coolest during July when the temperature drops to 0℃ on average during the night. The area receives an annual rainfall of about 410mm per year, with most rainfall occurring in mid-summer. It receives the lowest rainfall (0mm) in July and the highest rainfall (70mm) in January. This area was chosen for the study because of the prevalent rural practices in the locality and the availability and ease of accessibility of communal livestock farmers.

3.4 Sampling of communal areas

Three (3) municipalities (Matjhabeng, Masilo and Tswelopele) in the Lejweleputswa district were chosen and used for this study. The selection criteria that were used included communal livestock farmers who owned one or more livestock species in the communal areas in the Lejweleputswa district and livestock farmers who were willing to participate in the study. All farmers were recommended by the local extension officers and local farmers. Before the commencement of the interviews, a pilot study was conducted to test the validity and reliability of the questionnaire. A total of 60 communal farmers from these municipalities were randomly selected and used as respondents for the study, but only 53 completed questionnaires were eventually selected for statistical analysis because of the reliability of the answers.

3.5 Survey methods and instruments

3.5.1 Questionnaire design

The study was conducted using a mixed-methods questionnaire approach by administering both open and closed-ended semi-structured design questions to respondents as recommended by Creswell (2003). Ninety communal livestock farmers were previously targeted for this study but due to the COVID-19 lockdown regulations and movement restrictions, only 60 farmers were eventually interviewed. Prior consent was sought from the farmers before the commencement of the study. The interviews were conducted in groups or on a one-on-one basis. The questionnaire was designed to gather data on the communal farmers' management practices, the livestock species that are predominantly reared in the communal areas, the constraints faced by communal farmers, feed practices, sales, information dissemination, farmers' attitude towards animal health care programmes and breeding programmes, amongst other aspects of production. All questions were designed to address the various components of the research objectives.

To facilitate the speedy distribution of the questionnaires to communal livestock farmers within the study areas, the database of the farmers was obtained from the Department of Agriculture and Rural Development in the Lejweleputswa district. The database information included the names of farmers, contact details and the location. The questionnaires were both interviewer-administered and self-administered between the months of August and November 2020.

3.5.2 Analysis of the data

Data was captured, cleaned-up and coded in Microsoft Excel® ver.365 and then exported to the Statistical Package for Social Sciences (SPSS) version 26 (IBM SPSS, 2019) for analysis.

3.5.3 Statistical technique

Descriptive statistics such as frequencies, percentages, mean and standard errors and pictorials like pie-charts and histograms were used to interpret the results and to achieve the study objectives.

3.6 Reference

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CHAPTER 4

4.0 RESULTS AND DISCUSSION

In this chapter, the results of the survey that was carried out on communal livestock farmers in three selected areas: Virginia, Theunissen and Bultfontein in the Lejweleputswa district municipality, Free State are presented sequentially according to the objectives of the study. The aim of this study was to investigate the constraints and current status of communal livestock production in the Lejweleputswa district and provide possible opportunities to alleviate these problems. Some of the characteristics of the sampled households include level of education, household size, size of farm land, herd size and composition, purpose of rearing livestock, livestock sales, information dissemination, marketing strategies, financial management and production challenges. The educational level of communal livestock farmers, a lack of infrastructure, and a lack of financial literacy were the hypothesized constraints of the study.

4.1 The current status of communal livestock production in selected areas in the Lejweleputswa district municipality

The results of this objective are stated below.

4.1.1 Socio-economic characteristics of communal livestock farmers

The respondent's socio-economic characteristics are summarized in Table 4.1. The findings indicated that all respondents were African farmers, with the majority being between the ages of 50-70 years (32%, freq= 17), while a few (11%, freq= 6) were younger than 35 years. This demonstrates a lack of youth participation in livestock farming. This finding corroborated those of Mathivha (2012) who reported that some of the factors impeding youth participation in agriculture may include a lack of access to farm credit, a lack of government support, and a lack of information and communication technologies. The majority of respondents (83%, freq= 44) were male. The low female participation rate can be attributed to the fact that most women stay at home and perform domestic chores, while others work full-time in other fields of life. This result agrees with the submissions of Oni et al. (2010) who stated that farmer participation in the Vhembe region in Limpopo is contingent on the perception that only male members engage in agriculture because most women do not own land.

English language was the most widely (47.1%, freq= 24) spoken language amongst the respondents even though many respondents (39.6%, freq= 21) lacked formal education. Similar findings were observed by Khapayi & Celliers (2016), who discovered that farmers in the Eastern Cape province recorded low levels of formal education, resulting in their inability to interpret market information for use in production planning and marketing. This study further revealed that 11.5% (freq= 6) of respondents had agricultural-related qualifications. Education and training strengthen farmers' capacity and willingness to make successful management changes (Kilpatrick, 2000).

The respondent’s arithmetic ability was surprisingly high (67.9%, freq= 36), indicating that the majority of farmers can comprehend and calculate numbers. This contrasts with the findings of Nwafor (2018) who discovered that the arithmetic ability of smallholder farmers in selected towns in Mangaung municipality in the Free State was generally poor. On the other hand, farmers whose arithmetic ability is poor often indicate the contrary.

With regard to household size, an average of six members per household was observed. This is comparable to the 12 household members reported by Awazi & Tchamba (2018) in the north-west region of Cameroon. These authors also reported that larger households have a higher propensity to adapt in the face of climate variability and change than smaller households.

In this study, the maximum period of farming was 50 years (1.9%, freq= 1), while the minimum period was between 6 months and 5 years (34%, freq= 18). This indicated that a large proportion of respondents were new to the livestock production industry. Perhaps, the latter status could be advantageous considering the submissions of Ainembabazi & Mugisha (2014). These authors investigated the role of farming experience on the ability of smallholder farmers to adopt agricultural technologies in Uganda. They discovered that limited farming experience is beneficial during the early stages of adoption of a given technology because novice farmers are quick to evaluate its potential benefits, which ultimately determines its retention or dis-adoption of the technology over time.

The average size of land in communal areas within the municipality of Lejweleputswa is 402 ha, and the results of this study indicated that the majority of respondents (73.6%, freq= 39) rear their livestock on communal land/commonages. Other farmers (5.7%, freq= 3) farm on their own land or rented land. This is a common practice in livestock farming to obtain additional grazing fields. It is important to note that only one respondent obtained land under the restitution law. Earlier, DARD (2013) reported that communal tenure refers to the systems that most rural African communities operate to express order, ownership, possession and access to regulate the use and transfer of land. It is a kind of land tenure in which a group of people hold land under common laws and administer it in line with shared values and customary norms.

Table 4.1: Demographic characteristics of livestock farmers in Virginia, Theunissen and Bultfontein

Factor	**Variable**	**Response frequency**	**Percentage**	**Total no of respondents**
Ethnic origin	African	53	100	53
	White	-		
	Coloured	-		
	Indian	-		
Gender	Male	44	83	53
	Female	9	17	
Age	21 -30	5	9	53
	31-40	4	8	
	41-50	12	23	
	51-60	17	32	
	61-70	13	24	
	71-80	2	2	
	80+	0	0	
Language proficiency	Sesotho	20	37.7	53
	English, Afrikaans and Sesotho	24	45.3	
	English, Tswana. Afrikaans and Sesotho	9	17.0	
Level of education	Uneducated	15	28.3	53
	Below matric	21	39.6	
	Matric	13	24.5	
	Graduate	1	1.9	
	Post graduate	3	5.7	
	0-5 members	36	67.9	53

Household size	6-10 members	15	28.3	
	>10 members	2	3.8	
Years of farming experience	0-5 years	18	34	53
	6-10 years	16	30	
	11-20 years	6	11.3	
	21-30 years	6	11.3	
	31+ years	7	13.2	
Land ownership	Own land	3	5.7	53
	Municipal/commonage	39	73.6	
	Land affairs land	9	17	
	Restitution	1	1.9	
	Rented land	1	1.9	
Number of years farming in that land	0-5 years	23	43.3	53
	6-10 years	15	28.3	
	11-20 years	10	19	
	21-30 years	5	9.4	
	>31			
Number of farmers farming in that land	5-10 farmers	13	25	53
	11-20 farmers	3	6	
	21-30 farmers	10	19	
	31-40 farmers	5	9	
	41+ farmers	22	41	

4.1.2 Income sources

The findings of this study indicated that 43.3% (freq= 23) of respondents rear livestock to meet their daily living expenses and agreed that it is their primary source of income, while others have additional sources of income and do not rely solely on farming. Income is critical to a business's success and sustainability. Agricultural production currently accounts for 0,3% of South Africa's GDP (fourth quarter 2021) (Stats SA, 2021). Multiple income sources are important strategies for reducing the liquidity constraints and overdependence of smallholder farmers on a single source of income (Dembele et al., 2018). The various income sources of respondents are recorded in Figure 2.

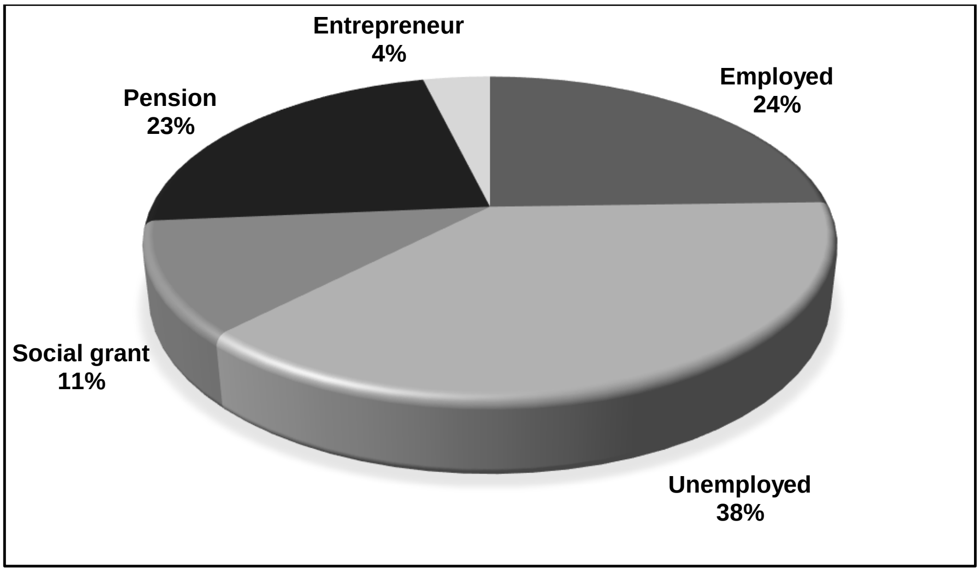

Figure 2: Income sources of communal livestock farmers in Lejweleputswa district

4.1.3 Species of livestock reared and purpose of rearing

Livestock species reared by the respondents are illustrated in Figure 3. It is seen that most (45%, freq= 24) respondents farm with cattle (Bonsmara breed). Respondents justified their rearing of the Bonsmara breed of cattle by citing its adaptability and ability to withstand drought in the study area. These results differ from the findings of (Mthi et al., 2017) who reported that the most dominant livestock species in the communal areas of the Eastern Cape province is sheep (71.8%), with cattle lagging at 7.7%. Also, Goni et al. (2018) observed that the most preferred dairy cattle breeds in the Eastern Cape were Holstein-Friesian and Jersey, with a combined percentage of 40%. Perhaps the disparity in the most reared livestock species in these areas could be as a result of temperature, humidity and environmental differences. According to the Department of Agriculture, Forestry and Fisheries (DAFF, 2017). The beef industry is the second fastest-growing enterprise in the agricultural sector following the broiler industry.

Respondents cited a variety of reasons for raising livestock, which varied according to household requirements. Meeting daily living expenses, business and investment purposes, culture and rituals, etc, were among the mentioned reasons. The purposes for rearing livestock recorded in this study are closely similar to those reported by Goni et al. (2018), who found that most farmers kept livestock to earn income and support their families, while other reasons are for animal traction and household consumption.

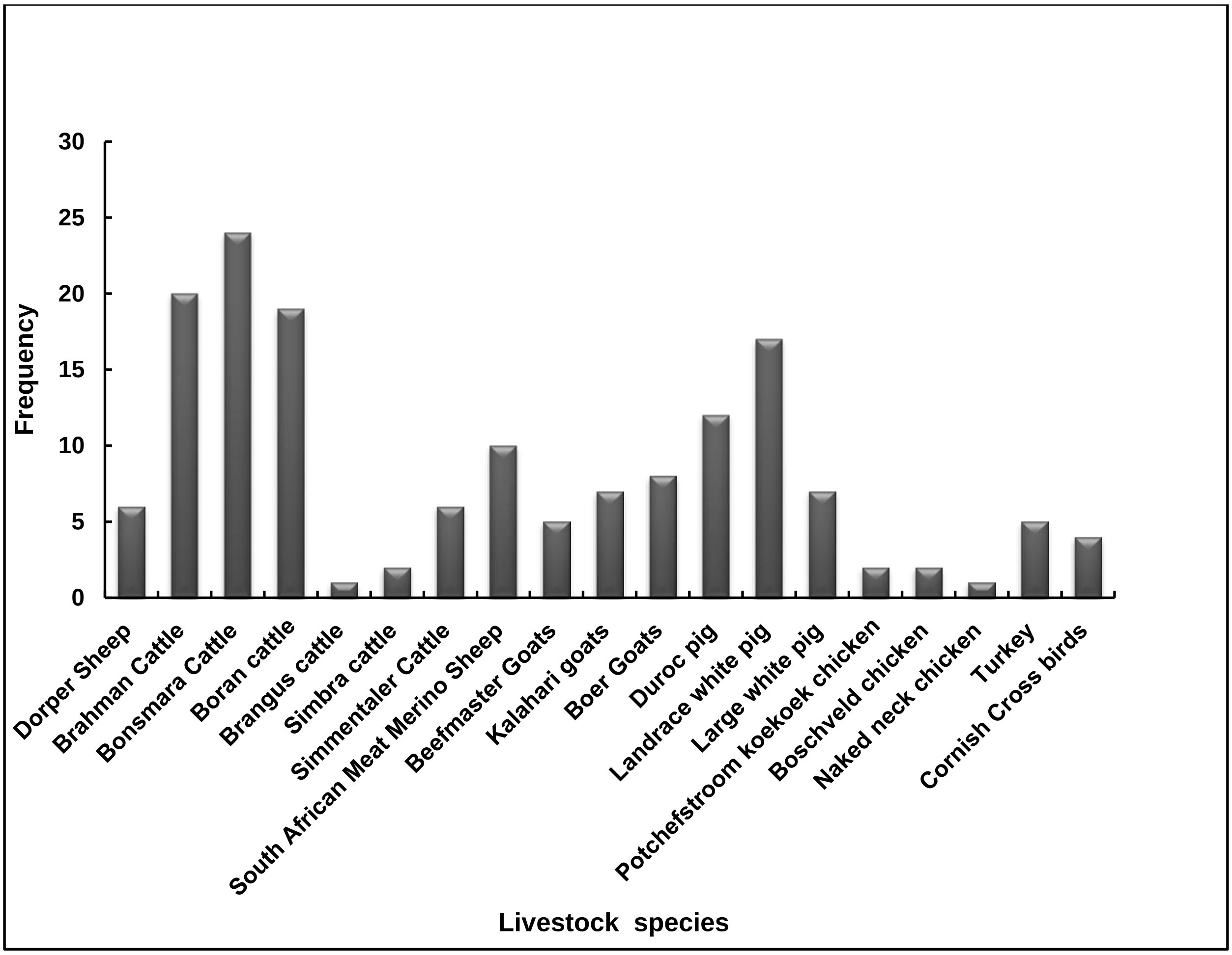

Figure 3: Livestock species farmed by communal farmers in Lejweleputswa district municipality

4.1.4 Government support, infrastructure and farm accessibility

Results in this section showed that 26.4% (freq= 14) of respondents had previously received government assistance in the form of feed and nutritional supplements, while 73.6% (freq= 39) claimed they have never received any form of government subsidy. Also, respondents who obtained government subsidies (78.6%, freq= 11) were assisted by their local Extension Officers, in comparison to those who received assistance from family members (14%, freq= 2). This finding is consistent with that of Muchesa et al. (2019), who reported that poor technology and an under-resourced extension department are two of the factors (p =<0.464) identified by Extension Officers (84%) as contributing to poor extension delivery in the in Mhondoro-Mubaira, Zimbabwe.

Inspection of farms in the study areas revealed that the majority (20%, freq= 10) of respondents used a combination of kraals (livestock enclosures), loading zones, and chutes as the primary equipment in communal areas. Some respondents (94%, freq= 50) reported that their farms lack tool houses and medication rooms. According to Katikati (2017), insufficient facilities were ranked as the primary challenge (80%) faced by emerging cattle farmers in the Eastern Cape province's Amathole and Chris Hani districts. A well-developed infrastructure consists of well-structured farm stead, easily navigable roads, efficient market structures, and well-kept storage facilities.

In Figure 4, the various conditions of infrastructure at farms were depicted at the time of the visit. Most farm infrastructure (55%, freq= 26) was in reasonably good condition (broken but repairable) and only 20.4% (freq= 10) were in a poor state. This means that farmers in the study areas face limited infrastructural constraints. These infrastructures have been built by the government and are well maintained by the farmers. When Musemwa et al. (2007) investigated the factors influencing smallholder farmers' choice of cattle marketing channels, they discovered that the auction pens in Kamastone in the Eastern Cape province were in poor condition and that infrastructure availability and state had a significant effect on the choice of marketing channel ($p < 0.05$).

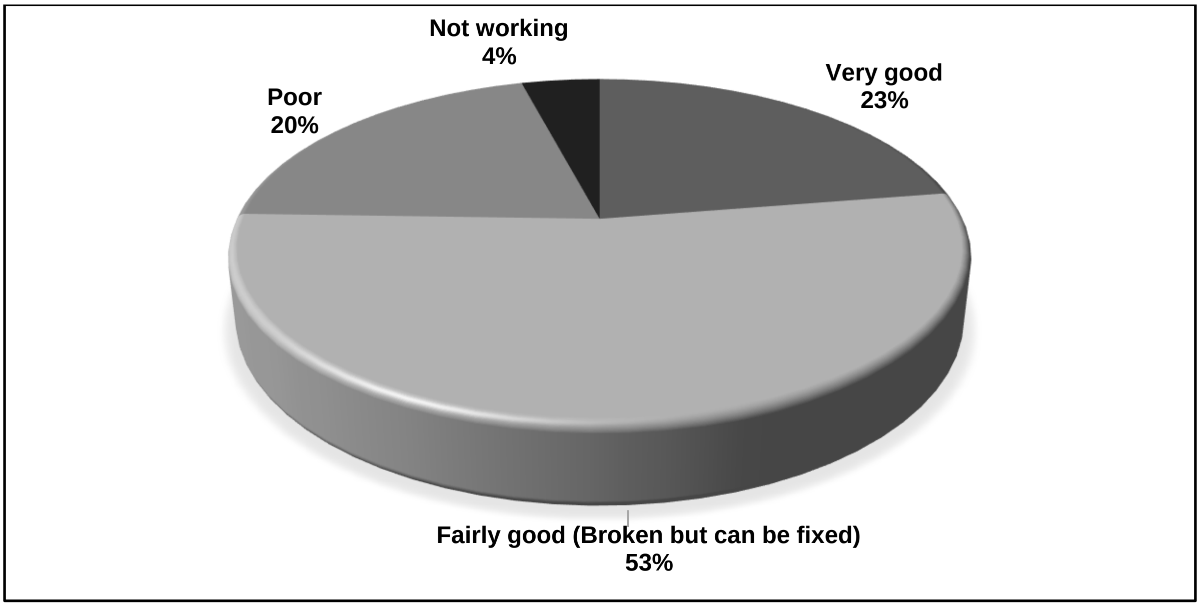

Figure 4: The state of farm infrastructure in the communal areas of the Lejweleputswa district

Additionally, most tools/equipment (80%, freq= 40) found in the sampled areas were owned by the municipality and the Department of Agriculture. According to Manyevere (2014), smallholder farmers in the Tyume River catchment in the Amathole district municipality, Eastern Cape province identified soil degradation and farming equipment as the primary constraints to their livestock production.

In terms of farm accessibility, results showed that the communal farms were mostly (78.8%, freq= 41) located just outside township areas with reasonably good roads. Some roads (19%, freq= 10) were in poor condition and only 2% (freq= 1) were in excellent states. Gravel roads or unpaved road networks, which are typically found in communal areas, play a critical role in sustaining rural livelihoods, particularly in remote rural areas (Nkomo, 2018). Between farms and market stations, livestock is transported through public roads, either on foot or by trucks.

4.1.5 Farm management systems and livestock management practices

In this section, it was observed that the majority (66%, freq= 35) of respondents were involved in semi-intensive farming, compared to 22.6% (freq= 12) in intensive farming and 11.3% (freq= 6) in extensive farming. Similarly, Munzhelele (2015) reported that 75% of farmers raised pigs intensively or semi-intensively. Additionally, 43% (freq= 23) of farmers make use of hired labour on their farms, while the other farmers do not. The low prevalence of hired labour in communal areas corroborated the findings of a study conducted in the Eastern Cape province (Mahanjana & Cronje, 2000). The authors reported that only 19% of respondents in that study area indicated that they hired labour to herd their flocks.

In terms of the type of hired labour, Figure 5 depicts the varieties of labourers. The results of this study are similar to the findings of (Mthi et al., 2017), who reported that family labour was mostly used for animal management and herding, which is usually done by men (65%) and boys (30%).

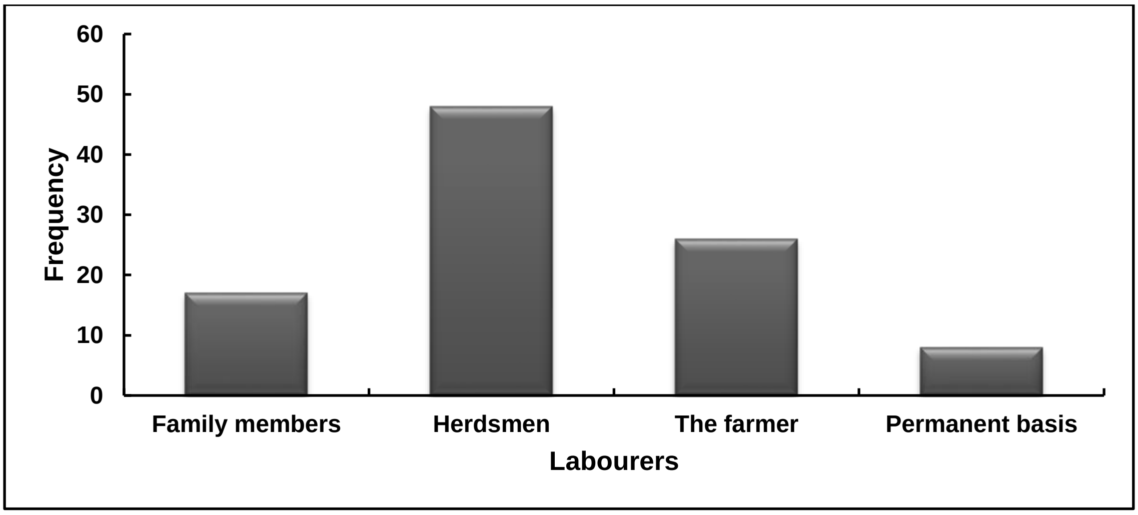

Figure 5: Type of hired labour by communal livestock farmers in the Lejweleputswa district

Additionally, the majority (28%, freq= 7) of labourers possess skills in animal health, while others (16%, freq= 4) have a combination of skills in managing livestock health and welfare, controlling livestock diseases, and assisting in animal birth. Rodriguez and Walters (2017) emphasized the importance of enhancing the employees' technical skills and knowledge through education and training to help the company achieve a variety of objectives, including enhancing morale, a sense of security, employee engagement, and the general abilities required to carry out a certain job.

Table 4.2 summarizes the livestock management activities carried out by communal livestock farmers in the study areas and the seasons during which they were carried out. The study discovered that de-horning (78%, freq= 22), castration (90%, freq= 28), and de-worming (100%, freq= 28) were the most frequently conducted livestock management practices on the farms. Many farmers use castration to enhance the quality of meat produced by livestock species such as pigs, sheep, and cattle (Needham et al., 2017). Additionally, Mäkinen (2013) reported that farmers' managerial thinking and ability to integrate various management activities are related to farm profitability.

In the case of unforeseen circumstances, a lot of respondents (45%, freq= 22) indicated that they are aware of what to do in emergency situations such as fires, bloating, flooding, or injuries. On the other hand, 29% (freq= 14) indicated that they are unsure of the level of information they have to effectively handle emergencies, even though they possess a limited understanding of what to do in an emergency. The Occupational Health and Safety Act (Act No. 85 of 1993) regulates occupational health and safety, even on farms (Greyling, 2018). Therefore, farmers as employers, are responsible for providing and maintaining a safe and healthy working environment for their employees, to the extent that is reasonably possible.

Table 4.2: Livestock management practices performed by communal livestock farmers in the Lejweleputswa district

Management practices	**Percentage of respondents *as per* seasons (%)**					**Total number of respondents**
	Winter	Summer	Spring	Autumn	All year	
De-horning	78.6	-	-	-	21.4	28
Castration	-	6.5	-	3.2	90.3	31
De-worming	-	-	-	-	100	32
Ear-tagging	-	-	-	-	100	40
Branding	58.3	-	-	-	41.7	24
Vaccination	-	2.3	-	-	97.7	44
Treating sick animals	-	-	-	-	100	46

The weaning percentage indicates the ability of young animals to survive from birth to weaning. According to the results of this study, 54.7% (freq= 29) of respondents weaned their animals and the most frequently used method of weaning animals was through the use of a nose clip/ring (69%, freq= 20), followed by the separation of camps and houses (10.3%, freq= 3), and exchange with different herds (6.9%, freq= 2). Other respondents (44.2%, freq= 23) do not wean their animals due to a lack of space and ignorance of the practice of intentional weaning. Additionally, some farmers reported that they previously weaned their calves using nose-flaps (plastic devices that prevent the calf from grabbing a teat to suckle), but discovered that this method is ineffective because the calves still managed to suckle the udder. In the North West province, Sebei et al. (2004) conducted a study to determine the factors affecting the weaning percentages of indigenous goats on communal grazing. Their findings indicated that farmers weaned their kids at approximately five months (150 days). Furthermore, the authors discovered that the primary causes of low weaning percentages were substandard housing, which resulted in winter time cold stress, and a build-up of manure, which is likely to increase parasitic infection amongst herds.

Regarding culling, 53.2% of the respondents (freq= 28) indicated that they did not cull their animals, while 46.2% (freq= 24) indicated otherwise. Lack of productivity due to age (29%, freq= 7) and economic factors (drought, herd reduction, market conditions) (25%, freq= 6) were the most common reasons indicated for culling animals in the study area. In Shiraz, southern Iran, infertility (32.6%) and mastitis (6.5%) were top on the list of culled animals (Ansari-Lari et al., 2012). Additionally, Diniso & Jaja (2021) discovered that the majority (83%) of farm workers agreed that reproduction issues, low milk yield (77.3%), and age (81.1%) were the primary reasons for culling dairy cows. On the other hand, respondents in this study stated that the primary reason for not culling their animals was that they sell the animals at any time (34.6%, freq= 9), while others stated they had few animals (34.6%, freq= 9) and cannot cull any. Following that, 15.4% (freq= 4) of respondents stated that their animals were still young to consider culling. According to Mngomezulu-Dube et al. (2018), the vast majority of farmers in their study area were unaware of the appropriate time to cull aged cows and bulls. Culling livestock does not have to be limited to non-reproductive animals, old age, or culling for economic reasons. Infectious disease epidemics such as classical swine fever, foot-and-mouth disease, and avian influenza continue to wreak havoc on livestock. Controlling such outbreaks is heavily reliant on culling infected animals and animals in close proximity to infected animals or farms (Te Beest et al., 2011).

4.1.6 Farm productivity and profitability

Farm records contain information about the farms' static, temporal, and longitudinal characteristics (Bore et al., 2020). The results of this study showed that 67.9% (freq= 36) of respondents do not keep financial records, primarily due to ignorance, lack of time, and unfamiliarity with the simplest methods for keeping financial records. These are consistent with the report of Tham-Agyekum (2010), who stated that the majority of farmers do not keep all farm records because they believe those records are not beneficial to them. The different types of farm records kept by the other respondents are summarized in Table 4.3.

Similar findings were reported by Tham-Agyekum (2010), who discovered that poultry farmers in Ga-East municipality in Ghana kept different farm records like production and financial records (100% respectively), while 94% of respondents kept records on the health of their poultry birds and 62% of respondents kept labour records, etc. This could be because the majority of poultry farmers require this type of documentation when applying for financial assistance. Additionally, Habiyaremye et al. (2017) found that 92.5% of farmers in the study area do not keep records of cattle sales.

Table 4.3: Farm records kept by communal livestock farmers in the Lejweleputswa district

Record type	Frequency	Percentage
Production record	1	6.3
Financial record	2	12.5
Health record	1	6.3
Equipment purchase record	1	6.3
Livestock purchase and sale record	1	6.3
Production + Livestock purchase and sale + Health + Financial records	1	6.3
Production + Livestock purchase and sale + Parturition + Equipment purchase records	4	25.0
Production records + Livestock purchase and sale + Health + Financial + Parturition + Equipment purchase records	2	12.5

In Table 4.4, descriptive statistics on the number of animals sold by communal livestock farmers in the study area between June 2019 and mid - 2020 are presented. Poultry (500) and cattle (140) recorded the highest numbers, while goats were sold the least (48). In 2013, Sikhweni & Hassan (2014) reported that approximately 53% of farmers surveyed in the Vhembe district in Limpopo province had not sold any cattle in the previous year before the survey. This could be attributed to the relatively small herd size owned by the farmers in the study area.

Table 4.4: Descriptive statistics of animals sold between June 2019 - mid 2020 by communal livestock farmers in the Lejweleputswa district

Livestock	No of animals sold	Min. amount (R)	Max. amount (R)	Mean	Std. Error	Std. Deviation
Number of cattle	41	2	140	16.22	3.974	25.448
Number of sheep	7	2	65	23.00	8.006	21.182
Number of goats	9	2	48	24.00	5.560	16.681
Number of pigs	24	1	75	17.29	3.424	16.776
Number of poultry	6	5	500	112.17	78.997	193.503

No- Number; Min- Minimum; Max- Maximum; R- Rand; Std- Standard.

Results depicted in Figure 6 demonstrated that nearly 28% (freq= 14) of respondents generated profit that ranged from R5 000-R15 000 per year, while most (45%, freq= 23) of the other respondents claimed that they were unaware of their profit margins. However, the respondents provided justifications for their obliviousness which include the inability to keep records, high transportation costs, and distance to the market. In 2013, Wilson (2014) conducted a study in the United Kingdom (UK) and discovered that making a profit was a common objective among farmers in the study area.

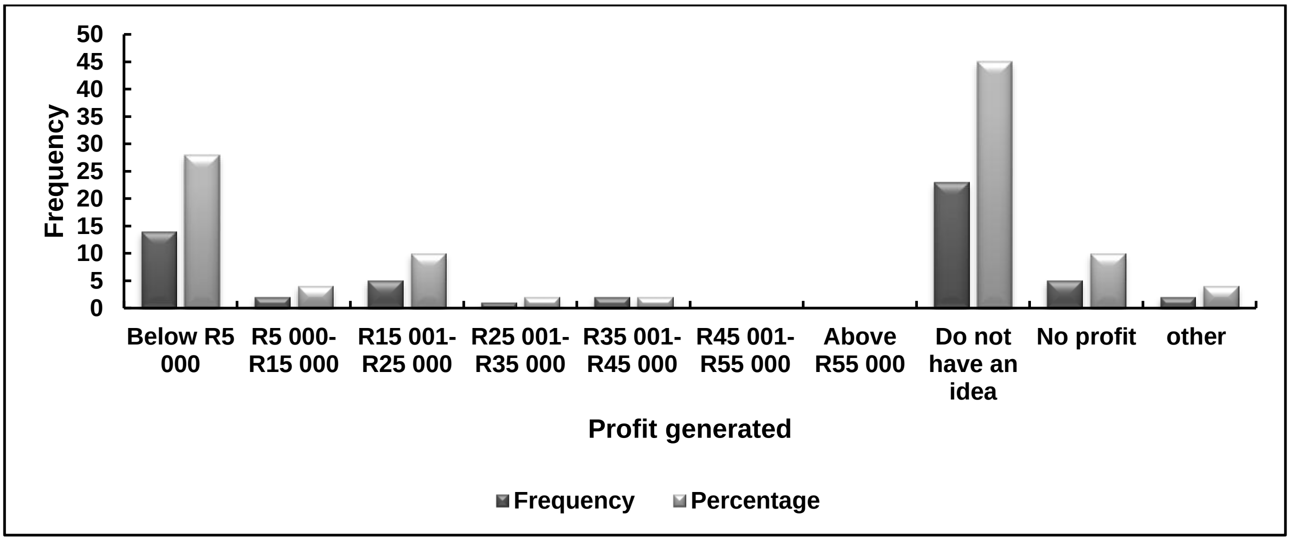

Figure 6: The average profit generated by communal livestock farmers in the district of Lejweleputswa

Table 4.5 summarizes all expenses incurred by respondents between June 2019 and mid-2020. Expenses were made mostly on transportation (n=42), veterinary medicaments and supplements. The findings corroborate those of Habiyaremye et al. (2017) who discovered that 89% of farmers spend a significant amount of money on animal health care, nearly half

(49%) spend money on animal feed, and almost 43% spend a significant amount of money on feed supplements. No money was spent on procuring Assisted Reproductive Technologies (ARTs) because these processes are quite expensive. According to Uys (2018) in the *Farmers Weekly* magazine, the cost of labour, semen, and synchronization hormones is approximately R350/cow/insemination. This may be the main reason why communal farmers in the study areas refrain from purchasing or investing in ARTs.

Table 4.5: Amount of money spent by communal livestock farmers on inputs procurements

Input	No of respondents	Min. amount (R)	Max. amount ®	Sum	Mean	Std. Error	Std. Deviation
Feed supplements	28	100	5000	29900	1067.86	253.079	1339.169
Machinery	3	105	15000	16905	5635.00	4707.996	8154.488
Medications/treatment	34	200	20000	55400	1629.41	627.653	3659.817
Animals	8	2000	42000	119000	14875.00	4311.271	12194.115
Computers	2	7000	15000	22000	11000.00	4000.000	5656.854
Assisted Reproductive Technologies (ARTs)	0	0	0	0	0	0	0
Transport	42	50	10000	84800	2019.05	461.559	2991.246
Miscellaneous	10	300	20000	33300	3330.00	1907.182	6031.040

No- Number; Min- Minimum; Max- Maximum; R- Rand; Std- Standard.

According to Figure 7, stock theft (36.5%, freq= 19) was the leading cause of livestock loss in communal areas of the Lejweleputswa district, followed by disease outbreaks (28.8%, freq= 15). The results differ slightly from those reported by Sikhweni & Hassan (2014), who stated that farmers estimated that 11% of livestock losses occurred as a result of predation, 3% as a result of theft, and 23% as a result of animal diseases.

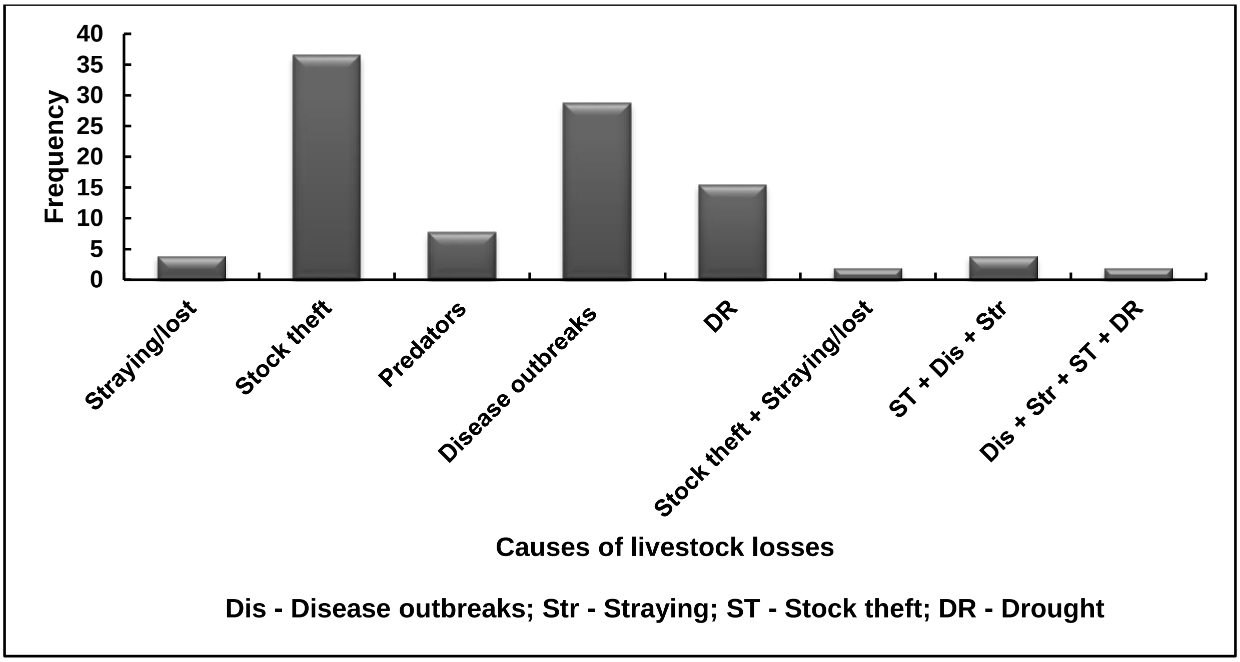

Figure 7: Primary causes of livestock losses in the communal areas of the Lejweleputswa district municipality

Responses from farmers regarding the profitability of their enterprises were recorded. Results showed that more than 45% (freq= 24) of respondents stated that they have no idea whether their operation is profitable or not. On the other hand, 39.6% (freq= 21) indicated that their businesses were profitable, while other respondents reported that their businesses were not profitable. The commonality between farmers that do not make profits and those that have no idea about the profitability of their ventures was mostly a lack of record keeping (59%, freq= 19). Arzeno (2004) stated that maintaining accurate financial records in addition to production data will assist farmers in analyzing the data and making necessary adjustments to operate more efficiently, thereby increasing profitability. Such analysis will assist the farmer in planning for the future by identifying the farm's strengths and weaknesses and allowing the farmer to act accordingly.

4.1.7 Livestock feeding and herd management: water source

As reported by respondents, the communal borehole is the most frequently (44%, freq= 23) used water source for animals in the study area, followed by the dam and river (17%, freq= 9). Similarly, Ngqulana (2017) reported that the majority (97%) of respondents in their study indicated that they use a dam or a river to provide water for their livestock. According to Mutibvu et al. (2012), farmers in Simbe, in the Zimbabwean communal areas relied on a variety of water sources depending on their location, season, and capacity. Rivers (perennial 51%, seasonal 5.8%), dams/ponds (25.5%), and boreholes were all used as water sources (9.8%) in their study. Furthermore, the authors mentioned that in the rainy season, water from dams and rivers became muddy, while seasonal rivers, wells, and some springs dries up as the season progressed. (Hudson, 2002) conducted a study in the Eastern Cape province of South Africa and discovered that livestock on commercial farms utilized an average of 11 boreholes, compared to an average of two boreholes in communal areas. Water is a vital resource that is very necessary for lubricating joints and organs, maintaining blood volume, osmotic balance, regulating osmotic pressure, thermoregulation, and promoting disease resistance in the body of an animal. Water also aids in the excretion of waste products such as urea from cells, not only through the kidneys but also through the lungs and gut (El Mahdy, 2019).

Perceptions from respondents about the water quality in communal areas were recorded. The findings indicated that the majority of respondents defined water quality in terms of the smell, colour, and foreign materials such as animals, plants, and dense growths of blue-green algae found in their water. Sixty percent (freq= 31) of respondents reported that the water quality in the study areas was good-clear.

However, the availability of water in some areas was very limited. In Masilonyana local municipality in the Free State province, 10% (freq= 5) of the communal livestock farmers expressed a different view on the availability of water, reporting that they struggle to provide clean water for their animals and that the only solution is to fetch water from their homes in the township. Water is necessary for survival and it is a critical component of agricultural food production. In 2019, Food and Agricultural Organization reported that the livestock industry already consumes a significant amount of natural resources such as land and water. Hence, a lot of water is being used by both commercial and smallholder livestock farmers for production purposes.

4.1.8 Livestock feeding and herd management: Feed management

The practices of communal livestock farmers in the Lejweleputswa district regarding animal nutrition were summarized in Table 4.6. The table indicates that the majority (40.4%, freq= 21) of respondents fed their livestock on natural pastures, followed by a combination of natural pastures and commercial feed (15.4%, freq= 8). The farmers utilized pastures on commercial land (84.1%, freq= 37), own land (4.5%, freq= 2) and on rented land (4.5%, freq= 2). Many respondents stated that they were compelled to feed their animals on natural pastures located in communal areas due to a lack of funds to rent land with sufficient feed for their animals. Also, 48.8% (freq= 21) of respondents perceived their natural pastures to be in poor, deteriorating conditions with little grass. Respondents believed this condition was caused by the season during which the study was conducted. The type of feed and the area in which the pastures are located is critical in determining whether they are a hindrance to the low animal productivity in the study areas or not. Animal nutrition is the most critical aspect of animal production, encompassing feed type, supplementation, grazing strategy, and nutrition concentration (Katikati, 2017). Inadequate nutrition reduces livestock productivity, resulting in economic losses and losses to livestock farmers.

Furthermore, respondents indicated the practice of different grazing methods like continuous grazing, herding and rotational grazing. Similar findings were reported by Malusi et al. (2021) in the Eastern Cape province where 79.2% of the Nguni beneficiaries practiced continuous grazing, while 52.5% gave feed supplements to their cattle, and watered them using rivers. Since continuous grazing does not provide resting periods to the land and does not allow plant recovery and/ or regrowth, communal farms with continuous grazing are generally depleted of their respective nutrient stocks with depletion increasing as grazing pressure increases (Kotzé et al., 2013). Katikati (2017) observed different results in a situation where rotational grazing is practiced. Rotational grazing is a system that maintains the utilized forage at a relatively young and even growth stage, allowing livestock to consume higher-quality, low-fibre forages (Eagle & Olander, 2012).

Additionally, respondents identified small grazing land, overstocking, and overgrazing as the primary (17.5%, freq= 7) factors affecting livestock grazing, while weed encroachment was the least (5%, freq= 2) significant factor. Mahlobo (2016) concurs with these findings, stating that 52% of livestock were responsible for rangeland degradation mostly through overgrazing. In this study, drought (44%), bush encroachment (10%), stocking density, and an ineffective grazing plan (7%) were also identified as factors contributing to rangeland degradation. Nkonki-Mandleni et al. (2019) discovered similar results in four districts of the Free State province, where 21.6% of farmers interviewed indicated that small grazing land was the most prevalent factor affecting livestock grazing, while 3.6% indicated that weed encroachment was the most influencing factor.

Table 4.6: Feed management practices in the communal areas of the Lejweleputswa district

Factor	Variable	Response frequency	Percentage (%)	Total no of respondents
Feed	Natural pasture	21	40	53
	Pasture + Commercial feed	8	15.4	
	Pasture + Commercial feed + Swill/Kitchen waste	5	9.6	

	Swill/kitchen waste	3	5.8	
	Commercial feed + Swill/Kitchen waste	2	3.8	
	Pasture + Commercial feed + Compounded feed + Swill/Kitchen waste	2	3.8	
	Pasture + Swill/Kitchen waste	2	3.8	
	Pasture + Commercial feed + Compound feed	3	5.8	
	Pasture + Compound feed + Swill/kitchen waste	4	7.7	
Area of pasture	Communal land	37	84.1	45
	Rented land	2	4.5	
	Own land	2	4.5	
	Communal + Rented land	3	3.8	
Present condition of pasture	Good, plenty grass	1	2.3	43
	Fairly good, improving	4	9.3	
	Fair, reasonable amount of grass	12	27.9	
	Deteriorating, poor conditions but some grass	21	48.8	
	Very poor, little grass	4	9.3	
	Good, plenty grass + deteriorating poor conditions	1	2.3	

Grazing Management practiced	Grazing on camps	1	2.3	43
	Continuous grazing	35	81.4	
	Herding	3	7	
	Continuous grazing + Herding	2	4.7	
	Grazing on camps + Continuous grazing	1	2.3	
	Grazing on camps + Rotational grazing	1	2.3	
Factors affecting grazing land	Small grazing land	3	7.5	41
	Weed encroachment	2	5	
	Small grazing land + Over stocking + Overgrazing	7	17.5	
	Overstocking	3	7.5	
	Over grazing	2	5	
	Small grazing land + Weed encroachment + Overstocking + Over grazing +	6	15	
	Overstocking+ Over grazing	8	20	
	Weed encroachment + Veldt fire + Overgrazing	4	10	
	Small grazing land + Weed encroachment + Veldt fire + Overstocking + Over grazing	6	15	

4.1.9 Feed shortage and supplementary feeding

The result of this section is represented in Table 4.7 below. It was observed that the majority (84.9%, freq= 45) of communal livestock farmers in the Lejweleputswa district experienced livestock feed shortages mostly in winter (56.8%, freq= 15). Prolonged drought conditions, increase livestock population and the size of land may possibly be identified as the major driving factors for feed shortages in the study. Mthi et al. (2020) reported similar results on the shortage of feed (20.4%) during the dry season (winter) as the major constraint affecting livestock production in their study area. Earlier, Mtileni et al. (2012) conducted a study to determine the influence of socio-economic factors on production constraints faced by indigenous chicken producers in the rural areas of South Africa and the results revealed that 85% of farmers experience feed shortages. Communal cattle farmers located in Conservation and Transfrontier areas in the northern part of KwaZulu-Natal province, South Africa mentioned that conserving fodder through the provision of silage and hay bales for cattle would make a significant contribution to reducing cattle mortalities during drought periods (Mngomezulu-Dube et al., 2018).

As shown in Table 4.7, 64.2% (freq= 34) of respondents reported having information on the nutritional requirement of their livestock at different growth stages. Many of them mentioned lactation as an important nutritional requirement for calves, piglets, kids, lambs etc. About an average number of respondents (54.7%, freq= 29) were aware of the nutritional status of their livestock and reported that their animals reached the required nutrients on daily basis. Proper animal nutrition is key to profitable and sustainable agriculture. Livestock requires balanced proper nutrition in order to grow, develop, reproduce and develop a strong immunity to fight off infections.

Sixty-nine percent (freq= 37) of respondents in this study indicated that they supplemented their animal diets. Mlambo et al. (2011) observed a similar trend in the communal areas of Zhombe, Zimbabwe, observing that 90% of farmers supplemented their flock with supplementary feed. Phosphate lick and salt were the main nutritional supplement that farmers provided to their livestock. Contrarily. Beyene et al. (2014) recorded different results during their assessment of communal farmers' perceptions of livestock husbandry and rangeland degradation in the highland areas of South Africa. Their results revealed that the common feed supplements used by the farmers in that area were lucerne (10.7%), maize (9.7%), maize stalk (9.7%), pellets (4.5%) and salt (3.2%). Munyai (2012) reported different results and found that in Muduluni village in the Limpopo province, there was almost no supplementary feeding taking place in that area as the farmers cited a lack of funds to buy the supplements. This disparity in results may perhaps be due to vegetational differences in the geographical areas, type of livestock species kept, governmental support to farmers and the ability of farmers to improvise in periods of feed scarcity. Inadequate nutrients result in significant weight loss in animals due to the high cost of supplementary feeding.

Respondents provided reasons for supplementary feeding such as to increase lactation in the animals (18.9%, freq= 7), increase growth rate and fatten animals (8.1%, freq= 3). Earlier reports by Els et al. (1999) observed that licks were used in the eastern communal areas of the Omaheke Region in Namibia, but not in the intended manner; farmers typically provided insufficient licks to their animals. As a result, the animals did not benefit much from the inadequate supplement. On the other hand, Foster et al. (2016) discovered that farmers in Zastron in the Free State province supplemented their cows with a protein and mineral supplement at an average rate of 81.3% (n= 39), chicken litter at an average rate of 8.3% (n = 4), and protein supplement at an average rate of 6.3% (n= 3). The authors also reported that on well-managed veld in the south-eastern Free State, supplementing beef cows with a mineral (60g P/kg) lick during the wet season (summer) and a protein and mineral supplement derived from NPN – Non-Protein Nitrogen (urea) during the winter, achieves the highest economic return.

Table 4.7: Responses of farmers' feed shortage and supplementary feeding

Factor	Variable	Response Frequency	Percentage (%)	Total no of respondents
Feed shortages	Yes	45	84%	52
	No	7	13.5	
Season when feed shortage is most prevalent	Winter	25	56.8	44
	Summer	1	2.3	
	Spring	1	2.3	
	Throughout the year	15	34.1	
	Summer and spring	2	4.5	
Information about nutritional supplements	Yes	34	64.2	53
	No	19	35.8	
Animals obtain their daily nutritional requirements	Yes	29	54.7	53
	No	24	45.3	
Reasons for underfeeding	Little/no vegetation	12	60	53
	Poor quality of feed	7	35	

	Lack of feed (commercial)	1	5.0	
Nutritional supplements	Yes	37	69.8	53
	No	16	30.2	
Types of nutritional supplements provided.	Phosphate lick (ready mix)	2	5.4	37
	Protein/production supplement	2	5.4	
	Phosphate lick (ready mix) and salt	15	40.5	
	Salt	10	27	
	Phosphate lick (ready mix), protein/production supplement and salt	6	16.2	
	Phosphate lick (ready mix), protein/production supplement, home-made licks and salt	2	5.4	
Reason for provision of nutritional supplements	To provide energy	4	10.8	37
	To improve growth rate	2	5.4	
	To fatten the animals	3	8.1	
	To improve lactation	7	18.9	
	To provide energy, improve growth rate, increase fertility and fatten the animals	3	8.1	
	To provide energy, improve growth rate	4	10.8	
	Provide energy and medical need	7	18.9	
	To improve growth rate, increase fertility and medical need	3	8.1	

	To provide energy, improve growth rate, increase fertility, Medical needs, fatten the animals	4	10.8	
Have you experienced drought?	Yes	30	56.6	53
	No	26	30.2	
	Not sure	7	13.2	
Strategies to cope with drought	Lick supplementation	4	13.3	30
	Feeding with crop residues	4	13.3	
	Renting another piece of land	2	6.6	
	Destocking	7	23.3	
	Do not know	3	10	
	Feeding with protein-rich and energy feeds	2	6.6	
	Lick supplementation and feeding crop residues	5	16.6	
	Lick supplementation and feeding with protein-rich and energy feeds	3	10	
Support needed by farmers to cope with drought	Feeds	12	22	53
	Water	12	22.7	
	Supplements	11	20	
	Capital	2	3.7	
	Drought resistant breeds	6	11	
	Farm diversification	11	20.7	
	Other*	1	1.8	

Seed *

Drought can be defined simply as a prolonged and abnormally dry and hot period during which there is insufficient water to meet the community's or ecosystem's normal water needs (Van Loon, 2015). In South Africa, a severe drought was experienced between 2015-2016 with dire consequences in the agricultural sector specifically (Vetter et al., 2020). More than half (56.6%, freq= 30) of the respondents stated that they had previously experienced drought.

The respondents mentioned that drought had a negative effect on their animals, with some losing significant amounts of weight due to lack of feed and scarcity of water. Furthermore, farmers mentioned de-stocking (23.3%, freq= 7) as a strategy which they employ in coping with drought, followed by lick supplementation and feeding crop residues to their livestock (16.6%, freq= 5). Similarly, Bahta (2020) discovered that 64.2% of respondents in their study area survived the 2015–2016 agricultural drought season in South Africa by selling most of their livestock. Contradictory findings were observed in the Eastern Cape province, where 44% of communal farmers use drought-resistant crops/ animal breeds, farm diversification (32%) and irrigation (29%) as a coping strategy (Mdungela et al., 2017). In this study, the respondents' lack of information, farm experience, access to land, and educational level can be attributed to the lack of adopting similar strategies to those observed in the Eastern Cape province. However, the respondents indicated that feed and feed supplements, water and the diversification of farming operations will be a welcome assistance from government and the private sector to help curb the effect of drought.

4.2 Assessment of the role of technology adoption and adaptation in alleviating poor livestock productivity

The results of this objective are stated below.

4.2.1 Use of technological devices in accessing agricultural information

According to the findings of this study, 96.2% of respondents (freq= 51) do not receive agricultural information through a technological device, whereas 3.8% (freq= 2) of farmers claim to receive agricultural information through their technological device/s. Modern technology enables communal livestock farmers to expand their horizons. Science and technological advances have been major drivers of change in livestock farming (El Idrissi et al., 2021).

4.2.2 Sources of agricultural information, accessibility and farmer engagements

Figure 8 illustrates that respondents receive information through a variety of channels, including local Extension Officers (37.3%, freq= 19), radio, television, and cell phone messages from Extension Officers (18.9%, freq= 10). Makaula and Yusuf (2021) discovered contrasting results that smallholder farmers in Umzimvubu local municipality in the Eastern Cape province primarily use mobile phones (23%), radio (25%), television (20%), and the internet (6%) for agricultural purposes. Conversely, Simpson & Calitz (2014) surveyed South African commercial farmers to ascertain the technological apps which they utilized the most. Their results revealed that weather apps were the most popular (69%), followed by banking (61%), productivity-type applications (55%), news (47%), utility-type applications (42%), social media (40%), and financial type applications (28%). Interestingly, gaming (13%) and entertainment-related apps (12%) received little usage, confirming that the farmers' mobile devices are primarily used for business purposes. Furthermore, Hailu et al. (2018) mentioned that radio broadcasts are an extremely effective method of disseminating information to farmers.

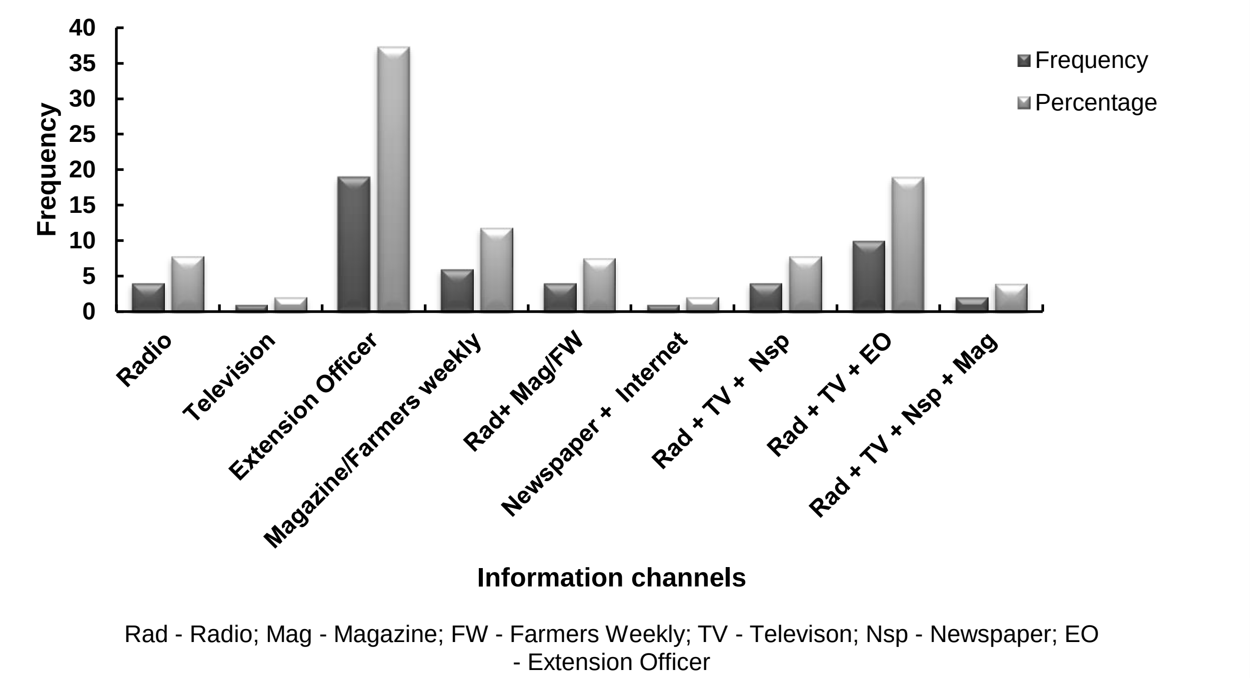

Figure 8: Primary sources of information for communal livestock farmers in the Lejweleputswa district

In terms of information accessibility, respondents indicated that they prefer to obtain information through SMS (19%, freq= 10), followed by additional training opportunities (15.4%, freq= 8), WhatsApp, and agricultural radio programs (11.5%, freq= 6). Nwafor & Nwafor (2020) stated that during disease outbreaks, smallholder farmers in the Free State province frequently relied on sources of information such as peers, veterinary technicians or extension staff from government departments, radio and television programs, and even knowledgeable livestock traders and family members. The authors further observed that radio, television, and smartphones are among some of the ICT-based information sources available to South African smallholder farmers.

Results obtained for farmer engagement showed that 42.3% (freq= 22) of respondents never attended an agricultural workshop, farmers' day, training workshop, or farmer group engagement. Additionally, 34.6% (freq= 18) of farmers reported having attended these events at least once. Only one (1) participant reported attending information days which were sponsored by private companies four (4) times in the past year. Ampaire & Rothschild (2010) discovered that farmers who received additional training and support had fewer pig diseases than farmers who were not trained. Also, farmers who received additional training and support consumed more and sold more livestock.

4.2.3 The status of extension services, farmer information and training access in the communal areas of the Lejweleputswa district

As illustrated in Figure 9, 71.4% (freq= 20) of respondents stated that they had no contact with Extension Officers during the 2020 data collection period. Those respondents who have access to Extension Officers (41.4%, freq= 12) indicated that they are the ones who usually contact them. It was observed that the average distance between Extension Officers and communal farmers in the study area is 8-11 kilometres and it is arguably not too far for such visits to occur once in a while. Agricultural extension contributes to farmer productivity and income growth by assisting farmers in growing their businesses, thereby alleviating poverty and increasing food security.

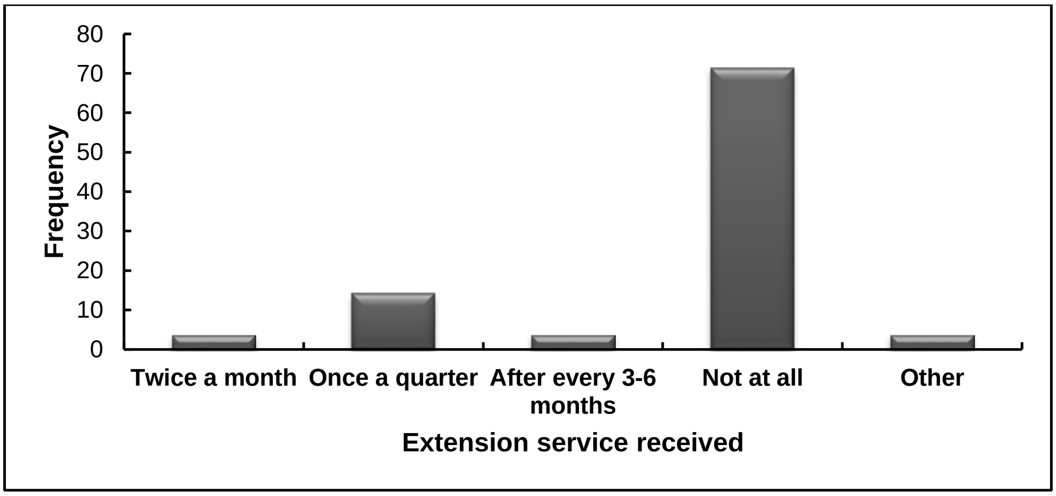

Figure 9: Farmers' access to extension services

Concerning farmer information and training access, results from this study showed that 84.9% (freq= 45) of respondents were having difficulties in getting services and training. Services such as veterinary and extension were not being accessed at the time of this survey. A lack of information and training for farmers is a major concern that can easily be addressed through an organized and efficiently implemented programme.

4.3 Communal farmer's knowledge and attitudes toward animal health care and breeding programs

4.3.1 Animal health and diseases

Various responses from livestock farmers in the study areas based on their livestock health experiences and the professional help available to them were recorded in Table 4.8. The majority (89.4%, freq= 45) of respondents in this study indicated that they do not work with any health professional, while 15% (freq= 7) indicated that they work with private Vets (71.4%, freq= 5) and state Vets (28.5%, freq= 2). In South Africa, veterinary services are divided into two sectors: private and public, with the private sector being relatively larger and more developed than its public counterparts (Gehring et al., 2002). Animal health care services are heavily reliant on state veterinary services for livestock farmers in communal areas. The state veterinary services enable livestock farmers to monitor the health of their livestock and obtain information on animal care (Jenjezwa & Seethal, 2014).

Eighty-three percent (freq= 44) of the respondents claimed that they vaccinated their animals, even though they did not have any vaccination records (92.6%, freq =51) or vaccination plan. The most frequently vaccinated animal according to the respondents is cattle (68.3%, freq =28). A prerequisite for communal farmers to succeed is that herd or flock health must be promoted because animal diseases in the broadest sense will negate all efforts to improve livestock farming for the communities if left undiagnosed and unchecked (Masika & Mafu, 2004; Mapiye et al., 2009).

Most (84.9%, freq= 45) of the respondents reported having difficulty obtaining animal health information or training related to animal health. In contrast, Hertzog, Jenjezwa & Seethal. (2014) discovered that the state played a significant role in animal healthcare and farmer education. However, a shortage of skilled labour hampered effective service delivery. Similar findings may be argued to apply to the services rendered by veterinary/Animal Health Technicians in the Lejweleputswa district, where the workforce is insufficiently skilled, posing a significant constraint on the communal livestock farmers in the area. Mehar et al. (2016) mentioned that exposure to agricultural extension and training programs has a positive influence on choosing appropriate coping mechanisms for farmers in dealing with animal health-related constraints.

Table 4.8: Farmers' responses to livestock health and animal care services

Factor	Variable	Response frequency	Percentage (%)	Total no of respondents
Access to Veterinarian/ AHT	Yes	7	13.2	52
	No	45	84.9	
Communication channel with the Vet/ AHT	Personal visit to the professional	4	57.1	7
	Via calls/SMS	2	28.6	

	Either way	1	14.3	
Time frame for the need of service	After every 3-6 months	5	71.4	7
	When necessary	2	28.9	
Challenges with accessing animals' health care services	Yes	45	84.9	53
	No	8	15.1	
Vaccinations	Yes	44	83	53
	No	9	17	
Up to date Vaccination records	Yes	2	3.8	53
	No	51	96.2	
Type of animal frequently vaccinated	Cattle	28	68.3	41
	Pigs	9	12.2	
	Sheep	2	4.9	
	Goats	0	0	
	Cattle + pigs	1	2.4	
	Cattle + sheep	3	7.3	
Person responsible for treating sick animals	Self	34	64.7	51
	The Vet/ AHT	2	3.9	
	Other farmers/ neighbours	2	3.9	
	State services	2	3.9	
	(Other) farm workers/ Labours	11	21.6	

AHT - Animal Health Technician

In South Africa, several constraints limit communal farmers' ability to increase livestock production. These include many infectious diseases as well as internal and external parasites. In every area, there is a set of common diseases that affect livestock and it is very important to know which diseases are prevalent in the area and which measures are taken by the farmers to curb/eradicate them. Also, this will provide information on the health-related assistance required by communal livestock farmers in the study area. As recorded in Table 4.9, respondents reported lumpy skin disease (23.4%, freq= 11), heartwater and bluetongue (12.7%, freq= 6) and black quarter and lumpy skin (10.6%, freq= 5) as some of the most prevalent livestock diseases in the study area. Similarly, Mugwabana et al. (2018) found that most communally reared livestock are susceptible to tick-borne diseases like heartwater and redwater diseases, lumpy skin, and other diseases such as foot and mouth disease. Furthermore, Habiyaremye et al. (2017) stated that when it comes to the knowledge of livestock diseases, the majority of farmers are familiar with lumpy skin disease, which was cited as the most problematic disease affecting farmers, followed by black quarter and heartwater diseases. At the event of a disease outbreak, some respondents reported that they seek assistance from other farmers (24%, freq= 12), while others contact Extension Officers (22%, freq= 11) in order to mitigate the risks of the outbreak. According to the Animal Diseases Act, 1984 (Act 35 of 1984), controlled and notifiable diseases must be reported to the local State Veterinarian. This Act has not been carried out to the letter according to the respondents, who unfortunately bemoaned the slow response to disease outbreaks by the state veterinary services. Undoubtedly, disease outbreaks in South Africa pose a threat to communal cattle producers who lack access to medicine and disease control infrastructure (Musemwa et al., 2008).

Concerning external parasitism, a large number (87.2%, (freq= 34) of respondents use pour-on antiparasitic medicines to combat external parasites. Others utilize hand sprays, drenching and dosing. The primary threats to communal cattle production in the smallholder production system are livestock diseases, parasitism, and death (Rajput et al., 2006). According to respondents, external parasites were more prevalent in the area than internal parasites. External parasites on livestock are often overlooked until they become a major problem that causes sizeable economic losses (Brody, 2019). These parasites are vectors of diseases with a resultant loss in productivity.

Table 4.9: Common livestock diseases found in communal areas of Lejweleputswa district

Common diseases	Frequency of response	Prevalence (%)
Endoparasites	3	5.6
Sheep Scab mite	4	8.5
Lumpy skin diseases	11	23.4
Blue tongue and black quarter	1	2.1
Pulpy kidney and lumpy skin	2	4.2
Endoparasites and lumpy skin	2	4.2
Ectoparasites and lumpy skin	4	8.5
Black quarter and lumpy skin	5	10.6
Heart water and bluetongue	6	12.7
Foot rot	3	6.3
Heartwater, Bluetongue, black quarter and lumpy skin disease	4	8.5
Heartwater and lumpy skin diseases	2	4.2

Proper administration of medication to animals is critical in order to avoid death caused by misdiagnosis and maladministration. The majority of respondents indicated that they treat their animals and provide any type of medical assistance to them (67%, freq= 34). Katikati & Fourie (2019) stated that many farmers in their study had access to vaccines and medicines but were unaware of their proper use, thus, they frequently used them inappropriately or incorrectly. A possible solution was presented by Simela (2012) who mentioned a community-based animal health worker (CAHW) program as a workable model for providing Primary Animal Health Care (PAHC) services at the grassroots level.

4.3.2 Biosecurity and mobile clinics

Biosecurity refers to the measures taken to prevent diseases from entering populations, herds, or groups of animals where they do not currently exist, or to limit disease spread within the herd (Oladele et al., 2013). According to the current study findings, 81% (freq= 43) of respondents claimed they practice bio-security on their farms/communal lands, while 19.8% (freq= 10) of respondents reported not following any biosecurity measures. The latter group blamed it on the setting of the commonages, stating that they see no reason to follow any measures if their neighbours do not. The respondents who reported following bio-security measures cited dipping and deworming (24%, freq= 9) as the primary measures they use to avoid exposing their animals to diseases, particularly because their land is shared by multiple farmers. Additionally, they stated that they chose these methods due to their affordability and inability to install boundary fences. Rodent control, cleaning and disinfecting and isolation of sick animals were practiced by very few (2.4%, freq=1) respondents. According to Fasina et al. (2012), bio-security implementation can withstand changes in input costs, such as moderate feed price increases, increased management costs, and marginal output reductions. With respect to the provision of mobile clinics to enable prompt attention to infected animals, 100% (freq= 53) of respondents enthusiastically embraced the idea and agreed that it was the best solution to their animal health problems. Many of them added that this will assist them in administering medication to the animals in the proper manner and will also provide information about early symptoms of diseases and prevention methods for common diseases based on the season of prevalence.

4.3.3 Breeding management

Communal livestock farmers need to take into account that the choice of the animal breed must be compatible with the climate and farming strategy. In this study, 34% (freq= 18) of respondents stated that they raised a variety of livestock breeds on their farms. Other farmers 66% (freq= 35) reported that they do not introduce new breeds to their herd. There was an interesting debate between these two groups of respondents; the former group introduced other breeds into their herds because of the advantages of crossbreeding like better tolerance to heat, drought and diseases. The other respondents indicated that their flock mixes freely with other animals of different breeds and from other farms due to the communal settings of their farm lands. This invariably results in unplanned crossbreeding outcomes. Additionally, Mngomezulu-Dube et al. (2018) discovered that farmers in the KwaZulu Natal province continuously breed specific cows and bulls until they die of disease.

The improvement of feed efficiency and herd size/integrity was the primary reason (47.1%, freq= 8) for crossbreeding. Lehloenya et al. (2007) reported similar findings amongst livestock farmers in Bloemfontein, South Africa, where large numbers of breeding cows and heifers are retained by their owners and crossbred with specific breeds of cattle primarily to increase herd size. Laske et al. (2012) emphasized the importance of developing a model for economic traits that can guide the selection decisions of smallholders. Breeding objectives such as weaning rate, weaning weight, and cow weight can be incorporated into this model. This model will be used to guide their choice of animals and in the acquisition of bulls which will ultimately increase the productivity of their herds.

4.3.4 Breeding seasons

In this study, 7.7% (freq= 4) of respondents follow a breeding season, while the majority of respondents (92.3%, freq= 43) do not. Small land size (51%, freq= 24) and a lack of knowledge on how to implement the practice in their herds (31%, freq= 15) were cited as primary reasons for not following specific breeding seasons. Nthakheni (2006) also discovered that mating in Vhembe, in the Limpopo province was not regulated and occurred throughout the year, with the peak calving occurring in the summer. Furthermore, Kunene & Fossey (2006) reported similar findings in KwaZulu Natal, like the absence of a breeding season or breeding system in the study area. Other authors like Mthi et al. (2020) expressed similar sentiments in the Eastern Cape province, where farmers were not adhering to any breeding practices due to the absence of boundary fences on communal grazing lands. The respondents who reported that they adhere to a breeding season in this study indicated that they do so on a 60-90-day cycle. They stated that they have installed fences to aid in the maintenance of this system.

A lesson can be learned from Angora goat farmers in the Eastern Cape province, where evidence of controlled breeding resulted in increased flock size and low levels of crossbreeding with indigenous veld goats (Bester et al., 2009). Additionally, Tavirimirwa et al. (2013) advocated for the use of modern technologies in communal areas, such as micro-satellites, to characterize cattle based on their genetic diversity rather than their geographic origin, as these animals may be genetically similar. The authors provided a piece of sound advice, but it may not apply to communal livestock farmers in this study because the vast majority of them lack the financial means to install fences, let alone install micro-satellites. Furthermore, communal livestock farmers are financially constrained in so many ways and these prevent them from adopting and implementing modern technologies in livestock farming.

Concerning the method of breeding, all respondents in this study bred their animals naturally without human intervention. The respondents indicated that the natural method of breeding was practiced because it is economical and did not require specialized equipment or labour. Additionally, they stated that they do not use assisted reproductive technologies because they are prohibitively expensive. Nengovhela et al. (2021) discovered that the majority of handling facilities in Limpopo, Mpumalanga, and KwaZulu-Natal provinces were in poor condition, and communal farmers cited a lack of adequate infrastructure as a major constraint on development initiatives such as the implementation of reproductive technologies in farming communities. Similarly, Mthi et al. (2020) found that all respondents in the Eastern Cape province engaged in uncontrolled breeding due to a lack of infrastructure. Poor breeding management contributes to low reproductive rates in communal areas, and farmers must receive additional training on animal-related topics to broaden their knowledge. Additionally, there is a need to increase access to affordable livestock breeding services by recruiting and training additional artificial insemination providers (Mutenje et al., 2020).

Following the breeding season schedules is a very important management strategy to optimize the reproductive performance of a breeding herd and the pre-wean growth rate of calves

(Bergh, 2004). This, in turn, can profoundly influence the profit margin of a beef cattle enterprise.

4.3.5 Breed preference and selection

Breed availability (24.5%, freq= 13), advice from other (neighbouring) farmers (13.2%, freq= 7), advice from the Department of Agriculture (9.4%, freq= 5) and the affordability of breed (9.4%, freq= 5) were topmost on the list for breed preference reasons. Interestingly, Scholtz et al., (2008) discovered that the performance of the animal was three times more important than any other trait in determining the choice of bull for breeding purposes in some parts of South Africa's commercial sector, whereas, the size of the bull was the most important factor in the communal sector.

Furthermore, 83.3% (freq= 10) of respondents obtained their breeding animals from other farmers. The Extension Officer in the study area stated that they do not recommend this type of market to farmers because respondents frequently purchase poor-performing animals that were intended to be slaughtered by their previous owners at a cheaper price. These types of animals are usually expensive to manage and may cost the farmer more to maintain. On the contrary, one respondent believed that a lower-priced animal can still possess a number of beneficial characteristics that will aid in the development of the herd in the direction that the farmer desires in terms of increased production.

Regarding the selection of animals for breeding, this study found that most respondents (54.7%, freq= 29) practiced selection. These majority selected their animals based on age (69%, freq= 20), phenotype (10%, freq= 3) and weight (13.7%, freq= 4). The findings of this study exposed some inconsistencies in the respondents' responses because some believed that “selection” was basically for sale and not for breeding purposes. This perplexing situation can be attributed to some respondents' lack of knowledge about breeding management skills. Mapiye et al. (2018) found similar results in their study which reported that farmers in Limpopo faced significant breeding challenges, including a lack of breeding management skills (29%).

4.4 Assessment of marketing strategies available to communal livestock farmers in the Lejweleputswa district municipality

4.4.1 Market outlets and productivity

The marketing channel begins with the farmers who produce live animals and continues with the intervention of numerous agents to establish the chain of the sale process. Some (34.6%, freq= 18) respondents in this study sell their livestock on the black market (informal market). The majority of farmers prefer this market channel because it reduces transportation and transaction costs. Similar findings were made by Ngqulana (2017) and Mafukata (2015) who discovered that most smallholder farmers (44% and 54.6% respectively), sell their livestock in informal markets. Mzyece (2021) concurred by stating that in remote areas, middlemen serve as a link between farmers and consumers which then reduces the transportation costs that would have been incurred by the farmer. Interventions that can ensure farmers' profitable and sustainable market participation should prioritize connecting farmers to final consumer markets. Mzyece (2021) further stated that the type of buyer to whom a farmer sells his or her produce can affect the farm's profitability. Selling to aggregators (wholesale intermediaries) was significantly less profitable than selling directly to end users. Musemwa et al. (2008) conducted an analysis of the cattle marketing channels used by smallholder farmers in the Eastern Cape province and found that transactional costs had a significant effect ($p < 0.05$) on the marketing channel chosen by cattle farmers. Farmers faced transaction costs (TC) primarily as a result of transportation costs, information costs, payment speed, and enforcement costs. Other market outlets indicated by respondents include auction (32.7%, freq= 17), butcheries (11.5%, freq= 6) and on-farm sales (1.9%, freq= 1).

Concerning the factors that influence the sale of animals, unproductivity, urgent need for money, culled animals, and ceremonial requirements were amongst the top reasons for selling. However, the majority (35.3%, freq= 18) of respondents lacked a specific reason for selling their animals; they sold whenever they wanted. Different results were recorded by Kunene & Fossey (2006) who submitted that 79% of farmers sold livestock to meet cash needs such as school fees or other household expenses in the KwaZulu Natal province, and it contributed 20.2% to the farmers' total income.

Marketing should play a vital role in the process of transforming communal livestock farmers into commercial producers (Coetzee et al., 2005). Marketing enables livestock farmers to generate revenue and contribute to poverty reduction efforts. Ndoro et al. (2015) observed that access to agricultural markets represents a significant opportunity for rural development in developing and transitioning countries. Knowledge and understanding of livestock and meat prices, seasonal price fluctuations and movements and areas of high and low demand are crucial in livestock marketing and are key aspects of the marketing information needs of the smallholder farming community (Ntshephe, 2012). Earlier, Coetzee et al. (2005) posited that the condition of the animals plays a greater role than genetic quality with regard to marketability. Market access constraints can be attributed to farmers' poor livestock conditions and low marketable livestock numbers. As submitted by Nkhori (2004), producers are discouraged from selling livestock in poor condition because they do not generate good prices at auctions or other market places. The second constraint standing in the way of market access appears to be infrastructure. There is no disputing the fact that improved road infrastructure facilitates livestock trading and lowers transaction costs for both farmers and buyers (Sehar, 2018).

4.4.2 Market plan and prices

A good marketing plan will incorporate information about critical consumer preferences into a product improvement program (Woods & Isaacs, 2000). The vast majority (78.8%, freq= 41) of respondents in this study indicated that they had no market plan, while only seven (7) respondents (13.5%) stated that they had market plans. The former group of respondents explained that they sell their animals wherever and whenever they want, therefore, they do not have market plans. The group of respondents who have a market plan indicated that the market plan was chosen by comparing prices at different market outlets (85.7%, freq= 6), followed by determining the marketable size, age, and weight of the animals in order to determine which animal will generate the highest profit (71.4%, freq= 5). The marketing plan's critical components include the product decision or what product(s) the farmer sells, the pricing decision, the methods decision or how a farmer determines the price for the product and the handling decision or when, where, and how a farmer delivers the product to the buyer (Learning, 2020).

In terms of market prices, 59.6% (freq= 31) of respondents in the current study stated that they understand market prices and how they work. The findings contrast with those of Khapayi & Celliers (2016), who discovered that the majority (55%) of sampled farmers in King Williams Town in the Eastern Cape province lacked access to market information, and that such farmers were unlikely to participate in marketing because they are unaware of market developments. Additionally, 60% (freq= 30) of respondents in this study stated that they were not satisfied with the prices they received at markets, while 34% (freq= 17) of farmers reported otherwise. Low prices, unstable market prices, inability to negotiate prices and high transportation costs were the primary reasons for the dissatisfaction with market prices, especially in formal markets. Similarly, Hangara et al. (2011) reported that the constraints faced by communal cattle farmers in Namibia include low cattle prices at the market, buyers who are late or do not show up, a slow payment process, and buyers who are out of cash.

According to Whelan et al. (2001), the market price of a product or service is determined by the interaction of demand and supply; that is, the willingness and ability of consumers to purchase the product, as well as the sellers' willingness and ability to produce and sell the product(s). Changes in market prices are beyond the farmer’s control and market availability often affects the farmer’s livestock sales. Due to a lack of market information, price discovery is frequently guided by body conformation rather than the weight of livestock (Coetzee et al., 2005). Earlier, Gill (1998) and Musemwa et al. (2007) provided farmers with tips on what they should do in order to get better prices at the market which entails selling one's animals early before all that is left is a shell of a cow or other animals. However, farmers should avoid marketing excessively thin or excessively fat cows as these fuel excessive price fluctuations, farmers must exercise caution and concern when marketing animals treated with animal health products and they should strictly adhere to the medication's withdrawal date before selling the animal. Finally, farmers should follow market demands and sell the animals at close by market places to reduce the cost of transport.

4.4.3 Transportation to the market

Results show that 55.8% (freq= 29) of respondents did not own a vehicle and relied on hired transportation of their livestock to the market. This was one of the primary reasons why farmers complained about market prices due to ever-increasing transportation expenses. Farmers in King Williams Town in the Eastern Cape province reported similar results, stating that they spent between R3000 and R5000 per year on transportation to the market, citing transportation costs as one of the challenges they faced in that area (Khapayi & Celliers, 2016). The accessibility of transportation dictates the quality and price of delivered produce. Transport that is not reliable can result in farm produce being delivered late and quality deterioration may be inevitable.

To ameliorate the cost of transportation for communal livestock farmers, group marketing was proposed by the researcher, and this idea received an overwhelming majority (98%, freq= 48) positive response.

Pertaining to primary barriers to marketing experienced by the respondents, these were gathered from the study:

- Instability of the market;
- Transportation is prohibitively expensive;
- Auctions had low bids (including auction fees)
- Policing require permits which farmers don't have;
- Difficulty in penetrating the formal market and market price fluctuations;
- Inadequate market information;
- Poor livestock condition, resulting in low prices; and
- Extremely high feed costs.

4.5 Relationships between different correlated variables

Table 4.10: The correlation between different variables

Correlated variables	Significance (*p*-value)	Correlation index (r)
Educational level vs Ability to maintain financial records	0.24	-0.32
Size of land vs Condition of pasture	0.20	0.10
Educational attainment vs Extension officers' information	0.01*	0.11
Extension Officers vs Government assistance	0.09	0.20
Access to advice/training vs Access to extension officer	0.06	-0.32
Farmers' educational level vs Breeding season	0.00*	0.16
Farmer's information attainment vs Ability to keep updated vaccination records	0.05*	0.17
Farmers educational level vs farm profit	0.10	0.13

* Indicates statistical significance at $p < 0.05$

The educational level of farmers and the ability to maintain financial records had a negative correlation (r =-0.32), thus they were not significant in this study. This demonstrates that farmers who failed to maintain financial records exhibited a high level of illiteracy. Furthermore, the size of land was positively correlated (r =0.10) with the condition of pasture in communal areas. Poor veldt management practices such as overgrazing and overstocking, as well as climate-related factors such as drought, influence the veld's condition. Carrillo (2010) noted that farming experience and the size of the farm are important factors that determine the propensity of the farmer to keep records or lack thereof.

A positive significant correlation (r =0.11, p<0.01) exists between farmers' educational attainment and Extension Officers' information, albeit a weak positive relationship. This implies that as Extension Officers increase their visits, availability and communication with communal livestock farmers, the level of information available to the farmers will also increase. Bonye et al. (2012) concurred that extension services provide information to farming communities about new technologies that, when adopted, can increase production, income, and standard of living. Furthermore, the relationship between farmers who work with Extension Officers and those who receive government assistance was examined and found to be positively correlated (r =0.20). This implies that farmers who work closely with Extension Officers have a better chance of receiving government assistance than their counterparts. Agricultural extension is primarily concerned with increasing farmers' knowledge to facilitate rural development; as such, it has been identified as a critical component of technology transfer (Danso-Abbeam et al., 2018).

The relationship between access to advice/training and the number of farmers who work with Extension Officers was also examined, and the results indicated a negative correlation (r =0.-32). This indicates that the less farmers work with Extension Officers, the more likely they are to attend training and farmers' days. According to Crawford et al. (2015), extension was the least effective strategy for obtaining information among organic producers. A significant positive correlation (r =0.16, $p<0.05$) exists between the breeding season and the farmers' educational level. Thus, the more educated farmers are, the more likely they are to adhere to breeding seasons.

There was a significant positive correlation (r =0.17, $p<0.05$) between information attainment and the ability to keep up-to-date vaccination records. This demonstrates that farmers who keep records are primarily influenced by their information attainment.

The relationship between farmers' educational level and farm profit was examined. A positive correlation (r =0.13) exists indicating that educated farmers have a tendency to select better market outlets and they are likely to be more productive if they are satisfied with the market prices. Similar results were recorded by Das and Sahoo (2012) who found that there was a clear positive, continuous and significant relationship between the farmers' educational level and productivity. Additionally, the study discovered that variation in productivity increased as one's level of education increased. The authors further argued that investment in education by both the government and the private sectors would improve agricultural productivity, which would obviously raise food security.

4.6 Conclusion

The majority of communal livestock farmers surveyed were elderly males who mostly possess the primary level of education and lacked formal agricultural training. Most farmers indicated a desire for training, with a particular emphasis on cattle production and breeding practices, veld management, and disease resistance. Income was derived from a variety of sources, including government assistance, private employment and livestock sale.

Many respondents had access to extension services, which invariably had an impact on production. Farm records were not mostly kept, and this negated the knowledge of farm profitability for most farmers. It was also concluded that farmers' low educational level may have contributed to record keeping failures. Access to land is a barrier to communal livestock farming in the study area, as they lack title deeds and financial capacity to lease land or obtain loans.

Treatment of sick animals, vaccinations, and ear-tagging were the top three management activities practiced by most respondents. The infrastructure in the communal areas of the Lejweleputswa district was seemingly adequate and in a reasonably good state of repair. Most of the communal lands were equipped with all necessary amenities. This refuted one of the study's hypotheses which stated that the majority of communal livestock farmers have insufficient infrastructure and proved that the infrastructure has no effect on productivity. It can be concluded that infrastructural challenge was not a constraint that plagues the communal livestock farmers in the study area, but stock theft and high input costs were high on the list.

It was fascinating to observe that farmers weaned; they were knowledgeable about various weaning methods and also culled their animals. Additionally, they knew when to cull. This demonstrated that farmers' financial circumstances did not dictate certain traditional methods of production.

Sustaining animal production requires adequate nutrition for animals, safe drinking water, and veterinarian services. The communal livestock farmers in the study area were observed to be facing feed shortages; the majority were able to provide lick supplements to their animals, with salt being the most frequently provided, and the animals relied heavily on the natural veldt, which was deteriorating during data collection. Therefore, this resulted in poor animal growth and sales profitability.

It was observed that communal livestock farmers in the study area faced a number of constraints that limited their adoption of new technologies. Top among the constraints were a lack of information and training. Additionally, most communal farmers have access to local Extension Officers, and information devices even though these gadgets are seldomly used for agricultural purposes. Access to information through human or technological means is beneficial for technology adoption and adaptation, and ultimately productivity.

The study sought to uncover what communal farmers do in the event of disease outbreak, and discovered that the majority of communal livestock farmers relied on assistance from other neighbouring farmers. While this partially supports the study's hypothesis that CLF lack knowledge about what to do in the event of disease outbreaks on their lands, reliance on other farmers clearly indicated a lack of information and a strong communication barrier with veterinarians. Additionally, biosecurity measures are not easy to implement, even more so when they are applied on a shared piece of land. This is why Extension Officers, veterinarians, and animal health technicians must educate farmers about the critical nature of biosecurity measures on their farms. An effective method of collecting and storing rainwater in dry areas will warrant farmers to become familiar with water harvesting techniques such as creating ridges or tying ridges together with a series of small basins. This technique will be advantageous during times of drought.

One of the difficulties faced by CLF was a lack of controlled breeding, which resulted in inbreeding, and the small size of land made it impossible for farmers to control breeding. As a result, communal livestock farmers will need to work together to ensure the success of any breeding program in their herds.

The communal livestock farmers who reported purchasing animals for breeding purposes stated that they purchased them from other farmers. This meant that farmers lack knowledge about stud breeders, or it can be attributed to the farmers' financial situation. To increase livestock productivity, a comprehensive approach should be taken that includes Extension Officers and farmer training on good husbandry practices such as feeding, health management, breeding practices, and hygiene. However, given scarce resources, government programs should prioritize livestock farmers who are committed to farming. Consequently, this study suggests that investing in farmers’ education and awareness of new technological innovations and appropriate measures and practices in breeding and veterinary services are critical for improving small-scale livestock farmers’ welfare.

Access to relevant market information remains a significant impediment to communal livestock farmers' ability to use market plans. Market opportunities exist for communal livestock farmers in the study area, but the majority of farmers do not take advantage of them. Market infrastructures are available in the study area in fairly good condition (some broken, but repairable), but because some farmers are unable to fund their own infrastructure, external intervention is needed. Additionally, it is recommended that all livestock extension training programs include livestock marketing because it is a critical component of livestock production.

The literature on market participation generally advocates for increased levels of participation from farmers (selling more). However, the results of this study demonstrate the possibility of a farmer selling an optimal amount of product given his specific market conditions. The study strongly recommends the formation of livestock marketing groups to reduce transaction costs, increase bargaining power, information access, and participation in formal markets.

Communal livestock farmers should take advantage of opportunities such as group marketing and online livestock market applications.

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CHAPTER 5

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In this study, it was hypothesized that illiteracy, inadequate market support structures, poor infrastructure, livestock health issues, and low technological input contribute mostly to the low livestock productivity of communal livestock farmers. The results confirmed this to be true, as the majority of farmers (39.6%) lacked formal education and (28.3%) were illiterate, thus, the low rate of technological adoption. The study also proved that some parts of the hypothesis were incorrect: the infrastructure and market structures in the study area were not in poor conditions and they had no effect on farmers' livestock production.

Most communal farmers did not have a relationship with veterinary services, which was a significant constraint because communal farmers relied heavily on information from other farmers rather than from professionals in times of emergency. The veterinarians and animal health technicians are the carriers of information about prevalent animal diseases in the study area, the symptoms and prevention methods that can be used by farmers. Therefore, these professionals should be encouraged to constantly be in contact with communal livestock farmers for improved livestock production outcomes. Access to land is a major constraint in implementing breeding and selection practices, the farmer-Extension Officer relationship should be used wisely to educate farmers about breeding and selection practices.

The technological parlance in South Africa is rapidly changing and the agricultural industry must adapt to these new technological advances. The communal livestock farmers were affected by their socio-economic characteristics in adopting new technologies and improving their livestock production. There was a relationship between the lack of technological adoption, animal health knowledge and the impact on agricultural production. It was concluded that low technological input contributes to the low livestock productivity of farmers living in the communal areas of the Lejweleputswa district.

Furthermore, the communal livestock farmers in the study area faced significant challenges in pursuing sustainable and profitable agriculture due to a lack of transportation and low market prices. The majority of respondents were dissatisfied with market prices due to poor livestock conditions. It is concluded that a market exists in the study area for communal livestock farmers. The issue at hand is ensuring that farmers meet market demands in order to obtain higher prices for their livestock.

Farmers were aware of the challenges they faced, and they were willing to change their *modus operandi* to achieve improved livestock productivity. Moreso, some farmers believe it is the responsibility of the government to help them with these challenges. The implication is that the government should only assist farmers who are committed to farming.

The results of the study support the hypothesis that training and introducing new technologies and advanced agricultural methods will increase production. The COVID-19 pandemic created a significant communication barrier between farmers and Extension Officers. Therefore, the use of agricultural devices will eliminate the information gap between these two groups. Furthermore, agricultural information must be relevant and accessible to all farmers to facilitate change among communal livestock farmers, individuals, and the community. The study concludes that communal livestock farmers should receive regular training on relevant topics such as animal nutrition, animal health, breeding and selection, and producing to market specifications so as to obtain higher market prices.

5.2 Recommendations

In light of the findings from the literature review, previous studies, and the findings of the current study, the following recommendations are made to assist the communal livestock farmers in the study in combating their challenges:

- Farmers' capacity to identify and assess animal diseases should be strengthened through education and other relevant stakeholders such as government Extension Officers and private institutions should participate actively in ensuring such education.
- Engaging in intentional and research-proven breeding practices, and ensuring farmers can identify and obtain breeds suitable for their production area is suggested as a critical future focus area for increased production.
- Group marketing should be used to reduce the cost of transportation to the market.
- Available information, support services and technology should be packaged into an accessible and user-friendly interface for farmers and the implementation of these technologies should be specifically designed based on the needs of the farmers. An example of such would be mobile messages that cover market price alerts from local auctions and feedlots. The Apps that cover the date of grazing management based on individual farmers' specific profiles, dates of weaning and breeding etc. should be designed.
- There is a need to develop free online information platforms like Agricultural applications that have 24-hour online services using qualified agricultural consultants. This will not only benefit the farmers but it will also create job opportunities for youths.

- Attention should be paid to the development of local agro-processing industries and farmer training in the processing of livestock products.
- Grazing management education should be prioritized for farmers for them to learn how to maintain the quality of their pastures for longer.
- The next generation should be included in the education about new technologies and advanced methods of farming, as they will inherit their parents' wealth.

Appendix i: Questionnaire

Questionnaire survey

Title: Constraints and opportunities for increased livestock production in the communal areas of Lejweleputswa district, Free State

Aim of study

To identify the constraints and opportunities for increased livestock productivity in the communal areas of Lejweleputswa district, Free State.

Objectives:

vii. To determine the current status of livestock production by communal farmers in the study area;
viii. To gain insight into the communal farmers' knowledge and attitudes towards animal health care and breeding programmes;
ix. To access the role of technology adoption and adaptation in alleviating poor livestock productivity;
x. To assess the marketing strategies available to communal livestock farmers in the study region;
xi. To present opportunities that can be utilised by communal livestock farmers to increase productivity; and
xii. To provide recommendations on how communal farmers can overcome their challenges.

Instruction for completing the questionnaire

This questionnaire is to be completed by a communal farmer or communal farm manager.

Please tick (×) to the applicable answer. You can also provide your own answers where necessary.

Confidentiality statement

Your responses are voluntary and will be confidential. Responses will not be tagged to any individual or identified as the same. The results will be compiled together and analysed as a group.

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Background information

1. Farm address/location ……………………………………………
2. Telephone number (optional) ……………………………
3. What is your ethnic origin?

African	
White	
Coloured	
Indian	
Other	

4. How old are you? ....

5. What is your gender?

Male	
Female	
Other	

6. Farming experience (years)? …………………
7. How was the land acquired?

   ....
8. How many other farmers farm on this land? ....
9. Is farming your main source of income?

Yes	
No	

10. If "No", please specify other sources of income……………………………………………………
11. How many family members do you support with your income? ....
12. What is the measurement of your farm? ....

13. How long have you been farming on that land? ....

14. What kind of animals do you raise on your farm?

Animals	**(×)**	**Number**	
Cattle			
Sheep			
Goats			
Pigs			
Poultry			
Other (specify)			

15. What are your reasons for raising these animals?

Investment for emergencies	
To meet daily living expenses	
Paying school fees	
For business purposes	
Culture and rituals	
Other (please specify)……………………………… ………………………………………..	

16. Did you receive any Government subsidy before?

Yes	
No	

17. If "Yes" who helped you apply? ………………………………………

18. What management system do you practice?

Intensive	
Semi-intensive	
Extensive	
Other (specify)	

19. Do you have hired labour on your farm?

Yes	
No	

20. If yes, what kind of hired labour?

Family members	
Herdsmen	
Permanent basis	
Casual basis	
Other (specify)	

21. What kind of skills do your labourers have?

Operate agricultural machinery e.g. tractor	
Manage the health and welfare of livestock	
Control livestock diseases	
Breed stock	
Maintain pastures	
Maintain farm equipment	
Assist animal birth	
Other (please specify)	

Educational background

22. Which educational level did you obtain?

Uneducated	Below matric	Matric	Undergraduate	Graduate	Post graduate

23. Which of the below languages can you speak, read and write?

	speak	read	Write
English			
Tswana			
Afrikaans			
Sotho			
Other			

24. What is your arithmetic ability?

	None	Little	Average	Good
Addition				
Subtraction				
Multiplying				
Division				

25. Do you have any agricultural-related qualification?

Yes	
No	

Management practices

26. Which livestock management practices do you practice and which season?

Management activities	Summer	Winter	Autumn	Spring	Throughout the year
De-horning					
Castration					
Deworming					
Ear tagging					
Branding					
Treating sick animals					
Vaccinations					
Other					

Animal nutrition

27. What is your source of water for the animals?

Borehole(communal)	
Own borehole	
Dam	
River	
Windmill	

Other (specify)

28. What is the quality of the drinking water?

Clear –good	
Salty	
Muddy	
smelly	
No idea	
Other (specify)	

29. What kind of feed do you use? For which animals?

Feed type	(×)	**Animal class**
Pasture		
Hay and silage		
Commercial feed		
Compounded feed		
Swill/ kitchen waste		
Other (specify)		

30. If your animals graze on pasture, what type of pasture?

Own land	
Communal land	
Rented land	
Other (specify)	

31. What is the present condition of the pasture land?

Good-plenty grass	
Fairly good- improving	
Fair- reasonable amount of grass	

Deteriorating- poor conditions but some grass	
Very poor – little grass	

32. What grazing management practice do you employ?

Grazing on camps	
Continuous grazing	
Rotational grazing	
Herding	
Other (specify)	

33. Which factors affect the grazing of your animals?

Small grazing land	
Weed encroachment	
Veldt fire	
Overstocking	
Over grazing	
Other (specify)	

34. Do you experience feed shortages? If, “Yes” when (season)?

....

35. Do you know the nutritional requirements of your animals at their different stages of development?

Yes	
No	

If “Yes”, what are they? ....

If “No” Why not? ....

Do you think your animals reach their daily nutrient requirements with the feed they obtain?

36. If “No”, why not? ....

37. Do you provide any nutritional supplements to your animals at any stage?

Yes	
No	

38. If “Yes” what nutritional supplement do you provide and for how long?

Phosphate lick (ready mix)	
Protein/production supplement	
Home-made licks	
Salt	
Other (specify)	
Duration:	

39. What are your reason(s) for supplementary feeding?

To provide energy	
To improve growth rate	
To increase fertility	
To fatten the animals	
Improve lactation	
Other (specify)	

Extension delivery service

40. Do you work with any Extension Officer(s)?

Yes	
No	

41. Does the Extension Officer visit you in your farm or do you visit him/her?

....

42. What is the distance to the service provider? ……..... Km.

43. How often do you require the service?

Weekly	
Twice a month	
Once in a quarter	
After every 3-6 months	
As the need arises (no specific period)	

Not at all	
Other	

44. Do you work with any Veterinarian or Animal Health Technician?

Yes	
No	

45. Does the Vet visit you or do you visit him/her? ……………………………………………

46. How often do you require their services?

Weekly	
Twice a month	
Once in a quarter	
As the need arises	
After every 3-6 months	
Other	

47. Do you have problems with getting service advice and training? If "Yes", please explain……………………………………………………………………………………

Breeding and reproduction

48. What animal species/breeds do you have on your farm?

Meatmaster Sheep	
Dorper Sheep	
Brahman Cattle	
Bonsmara Cattle	
Brangus Cattle	
Simbra	
Simmentaler Cattle	
South African Meat Merino sheep	
Beefmaster Cattle	
Kalahari Goats	
Boer Goats	

Cross breeds	
Durok pig	
Landrace pig	
Large white pig	
Potchefstroom koekoek	
Boschveld chicken	
Naked neck chicken	
Turkey	
Other (specify)	

49. Reasons for specie/breed preference?

Fast growth rate	
Adaptable to your area	
Quality of meat	
Quality of milk	
Low feed cost	
Resistance to disease	
Availability	
Wool	
Others (specify)	

50. What informed the type of specie/breeds you farm with?

Advice from Department of Agriculture	
Popular breeds	
Affordable breeds	
Available breeds	

Advice from other farmers	
Other (specify)	

51. Do you follow a breeding season?

Yes	
No	

52. If “Yes”, which breeding season do you follow? ……………………………………..
53. If “No”, what are your reasons? ....
54. Do you practice the selection and weaning of offsprings?

Yes	
No	

55. If “Yes”, how do you select your offsprings?

    ....
56. How do you wean your offsprings?

    ……………………………………………………………….
57. If “No”, why not?

    ....
58. Do you introduce other species/breeds to your farm for cross-breeding?

Yes	
No	

59. If “Yes” where do you get them? ……………………………………………….
60. Why do you introduce other animals for breeding?

    ……………………………………………….
61. How do your animals breed?

Natural breeding	
Assisted breeding	
Other (specify)	

62. Do you utilize any Assisted Reproductive Technologies (ART’s)?

Yes	
No	

63. If "yes", what kind of assisted reproductive technologies (ARTs) do you use for breeding?

Artificial insemination	
Oestrus synchronization	
Other (specify)	

64. Do you cull animals on your farm?

Yes	
No	

65. If "Yes", why do you cull them?

Old	
Non-reproductive	
Economics (drought, herd reduction, market conditions)	
Abortion	
Other (please specify)	

66. If "No", why not?

....

Health and diseases

67. What diseases do you mostly encounter in your farm?

Disease	**(×)**	**Season of prevalence**	**Control**
Heartwater			
Bluetongue			
Pulpy kidney			
Endoparasites			
Ectoparasites			
Sheep Scab mite			
Black quarter			
Pasteurellosis			

Lumpy skin diseases			
Foot and mouth disease			
No idea			
Other (specify)			

68. Do you vaccinate your livestock?

Yes	
No	

69. If "Yes", against which diseases?

Type of livestock	**Disease name**

70. Is your vaccination record up to date?

Yes	
No	

71. How do you treat sick animals or animals that need medical attention?

By myself	
Private vet/ Animal health technician	
Other farmers/ neighbours	
State services	
Other (specify)	

72. How do you control external parasites? ....
73. How do you deal with disease outbreaks? ....
74. Do you apply Bio-security measures?

Yes	
No	

75. If "Yes" which ones?

Clean and disinfect animals and feed vehicles	
Dipping	
Isolation of new or sick animals	
Deworming	
Rodent and insect control	
Other (specify)	

76. Do you think a periodic mobile vet clinic visit will help in solving the disease problems, administering the medication to the animals correctly and educating farmers about animal health issues?

Yes	
No	
No idea	

Please support your answer

……………………………………………………………………………………..

Market

77. What are the market channels that are close to you and distance the from you?

Market channel	(×)	Km
Black market (informal market)		
Butcheries		
Auctions		
Feedlots		
Abattoirs		
On my farm		
Other (specify)		

78. When do you market your animals?

Unproductive	
Sick	
Culls	

Urgent need for money	
Anytime	
Other (please specify)	

79. How often do you sell your animals?

Weekly	
Fortnightly	
Monthly	
Anytime	
Other (please specify)	

80. How many animals have you sold since June 2019 until now?

....

81. Do you set a market plan before taking your animals to the market, e.g. where and when to sell?

Yes	
No	
Sometimes	

82. If “Yes” or “sometimes”, which plan do you follow?
83. Do you understand the weakly meat prices?

Yes	
No	
Not always	

84. Are you satisfied with the prices you get from your sales?

Yes	
No	

If “No”, why not? ....

85. What mode of transport do you use to the market?

Trekking the animal	
Hiring transport	
Using own transport	
Other (specify)	

86. How can the mode of transport be improved to increase the supply of livestock from communal farmers to the market?

....

87. Generally, what is your view on the kind of marketing system that is used in communal areas? ……………………………………………………………………………….

88. Do you think group marketing of animals can be a solution to lowering cost of transport to the market?

Yes	
No	

89. In your own opinion, what constraints do communal farmers face when it comes to marketing their livestock?

………………………………………………………………………………..

Information dissemination

90. Do you receive Agricultural information through any technological devices?

Yes	
No	

91. If "Yes", through which means do you get the agricultural information?

Radio	
Television	
Magazines (farmers weekly)	
Extension officer	
Internet	
Other (specify)	

92. How many times in a year do you attend farmer's day events, farmers groups or farmers' workshops? ....

93. What do you think should be done in order to make information more accessible to farmers?

....

94. Have you experienced drought?

Yes	
No	
No idea	

95. If "Yes", how has it affected your animals? ....

96. What strategy do you use to cope with the drought?

Lick supplementation	
Feeding with crop residues	
Feeding with protein and energy feeds	
Renting another piece of land	
De-stocking	
Don't know	
Other (specify)	

97. What kind of support do you think communal farmers require coping with drought? ....

Infrastructure

98. Does the farmer have the following?

Crush pens	
kraal	
Weighing scale	
Store house	
Loading zone	
Tool house and medication room	
Chute	
Partitioned farm houses	
Other (specify)	

99. If any of the above tools/equipment is ticked, how is the condition?

very good	
fairly good (broken but can be fixed)	

poor	
Not working	
Other (please specify)	

Are these tools/equipment yours or you are renting? ....

100. What is the condition of the roads on the communal area?

Very good	
Fairly good	
Poor	

Financials

101. Do you keep farm records?

Yes	
No	
Sometimes	

102. If “No”, why not? ....

103. If “Yes”, what kind of records do you keep at your farm?

Production record	
Livestock purchase record	
Health record	
Financial record	
Parturition record	
Equipment purchase record	
Other (specify)	

104. Averagely, how much profit do you generate on your farm yearly?

R5 000-R15 000 per year	
R15 000- R25 000 per year	
RR25 000-R50 000	
R50 000 – over	

Don't have idea	
No profit	
Other (specify)	

105. How much money do you spend on buying inputs?

Supplements	
Machines	
Medication/treatment	
Animals	
Computers	
Assisted reproductive technologies	
Transport	
Other (specify)	

106 Does the farmer know what to do in cases of emergencies like fires, bloating of animals/disease outbreaks, floods, etc?

Yes	
No	
Not sure, but have little information	
Need a lot more information	
Depends on the kind of emergency	

107 What are the main causes of livestock losses on your farm?

Stock theft	
Disease outbreaks	
Predators	
Drought/lack of sufficient feed	
Straying/lost	
Other (please specify)	

108 In your opinion, how can the challenges faced by communal farmers be tackled?

…………………………………………………………………….

109 Can you say your business is profitable?

Yes	
No	
No idea	

110 If “No” what are your reasons for your answer?

....

....

111 What major constraints do you usually encounter in your livestock?

Management	
Marketing	
Housing	
Diseases	
Feed cost	
Capital	
Professional knowledge	
Thefts	
High mortality	
High costs of medication	
Other (specify)	

Other comments

If you feel you have additional ideas or comments on areas not addressed in this questionnaire, please, feel free to provide these in the space provided below:

112 …………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………

Thank you for your kind responses!

Appendix ii: Photographs taken during data collection with communal livestock farmers in the Lejweleputswa district municipality

Photograph 1: Data collection conducted in Theunissen commmunal areas.

Photograph 2: Data collection conducted in Bultfontein and Virginia communal areas.

Photograph 3: Livestock loss and animal health constraints

Photographs 4: The condition of Infrastructure facilities in the communal areas of the Lejweleputswa district.

Photograph 5: The condition of grazing lands at the time of data collection

Phograph 6: Feed management by a farmer in Virginia

Photograph 7: Water sources in the communal areas of the Lejweleputswa district

Appendix iii: published article

Adoption of Climate Smart Agriculture by Communal Livestock Farmers in South Africa

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Abstract: The importance of adopting modern technology in agriculture, especially in a changing climate, cannot be underestimated in Africa. The aim of this review was to highlight the past and the *status quo* with regard to the adoption of current farming practices in relation to climate-smart agriculture (CSA) by communal livestock farmers in South Africa. The impact of animal agriculture on climate change was also deliberated. Different internet search engines and databases, like Google Scholar, EBSCO Host, Science Direct, etc., and peer-reviewed articles, books, and government and academic reports were employed to provide information to adequately address the aim. Keywords like "the impact of Climate Smart Agriculture on communal livestock farmers'', "communal livestock in South Africa", ''communal farming and technology adoption", etc. were used for the search. Various issues pertaining to the impact of animal agriculture on climate change, greenhouse gas (GHG) emissions, and implementing CSA in livestock farming were extensively discussed. The findings indicated that there is limited research on the adoption of CSA by communal livestock farmers in South Africa. The review concluded that strategies to adopt modern technology in communal areas should address the issues to enhance knowledge of farmers and all stakeholders, through increasing awareness, training, and skills programs. The government should build local capacity in innovative and affordable water and agricultural solutions, and reliable financial mechanisms should be in place to implement innovative sound technologies in communal areas.

Keywords: climate smart agriculture; communal livestock farmers; technology; adoption

1. Introduction

Climate change poses serious developmental challenges for Africa, starting from greenhouse gas emissions to the resultant effects of these emissions on agriculture. Therefore, the need for the adoption of climate risk perspectives and a reduction in greenhouse gases is crucial. Since African countries are amongst the most vulnerable to climate change and variability [1], the need to adopt mitigative strategies becomes imperative. The concept of climate-smart agriculture (CSA), which was introduced by the Food and Agriculture Organization (FAO) [2], is aimed at addressing the challenges of climate change and food security. Climate-smart agriculture (CSA) is defined as agriculture that sustainably increases productivity, enhances resilience, and reduces greenhouse gases (GHGs) (mitigation) where possible and enhances the achievement of national food security and development goals [2]. It has been reported that agricultural practices like animal production, forestry, crop farming, aquaculture, and other land-use sectors contribute 24% of anthropogenic global greenhouse gas emissions [3], hence, this vital concept of CSA.

Communal livestock farming is an agricultural unit in which livestock farmers or villages work together on the same piece of land and run their holdings as joint enterprises. Some of these units operate in state-owned lands, leased land, or privately owned land [4]. This system of farming is the oldest farming approach that is associated with improved household farming security and it is still practised in many rural parts of South Africa. Since more than 75% of the world's poorest people live in rural areas and 2.5 billion people live on small farms and are entirely dependent on agriculture for their livelihood [4], communal livestock farming then becomes a means to achieving food security.

Climate change knows no size of farming and it affects every citizen that depends on agriculture in South Africa or people living in other parts of the world. Its major impact is visible to the agricultural industry because of its vulnerability to changing climate patterns. It is also worth mentioning that agriculture is both the cause and the solution to climate change. Thus, mitigative measures aimed at reducing the effects of climate change must begin from the inception of land use decisions.

Adoption of CSA practices by communal livestock farmers is not easy because of many barriers that exceed the underlisted. Some of these barriers include the age of farmers (many older farmers are engaged in communal livestock farming), poor educational status, low farm income, inadequate farm experience, limited land size, lack of farm input/financial resources, infrequent contact with agricultural extension officers, and lack of exposure to media. Others include poor agricultural production activities, lack of membership to agricultural associations, and misperceptions of the impact of climate change on the environment [4–6].

Considering the aforementioned bottlenecks, the authors sought to provide answers to these challenges and to create pointers that may kickstart the effective adoption of CSA by communal livestock farmers in South Africa. To successfully achieve these, issues such as the prevalent age of communal farmers, their educational level, the relationship they have with extension officers, the financial mechanisms currently available to them and the strategies that are used in other countries that have successfully adopted CSA must be brought to the table and discussed.

Firstly, it has been reported by Mutuku [7] that most communal farmers are elderly and CSA practices are too complex for them to understand. Secondly, the educational level of communal livestock farmers is very limited, and this will impede the extent to which such CSA technologies will be understood, accepted and practised. Thirdly, it is important for extension services to provide information (education) on beneficial practices to farmers because they are the carriers of information to farmers. Training of extension officers will put a tremendous amount of influence on communal livestock farmers to adapt to the changing climate and adopt CSA practices [8]. Suffice to say that a well-managed livestock system is very important with respect to increased productivity, provision of services that benefit the ecosystems and the reduction in GHG emissions.

Furthermore, researchers have shown that farmers who do not have close relationships with extension officers struggle or show no means to adopt climate smart practices in Malawi and South Africa [9]. A lack of information and support from the government, private institutions, and other commercial farmers may also contribute to low or no adoption of CSA practices by communal livestock farmers in the Free State province and in South Africa as a whole. Amongst others, a lack of support by the relevant government departments includes inaccessibility of capital for broader farm investments and absence of or inadequate training of communal livestock farmers on CSA practices [10].

2. Methodology

This was a desktop review, which employed the use of various scientific search engines like Google Scholar, Scopus, ScienceDirect, EBSCO Host etc. to source for peer-reviewed published data. Relevant academic reports and government reports, unpublished farmer gazettes, and articles providing sound statistical data and figures on Climate Smart Agriculture and data were also consulted. The literature search was performed between 2020–2021 and it aimed to review the past and present status pertaining to the adoption of climate-smart agricultural practices by communal livestock farmers in South Africa. The impact of animal agriculture on the climate was first discussed to set precedence for the subject matter. Keywords and topics such as "climate smart agriculture", "communal livestock farming", "the impact of climate smart agriculture on communal livestock farmers'', "climate smart animal agriculture'', "communal livestock farming in South Africa'', "effect of climate change on communal farming'', "climate smart agriculture and communal livestock in Africa", "climate smart agriculture and extension services'', "communal farming and technology adaptation", etc. were imputed in to produce the desired information. Search results in line with the aim of this review were included and other results that did not fit the purpose of this study were excluded.

Information published in the English language in peer-reviewed articles, government reports, unpublished farmer gazettes, conference papers, or book chapters formed part of the inclusion criteria. Others included information that referred to developed countries and developing economies on the subject matter, and data that focused on the agricultural sector and had at least one of the CSA pillars.

The exclusion criteria included information that was not written in the English language, data that focused on non-agriculture-related sectors, and data that addressed none of the CSA pillars or the impact of climate change.

The preliminary search yielded more than 640 documents, amongst which 280 of them were presumed useful for the review. Endnote version 20 software was used to screen the search results and eliminate duplicates. A full text review was done and after further literature synthesis, 101 documents, which included 3 book chapters, were used for this review paper. The included information was found useful in terms of expanding the frontiers of knowledge on the adoption of climate-smart agriculture by communal farmers. Methodologies used in other publications that were reviewed in this paper included article reviews and research studies conducted by the use of quantitative, qualitative or mixed methods data. It should be noted that this article was intended to dwell majorly in the geographical regions of South Africa, however, mention is made of other countries that have similar results with the subtopics. Bearing in mind the aim of this paper, synthesized useful literature with similar trends were grouped and analyzed. Constructive conclusions were also made.

3. Impact of Animal Agriculture on Climate Change

Livestock farming represents a threat to the environment [11]. Its major impacts are seen in the high records of deforestation, land and water pollution, and greenhouse gas (GHG) emissions. Livestock production contributes 96% of deforestation at global levels [12] by means of grazing, fodder, and feed production. Additionally, pesticides, herbicides, fertilizers and animal manure management are major contributors to land pollution and water pollution [8]. Methane and nitrous oxide gases are the most important greenhouse gases produced by animal agriculture. According to [13] methane affects global warming 28 times more than carbon dioxide, while nitrous oxide, which arises from the storage of manure and fertilizers, contributes to global warming 265 times more than carbon dioxide. Therefore, livestock production contributes and suffers from the effects of climate change.

3.1. Deforestation

The main cause of clearing of forest is caused by the increasing demand for animal products, which invariably results in obtaining more pastures for the increasing animal numbers [11]. At the global level, deforestation is driven by agricultural expansion, which accounts for 96% of deforestation. Political, cultural, and socio-economic factors, including unsound policies and weak governance, corruption, landlessness and unclear allocation rights, migration, rural poverty, and a lack of investment and financial resources are indirect drivers of deforestation at the local level [12].

Agriculture is the main driver of deforestation in Africa. Deforestation in the Congo basin rainforest is caused by local subsistence activities by poor farmers and villagers who rely on forest lands for agriculture and fuelwood collection often using slash-and-burn/fallow techniques (Figure 1) [14]. There are approximately 10,000 species of tropical plants in the Congo Basin and a huge variety of animals, including big mammals like African forest elephants, forest buffalo, chimpanzees, bonobos, and a number of subspecies of gorilla. Some of these species have a significant role in shaping the character of their forest home. The South African forestry industry contributes 9.8% of the country's gross domestic product (GDP) and it is home to about 23,420 species of vascular plants and 1632 known species of amphibians, birds, mammals, and reptiles, of which 13.9% of these species are endemic. The natural beauty will all be greatly affected following the loss of forested areas [15].

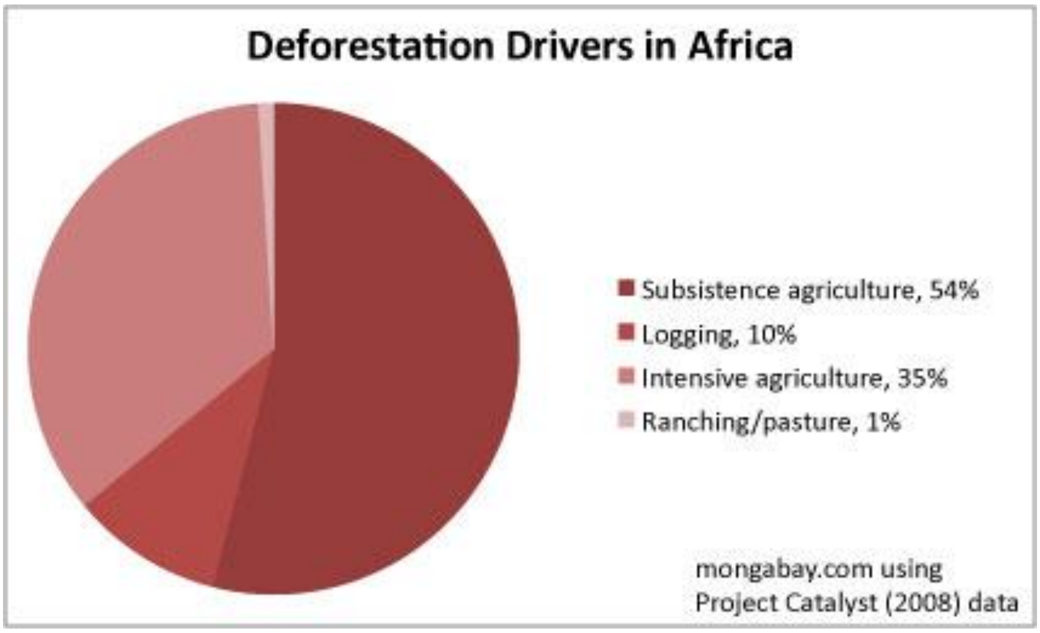

Figure 1. Reprinted with permission from Butler, R. Drivers of Deforestation, Copyright 1994–2020 [14].

Deforestation in southern Africa and Tanzania is primarily the consequence of human population growth, which results in increasing expansion of agricultural lands for more food production and grazing land [16,17]. In addition, the increase of income in many countries creates a greater demand for meat, other cash crops, and animal feed, given that approximately 40% of the harvested crops in the world are used as feed for animals [11].

It has been reported that reducing deforestation protects biodiversity and livelihoods in forest-dwelling communities [18]. Agroforestry is an integrated approach to the production of trees and non-tree crops or animals on the same land [18] and it is an important measure that is used to counter the effect of deforestation. Agroforestry is important in both climate change mitigation (carbon sequestration, improved feed, and consequently, reduced enteric methane) [19]. This system has long been practised in South Africa through what is known as the Taungya system, which is the management of forests in which land is cleared and planted initially to produce food crops [20].

Kaczan, Arslan, and Lipper [21] mentioned agroforestry as a climate-smart practice, which is also undertaken in Malawi and termed "fertilizer tree systems". Communities in Cameroon strengthened agriculture by using agroforestry practices by establishing four tree nurseries, each with 10,000 seedlings on their farmland, to reduce the need for agricultural expansion into the forests, reducing deforestation and degradation. Additionally, a silvopastoral system as an agroforestry arrangement is another strategy that can be successfully implemented in South Africa [22]. Silvopastoral systems in Africa involve extensive open grazing by free-roaming animals under scattered natural stands of trees and shrubs. The system combines forestry and grazing of domesticated animals on pastures, range land, or on-farm. This system also provides pastures for livestock in the dry season and improves pastures and fodder banks [23].

The benefits of silvopastoral system innovations are clearly visible, although the system requires correct management to implement in order to get successful results. A landscape approach was suggested by FAO [2], as an approach to reduce deforestation. This approach would promote high-carbon stock land uses in forests and in agricultural areas and would contribute to halting both deforestation and forest degradation while meeting future demands for food and nutrition.

3.2. Water and Land Pollution

Earlier reports by the United Nations have shown that South Africa's population will be around 65–67 million by 2030 and it is by far the most important driver for the demand for increased food and livestock products [21]. Water pollution is a global challenge that has increased in both developed and developing countries, challenging the economic growth as well as the physical and environmental health of billions of people [24]. The decline in rainfall, water scarcity due to drought, and farm profitability, has left South Africa with less than two-thirds of the number of farms it had in the early 1990s [25].

Seventy percent of water abstractions worldwide are caused by the agricultural industry [8] through water pollution. This is as a result of the deposition of animal excreta, feeds, antibiotics, fertilizers, carcasses, and hormones. [11]. Furthermore, the agricultural industry in South Africa also has to cope with unpredictable seasons, low and variable rainfall, droughts, gradual loss of soil fertility, soil degradation, veld fires, and bush encroachment, all of which are all fall-outs of climate change. Increasing pressures by human and livestock populations are also regarded as culprits [25].

A total of 69% of South Africa's land surface is suitable for grazing, and livestock farming is by far the largest agricultural sector in the country [25]. According to Gbetibouo and Ringler [26], South Africa's grazing land is stocked beyond its long-term carrying capacity. The South African Wildlife Foundation (WWF-SA) [25] has further reported that overstocking is most evident in the communal rangelands of Limpopo, KwaZulu-Natal, and the Eastern Cape provinces, which support more than half of South Africa's cattle production. Overstocking causes trampling and crusting of the soil and denudes the veld of vegetation.

Pesticides, herbicides, and fertilizers that are used on crops fed to animals are major contributors to land pollution. Many harmful substances reach our lakes, rivers, and eventually groundwater, leading to widespread contamination of waterways and groundwater and decreased water quality [24]. The use of artificial fertilizers damages soils by making them lose their water holding capacity, which invariably makes them subject to erosion. Poorly managed fertilization can also change the species composition and decrease the basal grass cover. This reduces productivity and increases water run-offs and erosion [24].

Increased carrying capacity can be achieved through simple techniques like planting pastures, adding fertilizers, and planting additional palatable species. Furthermore, Ndhlovu and Mpofu [27] mentioned that conservation agriculture (CA), popularly known as "Farming the God's Way", is one of the most popular climate change adaptation techniques in one of the districts in Zimbabwe. The system is also being introduced in South Africa by land care programs that aim to teach communities to responsibly manage the land by conserving vegetation, water, and biological diversity in their area [28].

Other CSA practices that are currently adopted in South Africa include water conservation, which utilizes the in-field rainwater harvesting technique; no-till technique, which ensures that the soil is less prone to erosion and effectively retains organic matter, water, and nutrients; the use of rotations; intercropping; and maintenance of permanent soil cover [25]. Furthermore, in the KwaZulu-Natal province of South Africa, the problem of maintaining soil fertility and soil structure is solved by using animal manure as alluded by [29]; their study showed that 40% of the farmers reported improved soil fertility following the application of manure.

Some of the CSA strategies to deal with water pollution and land pollution suggested by WWF-SA [25] to farmers are to ensure that stocking rates are within the land's carrying capacity, based on the commercial stocking rates for a given area and the present veld condition. Also, the reduction in the use of pesticides and herbicides that cause a decline in soil micro-organisms is advised. Other strategies include clearing alien vegetation, which is a cost-effective way of increasing water supply on the farm; using plant cover crops to prevent bare ground when the actual harvest is over; preventing soil erosion and loss of waterways; the use of wetlands; and planting grasses, trees, and fences along the edges of a field that lies on the borders of water bodies. Lastly, reduction in tillage of the fields in order to reduce runoffs, soil compaction, and erosion; maintain or improve veld condition and the health of the soil by ensuring appropriate rest periods after relevant grazing and/or fire events; prevention of overgrazing, trampling, and soil erosion; and the rehabilitation of degraded veld are the other approaches [25].

3.3. Greenhouse Gas (GHG) Emissions

Global emissions of methane have risen by nearly 10% over the past two decades, resulting in higher levels of atmospheric concentration of greenhouse gasses. The impact of GHG emissions on climate change was witnessed in 2015 in South Africa, where a total livestock mortality rate of 252 880 was recorded [30]. The delay in rainfall led to late plantings, a decline in available feeds, fodder, and limited crop production [30]. Lipper [31] also mentioned that changing temperature patterns threaten the agricultural industry and disrupt food markets and food supply to the resource-poor communities that depend largely on agriculture for their livelihoods.

The direct and indirect contributions of livestock to GHG emissions include animal physiology, animal housing, manure storage, manure treatments, land application, and chemical fertilizers [32]. Furthermore, Gerber [3], stated that livestock manure management and normal digestive processes (enteric fermentation) contribute 44% of the world's anthropogenic methane gas (CH_4) emissions. This buttresses the submission that global emissions of methane have risen by nearly 10% over the past two decades, resulting in higher-level atmospheric concentrations of greenhouse gasses [33]. In addition, Moran [34] also reported that global livestock production contributes an estimated 18% of anthropogenic greenhouse gas (GHG) emissions, mainly in terms of the release of methane and nitrous oxide gases.

Kenya showed various CSA practices that were implemented successfully by farmers to reduce the emissions caused by agriculture through the Mitigation of Climate Change in Agriculture Program (MICCA) pilot project, incorporated CSA practices like conservation tilling (CT) and improving animal breeds to create carbon sinks. A dairy herd management project was also introduced, which involves managing livestock nutrition so as to ensure that feed is broken down as efficiently as possible and with minimal production of methane gas [35].

Livestock manure emissions may be used as biogas, which may be utilized to generate electricity, heat, and fuel [13]. Farmers in China are already using this CSA practice to convert greenhouse gas to energy. Farmers are involved in a CSA project that channels the waste, mostly from pigs, to sealed tanks where it is converted into gas and it is used for cooking. This project incorporates straw in their biogas, where it is transformed along with pig manure into fertile compost [35]. The same project was carried out in Outeniqua research farm in the Western Cape province of South Africa, where a biogas fermenter was set up to digest manure from the research dairy farm and manure was converted to biogas and then to electricity for use by the dairy farm [36].

In reviewing literature pertaining to GHG emissions, it has been noted that animal emissions vary according to seasons. According to Gaitán [37], these emissions are usually higher in the dry season than in the wet season. Livestock farming is also responsible for overgrazing, land degradation, and the loss of forests. These practices release large quantities of greenhouse gases into the atmosphere. The research on GHG emissions, especially in communal areas of South Africa, is limited. This proves that there is partial information about the various mitigation strategies that are adaptable in South Africa, especially as it relates to communal livestock farmers. Knowledge about changing climatic conditions and the different trade-offs that are involved in communal livestock areas in South Africa are definitely beneficial in implementing mitigation policies [35].

4. Implementing Climate-Smart Agriculture in Livestock Farming

The impact of animal agriculture on climate change has so far been recognized. Hence, implementing climate-smart agriculture for communal livestock farmers will not come at a low cost. Some of the strategies highlighted in this section have already been adopted by some farmers. These measures include: the use of adaptable breeds; manipulation of rumen ecology, feed types, and feeding; education and extension services; and improved policies. Climate-smart agriculture as the way of farming has a maximum ability to rescue countless numbers of smallholder farmers across South Africa and the neighbouring countries and its practices are both economically and environmentally friendly.

4.1. Adaptable Breeds

Heat stress in livestock is mostly experienced when the temperature-humidity index (THI) is higher than 72 THI [38]. Heat stress causes adverse behavioural, chemical, physical, nutritional, physiological, and metabolic responses in livestock, which militates against preserving cell integrity and survival [39].

Discomfort caused by heat stress has known effects, such as reducing milk yields in dairy cattle and negatively influencing conception rates across almost all breeds and species of livestock [40].

The report from DAFF [41] has shown that farmers in the Free State province farm with animal breeds that they know or breeds that can be easily accessed and not necessarily as a result of the adaptive potential or characteristics of that breed. Therefore, it is important to identify breeds with inherent genetic capabilities to adapt to climate change. Kadzere [42], mentioned that indigenous breeds thrive with minimum input compared to imported breeds, and these breeds are pivotal to the development of climate-smart animal agriculture. It is worthy of note that communal and smallholder livestock farmers in South Africa have been practising CSA for a long time through traditional practices [43]. The majority of smallholder farmers in South Africa are targeting indigenous livestock breeds like Afrikaner, Nguni, Boer goats, free-range chickens, and locally developed composites like Bonsmara and SA Mutton Merino, while recognizing the adaptability of other breeds that have been in these areas over many generations [44]. All these breeds are known to be hardy, drought and disease tolerant, and have a lighter impact on the environment.

Changes in breeding strategies can help animals increase their tolerance to heat stress and diseases and improve their reproductive and growth development [45]. Some of the CSA management strategies that can be implemented to reduce heat stress include mechanical cooling, such as forced ventilation, water sprays, and shading. However, this can be difficult to apply, especially to livestock on pasture as this offers relief from hyperthermia for a short time [20,46]. Furthermore, a study in Nigeria [5] and a report from Schulze [47] both stated that keeping a large number of livestock in a limited space is a challenge. In such circumstances, stall feeding as a CSA practice becomes even more appropriate and the manure from dairy units can be used to produce biogas, which will reduce deforestation, thus, minimizing the release of carbon dioxide (CO_2) to the atmosphere [5].

Existing evidence on the impact of CSA on livestock farmers is very limited, only 3.5% when compared to 93% from crops. Nearly all data on livestock are on improved diets, with few on improved breeds [48]. Some of the most known livestock adaptation strategies, such as pasture management technologies and animal housing, are absent from the data reviewed by Rosenstock [48] in east and southern Africa. Rosenstock [48] additionally mentioned that this is an important gap to be filled as these technologies are also relevant as mitigation pillars of CSA.

Investments geared towards equipping farmers with much needed knowledge will help farmers to know which breeds are adaptable in their geographical location and they can be informed on which breeds can tolerate different climatic changing patterns. The Agricultural Research Council (ARC) in

South Africa also promotes the adoption of an integrated crop livestock system that effectively mitigates, adapts to, and reduces vulnerabilities to climate variability and climate change [43,49]. Educating communal livestock farmers about different breeds and their characteristics will not only help them with knowing how to choose adaptable breeds in their area, but it will also assist them with getting better prices at the markets, while saving the planet.

4.2. Manipulation of Rumen Ecology

It is now possible to increase or decrease the results of rumen digestion through rumen manipulation methods like the use of ionophores in feed, defaunation, and diet manipulations amongst others. The rumen is the first stomach chamber of ruminants; it is a compartment which receives food or cud from the oesophagus and where fermentation occurs [50]. Sixty percent of total digestion takes place in this compartment even though the rumen wall does not secrete enzymes [51]. This chamber contains different types of microbes including bacteria, protozoa, and fungi.

The various challenges that are currently facing the livestock sector are to reduce the high cost of feeds, improve product quality, and lessen the impact of production on the environment. The production values of CH_4 and CO_2 by rumen microbes are estimated at 400 L and 600 L d-I respectively in adult cattle. These high values contribute to the greenhouse effect, which is now threatening our planet [35,52].

There are several strategies that have been proven to reduce the emissions caused by ruminants. One of these includes rumen fermentation, which is the process that converts ingested feed into energy sources for the host [53]. Manipulation of rumen fermentation is crucial for improving nutrient utilization and productivity of animals. The more efficient the rumen is, the better will be the synthesized fermentation end-products [54].

Manipulating ruminal fermentation is intended to enhance beneficial processes and remove, decrease, and change processes that are harmful to the host. This can be achieved through maximizing the efficiency of feed utilization and increasing ruminant productivity (milk, meat, and wool) [54].

The genetic and non-genetic options are the other examples of rumen manipulation and ecology management methods. These two approaches employ the use of bacteriostatic chemicals such as ionophores, bacteriocins, feed additives (e.g., fats and oils), synthetic chemicals, natural compounds, and vaccination to inhibit methanogens. Enhancing non-methanogens through diet manipulations and the use of inoculants is also a rumen manipulation strategy [54]. The adoption of bio-digestion can increase farm profits by 10% to 20% and help reduce the environmental impact of livestock production

[55]. Also, introducing new species or strains of microorganisms into the gut has a great potential to increase the digestibility of feedstuffs and to improve animal health and growth [56].

Defaunation is the process of making the rumen of animals free of rumen protozoa and the animal is called a defaunated animal [56]. Rumen protozoa contribute 40–50% of the total microbial biomass and enzyme activities in the rumen. Using chemicals (copper sulphate, manoxol, and sodium lauryl sulphate) is another method of defaunation for obtaining animals free from rumen ciliate protozoa [57]. Defaunation has been proven to significantly decrease methane production compared with normal faunated animals [58]. There is ample scope to manipulate the rumen by feeding local plants, tree leaves, or agro-industrial by-products to defaunate animals for improved productivity.

Rumen manipulation has, therefore, been proven to be effective in increasing the efficient use of local feed resources and enhancing productivity in ruminants [59]. Since 8–12% of the digestible energy ingested by ruminants is lost in the rumen as methane, higher methane output of up to 15–18% of the digestible energy may be produced where cattle are fed on poor quality forage [59].

The use of unconventional feedstuffs may contribute to decreased feeding cost and environmental impact through reduced methane emissions. According to Patra [60], the methods to effectively reduce methane production in the reticulo-rumen include the use of synthetic chemicals; supplementation of organic acids like fats and oils, ionophores, and halogenated compounds; and processing of feeds and microbial feed additives.

4.3. Feed Types and Feeding

Climate change is heavily affecting South Africa and the agricultural industry at large. Feed production accounts for 47% of GHGs from livestock farming and improved forage-based systems [3]. In low rainfall areas, more farmers are interested in CSA technologies to minimize the climatic risks, mostly water scarcity and droughts [61].

Drought results in high prices of basic foods and it has been reported that cattle farmers are more vulnerable to drought when compared to other species of livestock production [62]. The use of manure in the form of synthetic fertilizers for forage contributes to GHG emissions. Global feed production and processing and transport contributed 3.2 Gt CO_2 eq, accounting for 45% of the sectors' emissions [3,21].

Forage grasses and legumes that are resilient to stress provide feed for livestock during drought or waterlogging**.** The use of drought-adapted forage legumes and concentrates in crop–livestock systems also provide high-quality feed in the dry season [63]. In Norway, the feed ration for dairy cows consists of 45% and 42% silage and concentrates, respectively [34]. This, on the other hand, might be a difficult mitigation tool to adapt in some provinces in South Africa as it will surely depend on the costs, knowledge of farmers, and availability of feed.

In the North West province of South Africa, fodder banks are constructed and promoted to maintain healthy productive animals, thereby adopting CSA practices. Moreover, in India, important CSA mitigation measures adopted by livestock farmers for improving livestock include adding digesters and CH_4 inhibitors in feed and enhancing the number of crossbred animals that have lower CH_4 emissions per unit of production [64]. Ayantunde [65] mentioned that in the Sahel region, digestibility and protein content of the feed, herd, and grazing management, and supplementary feeding are important factors in feed management [65].

On-farm CSA practices in livestock production that have been adopted in Uganda include silvopastoral systems (i.e., converting degraded extensive treeless pastures into a richer and more productive environment, where trees and shrubs are planted interspersed among fodder crops such as grasses and leguminous herbs), improved feeding regimes, and grazing land management (rotational grazing and forage conservation) [66]. Off-farm CSA related services include crop weather-index-based insurance and using automated weather stations to monitor specific parameters and triggers [67].

Pasture management is very important when it comes to proper nutritional requirements of livestock [68]. The use of correct pasture management practices, conservation agriculture (CA), crop rotation, and an intensive grazing system could be important mitigative practices that could guarantee more efficient conversion of forage into economically available products, hence, culminating in reduced CH_4 and N_2O emissions [3]. Furthermore, supplementing poor quality forages with fodder trees, as in silvopastoral systems, or with legumes, as well as increased protein content of feeds, can also improve digestibility and reduce the overall methane emissions per unit of product [66].

Some of the useful grazing management practices highlighted by Bezuidenhout [69] in an article published by *Farmers Weekly* magazine have been shown to be effective to livestock farmers in many parts of South Africa. These practices include setting aside forage by postponing grazing while forage species are growing, ensuring equal grazing of various species to stimulate diverse grasses, and improving nutrient cycling and plant productivity. Others include developing healthy pasture root systems, maintaining plant cover at all times, and promoting natural soil-forming processes. The results of a study in the Eastern Cape province of South Africa showed a different view as communal livestock farmers in that area highlighted a lack of strong local-level institutions, little to no knowledge of veld management, and inadequate fencing of paddocks as constraints that contribute to the lack of adopting CSA pasture management practices [70].

It is common knowledge that a well-managed pasture or feeding system requires a knowledgeable farmer, financial support, skilled labour, and technical resources to actualize it. We can arguably say that there is little impact of CSA in terms of feed management in some provinces and this indicates that the government of South Africa, the Department of Agriculture and Rural Development, and the private sector needs to actively evaluate the land and the equipment needs of farmers and provide farmers with specific CSA pasture management and feeding aids depending on the type of need and the location.

4.4. Education and Extension Services

Agricultural extension is a process of working with farmers to improve productivity and overall livelihoods [71]. In South Africa, extension officers are qualified workers appointed by the Department of Agriculture and Rural Development (DARD). These officers have a crucial role to play in the adoption of CSA practices in communal livestock farming. The main duties of extension officers are to help to facilitate sustainable agricultural productivity through raising awareness, capacity building, and the provision of up-to-date information, like an early warning of drought, input supply, climate change, adaptation strategies, new technology development, weather forecasts, access to markets, and credits to farmers [72].

Maka [72] conducted a study in the Eastern Cape province of South Africa and the results revealed that 68% of farmers claimed they have limited or no access to extension services in that area. This seems to be a norm as the beneficiaries of the Nguni cattle project in Raymond Mhlaba Local Municipality in that province also claimed that no extension support services were received by farmers to improve their socioeconomic status [73]. Similarly, in Mozambique, 52% of small-scale farmers were not adopting CSA practices due to a lack of knowledge and financial capacity to invest in on-field interventions [68]. As reported by Nyasimi [74], limited knowledge about promising initiatives can lead to poor uptake of CSA practices. One of the reasons for the lack of services from extension officers is that they may be unequipped to deal with the current challenges of climate change. There should be specific CSA-related training programs for extension officers to equip them in assisting farmers to deal with the challenges of climate change [72].

Interestingly, in some parts of South Africa (Mthonjaneni, Umhlathuze Gqumashe villages, etc.) farmers have adopted a number of strategies to cope with climate change and its resultant variabilities. Practices such as crop rotation, changing the time of farmer operations, introducing diverse crop varieties, increased efficiency of irrigation, promoting climate change awareness and education amongst each other, and working together with other farmers are some of the adopted measures [6,74].

Conservation Agriculture (CA) is an example of a successful project implemented in South Africa and the key approach is to train senior agricultural officials who will transfer knowledge to the farmers [28,75]. The implementation of CA in western Zambia has also shown a positive impact through increased yields. There was greater productivity in CA fields and the acquisition of seeds increased. These results were obtained from an app that was used in Namibia named the “Event Book” and “Mobile App” [75]. In Malawi, likewise, Dr Ngwira [76] also acknowledged that Malawian farmers find CA more profitable as it requires less labour for land preparation, weeding, and other agricultural practices.

The government of Uganda has trained 58,000 farmers in CA and 28,000 farmers have adopted and are practising conservation agriculture, and the adoption of CA is increasing, as well as the knowledge level of farmers in the country [24]. Ghana also introduced a private ICT-based platform that provides market price alerts, climate-smart agricultural advice, weather forecasts, and voice messages on CSA practices sent out to farmers in the language of their preference. This platform has so far trained and improved access of about 835 farmers (of which 33% have been females) to the use of down-scaled seasonal forecast and climate-smart agriculture technologies and practices through mobile phones [77].

In Nigeria, a study revealed that contact with extension agents, which denotes access to information, has positive effects across all the CSA practices in the country. This indicates that contact with extension services increases the likelihood of adopting CSA practices [5].

Since extension officers are the main carriers of information to communal livestock farmers, they should take the responsibility to ensure farmers get information on climate change, climate change impacts, and CSA. In view of these results from other countries and South Africa, it shows that implementation of CSA is not difficult for farmers to adopt, they just need knowledge and guidance. The use of media along with extension services should be increased in pushing awareness and information about CSA practices to communal livestock farmers in South Africa in order to help them cope and adjust to climate change. Therefore, this study infers that extension services must go to farmers to provide training and disseminate knowledge.

4.5. Government Policies

Climate Smart Agriculture and planning of agricultural adoption strategies requires clear policies in order to be effectively implemented. Policymakers in West Africa reinforce the adaptive mechanism to deal with the negative effects of climate change as a top priority [77]. In addition, Ben [78] mentioned the National Environment Management Policy, Forestry Policy, and National Policy for the Conservation and Management of Wetland Resources as policies that are active in Uganda. Despite this comprehensive policy framework, there is still a lack of strategic and comprehensive integrated planning for CSA in Uganda.

Contradictions with the statement made by Mnkeni and Mutengwa [44] were seen when other investigators reported that impressive progress has been made in the formulation of CSA policies in South Africa. Contrarily FANRPAN [8] mentioned that CSA policy has not yet been formulated in South Africa, but the Climate Change Sector Plan (CCSP) for Agriculture, Forestry, and Fisheries has been completed and made public for comment. Uganda is no exception as government agencies responsible for implementing environmental policies, including adaptation interventions, are under-resourced [8].

Designing policies that aim to improve factors affecting the adoption of CSA for smallholder farming systems have great potential to improve CSA compliance [44]. Policy initiatives and developments that promote CSA in Africa do exist and South Africa is actively responding to climate change challenges, which requires considerable changes in the national and local governance, legislation, policies, and financial mechanisms [79].

The Department of Agriculture, Forestry, and Fisheries (DAFF); National Departments of Environmental Affairs (DEA), Water Affairs (DWA), Rural Development and Land Reform (DARD); state-owned research institutions including the National Research Foundation (NRF), Agricultural Research Council (ARC), and Council for Scientific and Industrial Research (CSIR); and farmer organizations like Red Meat Producer Association of South Africa (NARPO) and the National African Farmers Union of South Africa (NAFU-SA) are stakeholders involved in formulating CSA policies in South Africa [44]. In Lesotho, Vuna provides policy influence, education, information, finance, and market knowledge for adopting CSA. Climate-smart agriculture policy is likely to be completed in South Africa after the CCSP (Climate Change Sector Plan) has been approved [8].

Despite the delay in CSA policy in South Africa, the good thing is that some farmer organizations have started to independently adopt and promote CSA principles. These organizations include the Red Meat Producers Organization (RPO), the KwaZulu-Natal (KZN) No Till Club, the Grain Producers Association of South Africa (Grain SA), the South African Wine and Fruit Industries (SAWFI), sugarcane growers, the National African Farmers Union of South Africa (NAFU-SA), the National Wool Growers Association (NWGA), Mohair SA, Dairy SA, and the Ostrich Business Chamber (OBC) [80].

5. Challenges to the Adoption of Climate Smart Agriculture

Smallholder agriculture in southern African countries is practised as a way of life. Agricultural productivity depends on people, principles, goals, knowledge, resources, and decision-making processes, amongst others [10]. This section presents the various barriers that prevent communal livestock farmers from adopting climate-smart practices. These challenges include a lack/dearth of infrastructure, inadequate policies and government services, inaccessible road networks, and the human factor (the farmers' beliefs and willingness to adopt modern technologies). These barriers have been implicated in the low/slow response of communal livestock farmers to CSA adoption.

5.1. Adoption of Technology

The rate of adoption of technology by communal farmers is very low [81]. This is due to the level of education and information-seeking behaviour of some of the farmers. Kunene [82] further mentioned that the high illiteracy level of most communal farmers is a stumbling block for the adoption of new technologies.

5.2. Government Services

Veterinarians and extension officers are assigned to every district in the agriculture sector, where they provide expertise to the farmers in South Africa. Nonetheless, Gwala [83] reported on the poor quality of work done by the extension services provided by the government in order to help communal farmers. Liebenberg [84] also stated that 8 out of 10 extension officers in South Africa are insufficiently qualified to carry out their responsibilities. Despite this challenge, the extension officers will remain a major source of information and knowledge to rural farmers.

5.3. Infrastructure

The most prominent infrastructural challenge for communal farmers in South Africa are transport and holding facilities [83]. Lack of facilities like temperature-controlled barns, crush pens, and dams are some of the struggles experienced by smallholder farmers. Available and affordable farm equipment are non-negotiables for better productivity since livestock is an inflation-free resource for communal farmers and a store of wealth. Farm animals can be sold to meet farmers' daily, weekly, and monthly expenses like school fees, medical bills, and household expenses [85].

5.4. Inadequate Cutting-Edge Technology Awareness

The use of modern technology creates opportunities for communal livestock farmers. ICT- based information sources available to smallholder farmers in South Africa include radio, television, and smartphones [86]. Similar results were reported in the southern district of Botswana, which revealed that the most used technological devices in communal areas were smartphones (89%), while local radio and television accounted for 59% of use respectively [87]. Lekopanye further recommended that the radio stations and television broadcasts need to incorporate livestock programs that combine mobile technology with radio and television, where participants will be involved in the various awareness topics through calls or short messages.

5.5. Farm Location and Inaccessible Road Networks

Long distances from major cities and poor road networks in communal areas affect the ability of farmers to adopt modern technologies and attract many buyers. Mthi [88] reported that poor accessibility of roads was ranked as the eighth most important constraint affecting livestock production in the Eastern Cape province of South Africa. Remote locations with poor states of roads result in high costs of moving livestock to markets and hinder marketing efficiency [89]. The results from the study concurred with the findings of Makhura and D'Hease [90,91], who reported that the smallholder farmers have been neglected in terms of infrastructural support by past governments.

5.6. Human Factor (Farmer Beliefs and Willingness to Adopt Modern Technologies)

The famers' decisions on whether and how to adopt modern technologies are conditioned by the active interaction between the characteristics of the technology, array of conditions, access to credit, capital availability, and the farmers' circumstances [92]. Profitability is a major concern to farmers, thus, the opportunity to witness an investment in profitable technology by a fellow producer with similar facilities and resources often assists in decision making and the willingness of the farmer to adopt the modern technology [93].

5.7. Climate Smart Agriculture Law and Policies

The South African government in 2019 published the Carbon Tax Act (Act. No. 15 of 2019), a climate change law to stabilize the greenhouse gas concentration in the atmosphere [94]. Smallholder farmers and local farming communities play a crucial role in implementing CSA practices. However, in many cases, locally established user rights are not legally formalized. Unclear tenure arrangements chase away external investors due to the risk of inconsistency and lack of accountability. A well-designed policy framework and law require relevant institutions and authorities to develop strategic institutional plans to ensure the effective implementation of new laws and other legal provisions [94].

6. Conclusions

This article reviewed the adoption of climate-smart agriculture (CSA) by communal livestock farmers in South Africa. The influence of animal agriculture on climate change was also discussed. The findings indicated that the quest to promote CSA will not be cheaply achieved [77]. There is limited research on the adoption of CSA by communal livestock farmers in South Africa. Some farmers are already practising some aspects of CSA, even though they might be unaware of it. It has been noted that the unavailability and unaffordability of technology is a big challenge to smallholder farmers. The media is a valuable source of information for communal farmers on matters of climate change adaptation and CSA adoption. It provides content pertaining to some techniques that are inapplicable to communal farmers or too expensive for communal farmers to implement.

There have been huge differences in the provision of extension services in countries like Uganda and Ghana when compared to South Africa. These countries (Uganda and Ghana) prioritized the education of communal livestock farmers, and this increased their adoption rates. This clearly shows that the implementation of CSA practices is not far-fetched, but a lack of information, support, and financial capacity to invest in on-field interventions might be hindering extension service training in South Africa, indicating that improvements are possible.

Mitigation tools to reduce CH_4 and N_2O emissions that are used in developed countries like China are not always applicable to developing countries like South Africa. This is due to a lack of information and insufficient resources to implement them. South Africa must use the mitigation tools adaptable to their conditions with adequate consideration of costs, knowledge, and availability.

Similarly, there is a big gap in enacting CSA policies in South Africa. Sound implementation of technologies requires innovative policies; thus, the Department of Agriculture and Rural Development needs to engage all stakeholders to make a common policy that embraces all aspects of the environment that are affected by climate change. The government should improve local capacity in advanced and affordable water supply systems, agricultural solutions, and reliable financial mechanisms in order to implement innovative sound technologies.

Another gap is seen in the deficient awareness and information sharing to communal livestock farmers. The reality of lack of information is a very critical factor to address for the implementation of CSA practices in any country. There is a lot that South Africa can learn from other countries with regard to the benefits of using CSA practices and their implementation strategies and policies. In future, CSA adoption and adaptation studies should focus more on the formulation and implementation of CSA policies relevant to the South African environment, considering the educational levels of target farmers, and propose solutions to make adaptability to modern techniques easily applied at local levels.

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