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Toward sustainable food system: the role of livestock farming in Matiyani village in the Vhembe Biosphere Reserve, South Africa

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This study explored the role of livestock farming in Matiyani village toward achieving a sustainable food system, in the Vhembe Biosphere Reserve, South Africa. Africa has made advancements in addressing agriculture and rural development. Most rural communities in South Africa mainly rely on agriculture. At the same time, population growth and concerns about food security cannot be ignored. Therefore, agriculture presents itself as an important factor in the economy, relied upon by large populations. However, much focus seems to be placed on crop farming, with limited attention to livestock farming, particularly in indigenous communities. In cases where livestock farming is considered, it is usually from a large commercial scale, while ignoring the contribution of livestock farming in enhancing sustainable food systems. These livestock farming activities usually reflect the culture and economies of local communities. The study adopted a qualitative research design, with a sample of 29 livestock farmers from the Matiyani village. Livestock farmers in Matiyani village under the Hlanganani Livestock Forum in the Vhembe Biosphere Reserve, South Africa, through purposively sampled. Thematic analysis was employed for qualitative data through focus group discussions and a desktop study. This study explored the influence of livestock farming practices within the community that contribute to sustainable food systems. The outcomes of this study reveal how livestock farming is important for the sustainable food system of Indigenous communities by sustaining their livelihood through the sales of the livestock among themselves and within the commercial market. The study also found that livestock farming in this community does not only benefits economic activities but also provides social and environmental benefits, as livestock are used for community rituals and their manure as crop fertilizer. Furthermore, the study findings indicate that communities residing adjacent to protected areas face more challenges of human wildlife conflict, which, in most cases, they never receive compensation for the loss of their livestock caused by wildlife from these protected areas, which influences their lack of participation in sustainable food systems.

KEYWORDS

agriculture, food system, indigenous communities, livestock farming, Vhembe Biosphere Reserve

1 Introduction

Food plays a crucial role in our daily lives, as echoed in the African proverb, “Your food should be your medicine, and your medicine should be your food” (Smith, 2004). Therefore, considering the amount and quality of food humans consume is critical, as it ties back to understanding the fundamentals of the food system and its analysis (Rosen, 2025). This perspective fosters respect for the food humans depend on and ensures the integration of sustainable food consumption into individuals’ daily lives. The food system evaluates the entire value chain rather than focusing only on food production. According to the United Nations Environment Program (UNEP, 2019), the food system is a comprehensive set of people, institutions, activities, processes, and infrastructure involved in producing and consuming food for a given population.

This comprehensive system is vital to ensure that sustainable food systems are consistently maintained while following relevant protocols and procedures, supporting the achievement of Sustainable Development Goal (SDG) 1: No Hunger. The Food and Agriculture Organization (FAO), underscores the crucial role of the food system in the bioeconomy. Consequently, it requires strategic guidance and support, as highlighted in the policy framework of Food 2030 and the European Union Bioeconomy Strategy 2018 (Food and Agriculture Organization, 2023).

These policy frameworks emphasize the inclusion of food systems in policy because it ensures food security and nutrition for all in a way that meets economic, social, and environmental needs. This approach prevents the activities of the present generation from compromising food security and nutrition for future generations (European Commission, 2020). It aligns with the broader goals of sustainable development, which emphasize meeting present needs without endangering the ability of future generations to meet their own (Emas, 2015). This ensures that environmental, economic, and social systems are interconnected, and their functioning together is essential to maintain the integrity of the food system.

Institute of Food Science and Technology (2024), supports the notion that a key characteristic of the food system is its extensive linkages, interdependence, and feedback loops across value chain stages, as well as with the broader environmental, societal, and economic contexts. To achieve an effective value chain, protocols and procedures must be adhered to, ensuring that safety and risk assessments are conducted at every step. This guarantees that food reaching communities meets all required standards across the entire system. Various definitions of food systems emphasize that food systems encompass the entire range of actors and their interlinked value-adding activities, including production, aggregation, processing, distribution, consumption, and disposal (Braun, 2021).

These systems originate from agriculture, forestry, and fisheries and are embedded within the broader economic, societal, and natural environments (United State Department of Agriculture (USDA), 2023). Furthermore, food systems must be analyzed in the context of interlinkages, especially considering factors such as rapid population growth, urbanization, increasing wealth, changing consumption patterns, globalization, climate change, and the depletion of natural resources (Berkum and Ruben, 2018).

The above-mentioned factors require urgent implementation of changes in food production to address current global challenges in agricultural practices. Despite the challenges, the past six decades have yielded positive outcomes, particularly in developing countries with

regard to food systems. It is indicated that, since the 1960s, developing countries have experienced a 20% increase in per capita food availability, highlighting that there are 150 million fewer hungry people compared to 1960 (Herdt, 1998).

Agricultural practices are central to food systems and have benefited communities significantly, particularly in livestock farming, which is economically sustainable through income generation. Livestock farming also provides broad-based societal benefits, including social status and wealth accumulation (Banda, 2021). It positively impacts on the environment through the rehabilitation of grazing areas and other ecological benefits such as the enhancement of soil health, biodiversity, and water retention, while also reducing greenhouse gas emissions (Maree et al., 2025).

Livestock systems contribute substantially to global food security, producing 90% of the world’s milk supply, 80% of meat, and while the livestock systems account for the consumption of nearly 50% of cereal production for feeding purposes (Thornton and Herrero, 2014). This system enhances crop production through manure recycling and animal traction hence, livestock farmers are viewed as great supporters of the community’s economic and social status, while also contributing to environmental conservation.

In addition, the adoption of a sustainable food system is crucial as it aligns with global and national collective efforts to bring about positive changes in food systems. It accelerates progress in achieving the 2030 Agenda and the SDGs, particularly those targeting hunger eradication, dietary improvement, and ecological protection (United Nations Development Programme (UNDP), 2024). The food system encompasses not only the basic elements of food production and distribution but also all related processes and infrastructure required to feed a population (Joachim et al., 2024).

The food system of most rural communities in South Africa mainly relies on agriculture (Netshisaulu et al., 2025). At the same time, population growth and concerns about food security cannot be ignored. Therefore, agriculture presents itself as a critical component of the economy, relied upon by large segments of the population (Thaba and Ramakgasha, 2025). However, much of the focus tends to be placed on crop farming, with limited attention given to livestock farming, particularly within rural communities. This limited focus has the potential to obscure the importance of livestock farming in sustaining the livelihoods and food systems of rural and indigenous populations.

In many cases where livestock farming is acknowledged, it is often viewed from a large-scale commercial perspective, overlooking the significant contributions of subsistence and small-scale livestock farming in enhancing sustainable food systems. These small-scale livestock practices are not only vital for household food security but also reflect the cultural values and economic structures of local communities. As such, the main objective of this study was to explore the role of livestock farming in Matiyani Village toward achieving a sustainable food system within the Vhembe Biosphere Reserve, South Africa.

2 Literature review

2.1 Agriculture in Africa

Agriculture is the primary source of subsistence and income for many African people in rural areas. It is estimated that about 20% of

export values are accounted for through agricultural activities (UNECA-SA, 2009). In this regard, agriculture is an important economic sector, particularly in African countries with non-oil exports. In the different forms of agriculture, Africa relies on, the focal point of this write-up is livestock farming.

For many years, livestock farming activities have contributed to the wellbeing of African communities (Meissner et al., 2013). Livestock farming systems have intensified from agropastoralism in the 21st century to various type of farming (Oduniyi et al., 2020). A study conducted by Coertze (1986) provides an account for livestock with a focus on cattle in that Africans have always been influenced to farm cattle through factors that are cultural, more than economic. According to Coertze (1986), the farming of cattle in African communities does not emphasize the economic production of beef, but the role cattle have in rituals, initiations, and other cultural practices that require cattle to be sacrificed. Cattle have been used as a form of maintaining good social relations and as dowry for marriage.

Cattle farming is interwoven into the lives of Africans. Saitot and Beckwith (1981), add that the day-to-day routines of cattle farmers in South and East Africa center around their cattle. The daily schedule of cattle farmers is influenced by the time cattle leave the kraal in the morning and return in the evening. This is also evident in their settlement patterns, which are in close proximity to the cattle kraal and are also being influenced by the Central Cattle Pattern theory (Badenhorst, 2009). The Central Cattle Pattern theory by Huffman (2001), interprets the spatial layout of Iron Age settlements in Southern Africa, where cattle kraals are centrally located within the residential structures, while also emphasizing the central role of the cattle in the economic, social, and ritual aspects of these societies. This theory is still applicable within the Maasai people, who are known to reside within the kraal itself, allowing the cattle to roam freely around the homestead.

The changing environmental landscape, driven by globalization and the rising demand for meat and milk produced from livestock, has significantly shifted the value perception of livestock farming. In South Africa, as in many other countries, the expansion of both urban and rural populations has led to increased demand for animal products, particularly meat and dairy. This growing demand is reshaping modern farming and production objectives, compelling producers to adopt advanced technologies to boost productivity and efficiency. One such advancement is the integration of Artificial Intelligence (AI) into livestock farming systems (Coertze, 1986).

AI technologies are increasingly being utilized to support livestock farmers, especially in rural areas, by providing tools for real-time monitoring, predictive analytics, and disease detection. For example, AI-powered wearable devices and smart collars are being used to track livestock health, movement, and behavior, allowing for early identification of illness or distress. Remote sensing and drone technology also support pasture management by analyzing grazing patterns and vegetation cover, helping farmers make informed decisions to prevent overgrazing and ensure optimal land use.

In developed countries such as the United States and the Netherlands, AI applications in livestock farming include automated milking systems, facial recognition of animals, and machine learning algorithms that analyze large datasets to improve breeding strategies and feed efficiency (Neethirajan, 2020). In developing countries, particularly in India and Kenya, mobile-based AI applications are being used by smallholder farmers to access veterinary advice, market information, and weather

forecasts, improving livestock productivity and resilience (Food and Agriculture Organization of the United Nations (FAO), 2022).

In the South African context, initiatives are emerging to introduce AI technologies in rural communities to empower farmers with limited access to veterinary services or extension officers. These technologies bridge the gap by offering digital livestock health diagnostics and early warning systems, thus enhancing livestock welfare and boosting food security. As the global demand for animal products continues to rise, the adoption of AI technologies in livestock farming becomes not only a necessity for efficiency and productivity but also a strategic approach to promoting sustainable, data-driven farming that benefits rural economies and aligns with broader food security goals.

2.2 Livestock farming in South Africa

South Africa is reported to have about 80% of land suitable for livestock production (Department of Agriculture, Forestry & Fisheries (DAFF), South Africa, 2018). According to Department of Agriculture, Forestry & Fisheries (DAFF), South Africa (2018), the livestock production sector in South Africa contributed nearly 40% of the income generation of agriculture. The farming practices in South Africa exist within two types, commercial and subsistence. In these two types of farming, cattle production is a dominant practice. Almost 60% of the cattle produced in South Africa are from commercial farmers, and the rest are from emerging farmers (Department of Agriculture, Forestry and Fisheries [DAFF], 2019).

Oduniyi et al. (2020), introduced the three systems in beef production in South Africa, intensive, semi-intensive and extensive production. The intensive beef production system takes place in the feedlot as a final stage. This is where cattle feeding is controlled for the required weight, particularly in a short period. The definition of the production system is determined by the food animals consume and the place where they sleep. In this regard, a production system where animals spend most of their time outside, grazing, is referred to as pasture-based, which is characterized by the existence of temporal shelter and few supplements provided (Wrobel et al., 2023).

This is more common in subsistence or small-scale livestock farmers, which is the focal point of this study. On the other hand, the commercial sector of livestock farming focuses on pasture-led practice to meet consumer needs, particularly for naturally fed animals, this is extensive production (Conner et al., 2008). In South Africa, there has been heightened interest and participation in farming due to the land redistribution arrangements (Oduniyi et al., 2020). These participants are referred to as emerging farmers (in the small-holder farming sector) who have received support.

This support allows them to have improved access to credit, extension, and land rights, in efforts to transform them into the commercial sector (McDonald and van Oudtshoorn, 2009). The smallholder farming sector of South Africa is made up of emerging and semi-commercial farmers. The small-holder farming sector is different from the commercial farming sector which is centered on high-level production through the demanding use of erudite and sophisticated machinery. The smallholder sector is characterized by a lack of access to the market, high labor intensity, and limited capital (Khapayi and Celliers, 2016). The limitation of resources in smallholder farming thus poses challenges in their growth, particularly with climate change experience.

Although there are challenges experienced in smallholder farming, there are efforts by different institutions to support them. The University of Pretoria has a training and skills development project for the smallholder livestock farmer (University of Pretoria, 2024). This project is to assist farmers with meeting their food security, economic and biosecurity growth. The project seeks to implement South Africa's National Agriculture and Agro-processing master plan through acknowledging the role livestock contributes to food security, employment and alleviation of poverty, thus efforts to address challenges faced by these farmers (University of Pretoria, 2024).

2.3 Understanding systems that support sustainable food systems in rural economies

Food systems are recognized to be at the center of most Sustainable Development Goals (SDGs) (Mutyasira, 2023). The current need for the transformation of food systems has also been recognized at the 2021 Food Systems Summit (Mutyasira, 2023). This summit was a response to increasing economic, health, and social predicaments manifested through food insecurity (Béné et al., 2020). With the achievement of the SDGs, the food system must be refashioned to be more productive and provide environmentally sustainable and nutritional benefits to all (FAO, 2018).

The food system is understood as the processes involved in the production, distribution and consumption of food (TechnoServe, 2025). This includes activities associated with growing, raising, harvesting, processing, and distribution, ensuring the safety of food and its consumption as well as discarding food. The food system does not ignore the contribution of people and resources and how food impacts them (Chmieliński, 2023). The sustainability of the food system has effects on people, this is because it determines what exists for people to consume, its access, and affordability (Thiry, 2023). In this regard, a sustainable food system is expected to provide food nutrition and security while considering the wellbeing of people and the environment for the present and future.

According to Mutyasira (2023), it is important to understand that a sustainable food system is not only dependent on increasing the production of food but also on how food is produced as this has social, economic and environmental implications. As such, there is a need for adjustments in the production of food, particularly in the agriculture sector (Mutyasira, 2023). This means that farmers need to implement changes in how food is produced. Communities in the Vhembe Biosphere Reserve are engaged in different means of food production to ensure they have access to nutritious food, as much of their food is a result of their agricultural activities.

The concept of sustainable food systems is conceptualized through system boundaries and system building blocks, which are interconnected and operate simultaneously. These systems collectively support the development of sustainable food and nutrition systems that deliver health and wellbeing, while also contributing to the broader transformation toward a sustainable circular bioeconomy (Béné et al., 2019). The diagram below illustrates how a sustainable food system functions by highlighting its core components, each of which plays a vital role in ensuring sustainability for both local communities and the global population. This framework outlines four key characteristics essential to achieving a sustainable food system:

inclusion, diversity, safety, and availability. These characteristics are directly influenced by four thematic systems: the health system, ecological and climate systems, economic and governance systems, and science and innovation systems.

Together, these thematic systems and characteristics interact dynamically to build resilient, inclusive, and equitable food systems that promote food security, environmental protection, and economic sustainability. The integration of these systems ensures that sustainable food systems not only meet present needs but also safeguard the ability of future generations to access nutritious, safe, and culturally appropriate food (Figure 1).

Systems are integrated structures that assist in the operation and implementation of processes. In the context of sustainable food systems, especially in rural economies, there are four critical interlinked systems that ensure sustainability and contribute to long-term food security. These systems include Ecological and Climatic Systems, Science, Innovation, and Technology Systems, Economic and Governance Systems, and Health Systems.

2.3.1 Ecological and climatic systems

The Ecological and Climatic Systems, is responsible for the assessment of the environmental conditions under which livestock are reared. These systems ensure that selected livestock breeds can withstand local climatic conditions (SA Farmers Magazine, 2023). This is critical as climate change continues to impact agricultural productivity globally, threatening both livestock health and food security.

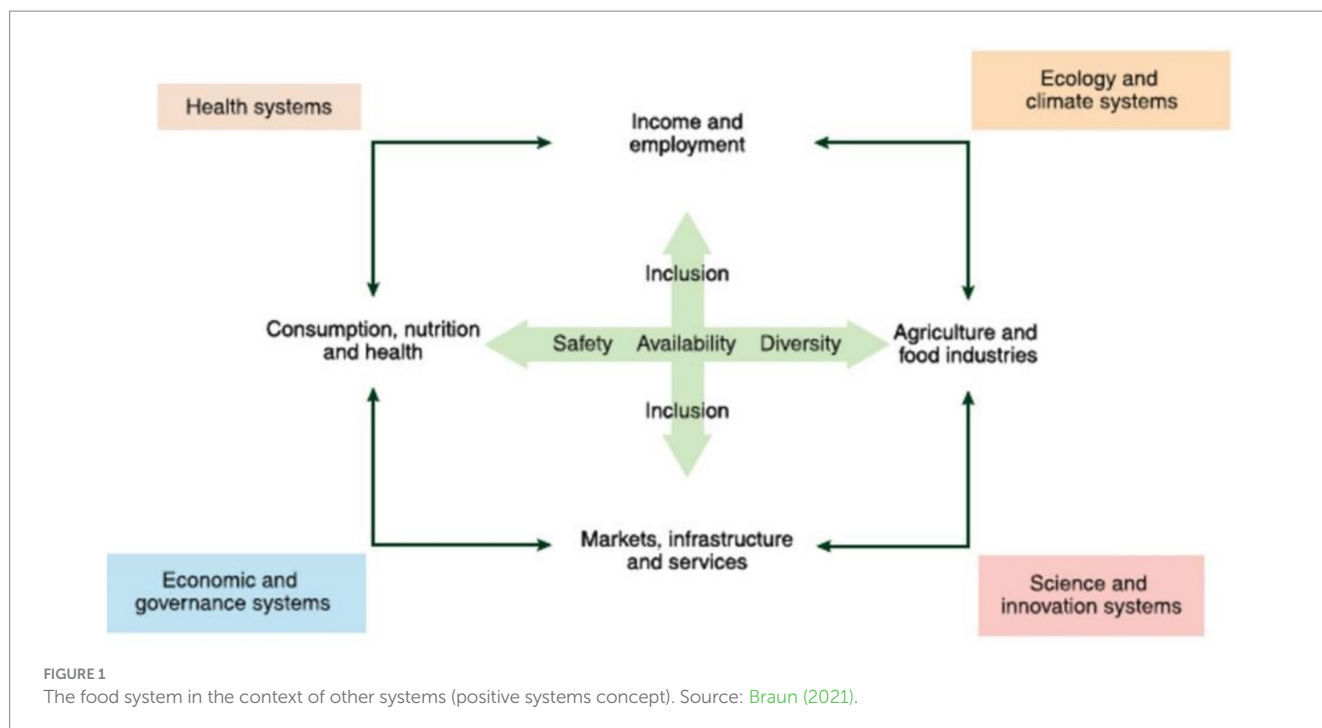
Ecological and climatic conditions directly influence the health, reproduction, and productivity of livestock. For example, rangeland degradation, water scarcity, and temperature extremes affect grazing patterns, disease prevalence, and animal mortality rates. Therefore, the sustainability of food systems is heavily dependent on environmental stewardship. This requires that farming practices consider biodiversity preservation, water and soil health, carbon and water footprints, and plant vitality, thereby ensuring that ecological impacts are neutral or positive.

In this system, diversification is a key component including promoting agroecological approaches such as intercropping, agroforestry, and the rearing of drought-resistant and indigenous breeds. These practices not only increase resilience to climate variability but also ensure food security by reducing dependence on single crops or species. As seen in countries like Kenya and Nigeria, smallholder farmers have successfully implemented such models (Raveloaritiana and Wanger, 2024).

2.3.2 Science, innovation, and technology systems

Science, innovation, and technology play an intersecting and transformative role in all components of sustainable food systems. These systems aim to enhance productivity, improve animal health, and introduce climate-smart agricultural practices. Scientific innovations such as genetic improvements, veterinary biotechnology, and precision agriculture contribute to ensuring food quality and safety (Satyanarayana and Risheen, 2023).

The integration of artificial intelligence (AI) and digital technologies in farming has also revolutionized livestock monitoring. Innovations such as GPS-enabled collars for livestock have proven useful, especially for communities adjacent to protected areas where



wildlife-livestock conflict is common. These technologies help in tracking livestock movement, preventing loss, and enhancing security. In addition, sustainable food systems benefit from knowledge-sharing platforms, community-based research, and farmer training programs that empower rural communities with the skills to adopt modern and adaptive practices. These systems support both ecological preservation and economic advancement.

2.3.3 Economic and governance systems

Economic and governance systems focus on creating enabling environments for sustainable agricultural production. These systems address land tenure issues, resource allocation, and the demarcation of communal lands, allowing farmers to access and effectively utilize agricultural resources (Deininger et al., 2014). Secure land rights are essential for long-term investment in land and livestock management, particularly in rural and indigenous communities. Governance frameworks also establish the institutional arrangements that allow for the inclusive participation of local stakeholders in decision-making processes. This is critical for ensuring ownership, transparency, and accountability in the management of food systems.

From an economic perspective, sustainability implies that all actors in the value chain farmers, herders, traders, and service providers, are commercially and fiscally viable. This means that food systems must generate tangible economic benefits such as fair wages, market access, enterprise profits, and local employment opportunities. Components such as availability, accessibility, and affordability also play crucial roles in this system. For example, infrastructure development (e.g., roads, markets, storage facilities) ensures that food products reach consumers efficiently, while also providing farmers with consistent access to inputs, services, and information.

2.3.3.1 Health systems

The health system in sustainable food production refers primarily to the animal health care system and its broader implications for

public health. Veterinary services are vital in safeguarding animal wellbeing, monitoring zoonotic diseases, and ensuring that meat and dairy products are safe for human consumption. The Constitution of South Africa (1966) mandates the provision of veterinary services to livestock farmers as a means to promote animal welfare and protect public health. Effective veterinary systems must have the capacity to prevent, detect, contain, and eliminate animal diseases and related public health risks. Regular vaccinations, parasite control, and disease surveillance are key components of a functional animal health system.

Furthermore, a well-structured health system supports stability and resilience by minimizing the impact of disease outbreaks, reducing losses, and ensuring the continuous supply of animal products. Together, these four systems ecological and climatic, science and innovation, economic and governance, and health form an integrated framework for sustainable food systems. However, within these systems, certain core characteristics must be addressed to ensure effectiveness: diversity, availability, accessibility, resilience, and equity.

Diversity refers to the cultivation of a range of crops and the rearing of livestock that are resilient to local conditions. For instance, smallholder farmers in Kenya and Nigeria have embraced agroforestry and intercropping systems, reducing their dependency on single harvests and enhancing food security (Raveloaritiana and Wanger, 2024). Availability involves ensuring that adequate food and support infrastructure exist, particularly for communities adjacent to conservation areas where access to markets and agricultural inputs may be limited. As noted by Exploreanthro (2023), growing livestock fodder during dry seasons not only improves food availability but also generates employment opportunities such as cattle herding and fodder production, which are critical for community resilience.

Resilience, another important characteristic, refers to the capacity of food systems to absorb shocks, such as droughts or market disruptions, and continue functioning. Resilient systems integrate traditional knowledge with modern science, prioritize risk management, and invest in ecosystem restoration. Equity

ensures that the benefits of food systems reach marginalized groups, including women, youth, and indigenous people, who often face systemic barriers to participation. This includes ensuring gender-sensitive approaches to training, land access, and financial support.

Sustainable food systems are anchored in four interdependent systems that are interconnected and collectively contribute to building a resilient, inclusive, and sustainable future. These systems, when effectively implemented, support local economies, preserve natural ecosystems, protect public and animal health, and ensure the availability and diversity of safe, nutritious food. Through integrated planning, multi-stakeholder collaboration, and policy coherence, sustainable food systems can be a powerful engine for rural development, climate resilience, and community wellbeing.

3 Methodology

This study applied a qualitative research design to gain insight into the contribution of livestock farming toward sustainable food systems, in the Vhembe Biosphere Reserve (VBR). This study was conducted in Matiyani village, involving 29 livestock farmers, representatives from Department of Agriculture, Limpopo Department of Economic Development, Environment and Tourism (LEDET), South African National Parks and Meat Naturally Africa. Their participation in the study was due to their continuous interaction with the communities residing adjacent protected areas and offering governmental services to the farmers and communities.

Data was collected through a series of workshops and focus group discussions. These engagements were aligned with a broader project led by the Vhembe Biosphere Reserve, which aimed to understand the challenges faced by communities residing adjacent to protected areas and to explore possible community-based solutions. Within these discussions, the role of livestock farming as a sustainable food system emerged as a critical theme.

The use of Focus Group Discussions (FGDs) provided rich, in-depth, and contextual data from local farmers, capturing their perspectives, challenges, and knowledge of traditional farming systems. This was supported by Shella (2024) from the UNFCCC Cop 29 Report, who stated that there is a need for engaging and consulting with the local communities while also being there to build an experience on the communities around the world where the lesson and discussion must serve as a strong foundation for comprehension and adaptation plan.

In addition to primary data collection, the study also employed secondary data collection methods to support and contextualize the findings. This included a comprehensive literature review of existing studies, reports, and relevant documentation concerning livestock farming in Matiyani and surrounding areas. A desktop study was used to access data related to sustainable food systems, using academic databases such as Web of Science, ScienceDirect, Taylor and Francis, SpringerLink, and Wiley Online Library. Additional sources included books, book chapters, peer-reviewed journal articles, newspaper bulletins, conference proceedings, and grant and project reports, including reports from the Vhembe Biosphere Reserve. The data collected covered a critical historical period marked by South Africa's transition from apartheid to democracy, which significantly impacted land access and use, particularly in rural areas such as Matiyani.

A purposive sampling technique was used to select participants for the study. The participants were identified as based on their long-standing engagement in livestock farming, with experience spanning over 30 years. Their participation provided valuable insights into traditional farming practices and how livestock farming supports their livelihoods, household food security, and socio-economic resilience. In total, the study engaged 50 local livestock farmers and several regional stakeholders, including agricultural extension officers, livestock specialists, and officials from the Vhembe Biosphere Reserve, who also played a facilitative role in the data collection process. The qualitative data was analyzed using thematic analysis, enabling the identification of key patterns, recurring issues such as the human wildlife conflict, and emerging themes related to livestock farming practices in the context of sustainable food systems. This methodological approach allowed for an in-depth exploration of the interconnected factors that influence livestock farming in the community and the broader implications for sustainability, resilience, and local development within the Vhembe Biosphere Reserve.

3.1 Description of the study area

The Vhembe Biosphere Reserve is known for its rich biodiversity, which includes the Soutpansberg Mountain Range, which is a key area for endemism and the source of the large catchment in the region, which is the Luvuvhu catchment. This catchment is by both livestock and communities for consumption and usages. The biosphere reserve is also recognized for its wealth of Indigenous knowledge that is shared among its three dominant cultural groups (Vhavenda, Vatsonga and BaPedi). Indigenous knowledge plays a vital role in environmental conservation and agricultural practices as communities share and apply this knowledge in the management of natural resources and daily practices. Furthermore, the Vhembe Biosphere Reserve is dominated by agricultural activities, which are supported by fertile soil and climate conditions (Linden et al., 2014).

This component supports crop and livestock farming, which is carried out in the community through subsistence or commercial farming due to the fertile land that allows for agricultural practices. This agricultural richness and practices are reflected in the Matiyani village in the biosphere reserve. The Matiyani village is located on the western boundary of Kruger National Park (KNP), 500 meters from the Punda Maria gate entrance in the northern cluster of KNP (Ledwaba, 2021). The village falls under Collins Chabane Local Municipality, within the Vhembe District Municipality, in the Limpopo Province, South Africa. The geographical coordinates of this community are -22.74594 south and 30.96797 east.

The area experiences a subtropical climate that is characterized by a warm summer, and mild winters and receives seasonal rainfall during the summer months (November–January). These climatic conditions are suitable for farming practices, influencing the community members to engage in cultivating cash crops such as maize, okra and tomatoes, as well as venturing into livestock farming, which predominantly includes cattle, chicken and goats. This agricultural practice also assists the communities to sustain their livelihoods (Figure 2).

4 Study findings and discussion

4.1 Livestock farming in the Vhembe Biosphere Reserve

African communities have been involved in livestock farming for many years. Livestock farming plays an important role in sustaining food systems and supporting rural economies (Varijakshapanicker et al., 2019). In Matiyani village, livestock farmers raise cattle, goats, pigs and chickens. Cattle are the most common in the community, raised through extensive and nomadic methods. Cattle and goats are taken out to graze, taking advantage of the rich biodiversity in the Vhembe Biosphere Reserve. Farmers make efforts to ensure that in all these livestock, food provided is without or with less synthetic chemicals such as pesticides and fertilizers.

Pigs and chickens have also been previously raised with an allowance to move around the yard, with shelter provided as well. However, their demands have transformed the manner in which they are raised, with a focus on intensive farming. This is where they are provided controlled shelter in efforts to maximize profit. In the community, the cattle and goats are raised for meat and milk, pigs for meat, and chickens for meat and eggs. The products of livestock farming have been relied on by communities for subsistence. Manner in which they are raised, with a focus on intensive farming.

This is where they are provided controlled shelter in efforts to maximize profit. In the community, the cattle and goats are raised for meat and milk, pigs for meat, and chickens for meat and eggs. The

products of livestock farming have been relied on by communities for subsistence. In most cases, as highlighted by the farmers, bartering takes place between members of the community to ensure that everyone has access to food. This is especially common among those who rely more on crop farming and have fewer livestock. In such cases, bulls are often lent to assist with reproduction and to introduce a variety of breeds within the kraal, with the Nguni breed being the most common.

The practice of lending bulls in the South African context is mainly to support reproduction and the sharing of breeding stock. This tradition is deeply rooted in local culture and plays an important role in promoting genetic diversity, social cohesion, and herd improvement (Muchenje et al., 2019). This practice is also common in other African countries. For example, in Botswana, lending bulls helps to increase breed variety and improve resistance to diseases. In Zimbabwe, it is used to improve the quality of herds and to prevent inbreeding among cattle.

Livestock has also been a source of capital in the indigenous communities. The possession of a large herd of cattle has been perceived as a sign of wealth and standing and is often a source of pride for many farmers in African communities (Kenya Wildlife Safari, 2015). During African indigenous rituals, cattle, goats and chickens are used for libation and appeasing ancestors. Cattle are valued more and are used as a form of currency in marriage negotiations. The migration from cattle to money as bride price has not changed the concept, in that the money provided by the groom is still referred to as “*kholomo*” (cow or cattle) for initiating marriage in African communities (Aasoglenang et al., 2024).

LOCALITY MAP OF VHEMBE BIOSPHERE RESERVE, LIMPOPO, SOUTH AFRICA

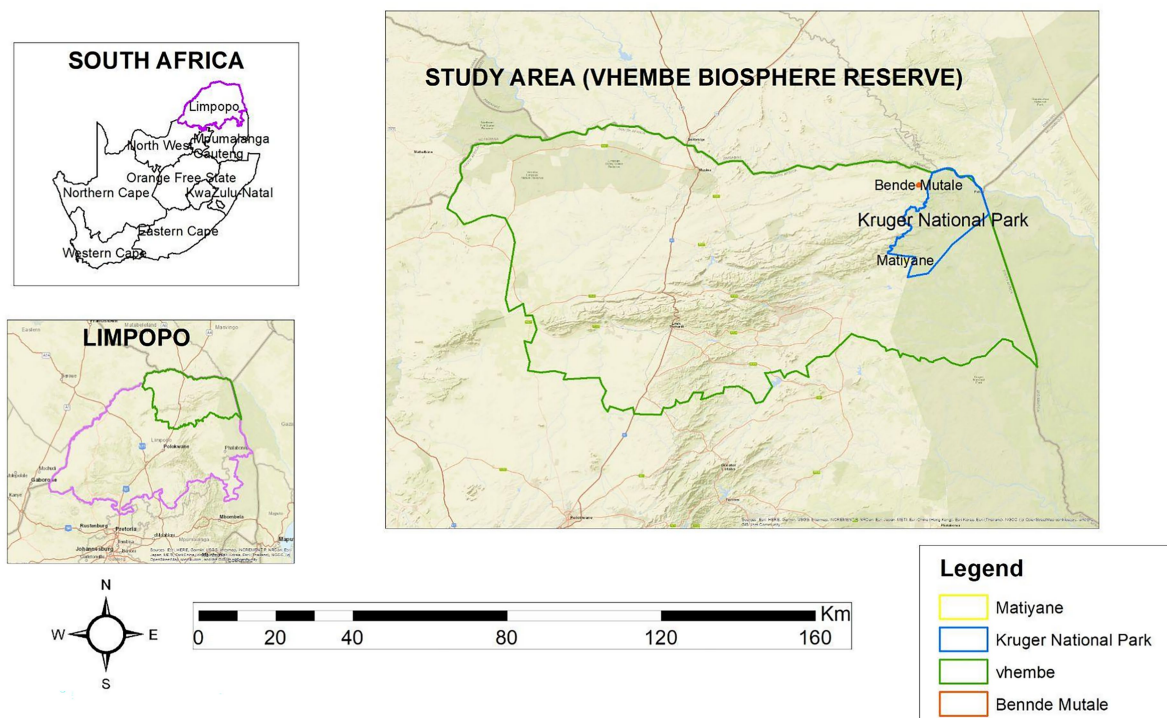


FIGURE 2
The map of the study area (Vhembe Biosphere Reserve, 2022).

4.2 The role of livestock in rural communities livelihoods

Livestock farming continues to play a crucial role in the livelihoods of rural communities situated near protected areas, such as those encompassed within the biosphere reserve. Insightful data was gathered from focus group discussions with 29 livestock farmers from the Hlanganani Livestock forum, underscoring the multifaceted importance of livestock farming in terms of economic, cultural, nutritional, crop farming, and ecological dimensions.

The findings of this study establish that the primary reason farmers keep livestock, particularly cattle, is to provide food. Most households depend on livestock as a direct source of meat and milk, which are essential for nutrition and food security. The community has limited access to alternative protein sources, thus these livestock products significantly contribute to daily dietary needs, helping to combat malnutrition and hunger, especially as the community is located in a remote area.

Furthermore, all the farmers indicated that they generate income through frequent sale of livestock to meet pressing financial obligations, such as paying for school fees, healthcare, and household needs. This was further supported by a farmer who highlighted that three of his children received their university registration fee and graduation money from the sale of his oxen at a price of Rs. 13,500 each which has been a common practice. This practice is critical in sustaining livelihoods and providing a financial safety net. During financial hardships, the ability to sell a cow or goat can be viewed between economic resilience and poverty (People in Need, 2024).

Farmers also sell livestock occasionally, during holidays when the majority of the people are on break from work. During the Good Friday season, goats are bought for consumption and spiritual purposes, young men enjoy pork during their relaxation times, thus a result in a huge sales of pigs at a price of Rs. 2,350 each. Cows are bought, particularly for events. However, during the festive season in December, families buy a cow for beef. In some cases, community members who enjoy beef join stokvels, traditional savings groups, where each contributes a fixed monthly amount, such as Rs. 2,000 from January to December, to assist in the collective purchase of cattle and essential household goods. This shared investment model is especially common among rural women and has been documented in Limpopo and other provinces as a way to strengthen food security and economic resilience (Verhoef, 2001; Mulaudzi, 2016; Mago and Hofisi, 2014).

Dairy production and small-scale value addition were identified as emerging opportunities, particularly for women and youth. Women are typically responsible for milking cows and processing milk into products such as sour milk (amass) and butter, which are sold in the community and to the nearby markets. This empowers women economically and increases household resilience.

Additionally, animal by-products, such as hides and skins, are used in traditional celebrations such as the inauguration of the king and in interior decoration in the palaces. In other cases, animal by-products are also used to make craft items such as bags, wallets, shoes, and traditional drums, promoting local entrepreneurship and cultural preservation. This practice is also being implemented in other African countries such as Mozambique, where the communities residing adjacent to Banhine National Park, under the Peace Park Foundation Program, are making shoes and

backpacks from cattle skin and selling them locally and internationally. This has resulted in the creation of employment and economic activities.

These practices are also found in Kenya and Ethiopia, where women and youth play a key role in small-scale dairy processing of milk into products such as mursik, ayib, and spiced butter for sale. These practices have been highlighted not only for strengthening household economies and food security but also for promoting cultural heritage and local entrepreneurship, thereby contributing to a sustainable food system, especially for rural communities.

The third major function of livestock identified during the focused group discussion with the farmers was agricultural support, particularly through the use of oxen for plowing and cultivation. The use of oxen for plowing and cultivation is a well-documented agricultural practice across many African countries, especially in rural communities such as Matiyani. Matiyani village lacks access to mechanized farming equipment due to financial and infrastructural constraints, and animal traction continues to be a practical and sustainable method for crop production.

This reinforces the interdependence of livestock farming and local food systems. This practice has been deemed efficient, especially in Burkina Faso, where animal traction has shown labor efficiency for poorer households by enabling timely land preparation. This method of animal traction is further viewed as a climate-smart farming strategy (Koussoubé and Nauges, 2017).

Cultural significance emerged strongly as another key driver of livestock keeping. Cattle are often used in traditional ceremonies, such as lobola (bride price), funerals, and initiation rituals. On the other hand, goats are usually preferred when performing libations and other activities informed by the ancestral or spiritual beliefs (Rankoana, 2024). These cultural practices are vital for maintaining social identity, heritage, and cohesion, and they affirm the community's connection to ancestral customs, their significance in that they become a bridge between the physical and spiritual realm. Livestock are viewed not only as assets but also as symbols of status, legacy, and respect (Salmon et al., 2018).

A significant insight from the discussions was the employment potential of livestock farming. Farmers reported hiring 50% of young people, especially boys to herd animals, thereby reviving a practice that had declined in recent decades. This form of employment provides youth with skills in animal husbandry, basic veterinary practices and entrepreneurship. These skills that the youth acquire through herding do not only contribute to livestock management and herding but also contribute to building resilience through the management of the grazing land for the livestock.

The skills further promote a sense of responsibility, social cohesion and offer a valuable foundation for future employment and leadership roles in rural or urban setting. This practice of herding has been seen in serving as a proactive measure to reduce youth idleness and related social issues, such as substance abuse and crime. As discussed above, the primary objective of farming is the production of food or products that can be processed and consumed. However, the increasing demand for meat, eggs and dairy products in South Africa has led to the commercialization of livestock farming in South Africa. This has resulted in most farmers engaged in the trade of livestock and products, particularly with the rise of unemployment. The contribution of livestock farming in the Vhembe Biosphere Reserve contributes directly and indirectly to sustainable food systems.

This means that livestock farmers who produce for commercial purposes can generate income to support them in accessing other food items, thus addressing food insecurity (Varijakshapanicker et al., 2019). The form of employment created sometimes allows for other members of the family and community to be employed and earn money to support themselves. The sale of meat, milk and eggs is not limited to generating income to purchase other food items. The study establishes that for a sustainable food system to be achieved, there must be other ways to fight against poverty. Farmers use their profit to send children to school, with the idea that the employment of their children after completing school is a way to ensure there is household food security. This means that the quest for education allows for members of the community to accelerate their food access means, thereby ensuring food security.

It is important to note that livestock farming provides access to food that is high in protein, vitamins, and minerals, making it crucial for human nutrition (Flores and Manzano, 2020). The food system cannot be sustainable if the food produced harms the human body. This is important in a society that fights against malnutrition and food insecurity, thus contributing to the SDG's as per the above discussions.

Cattle, pig and chicken waste are used by crop farmers as natural fertilizers. Crops are usually grown by small-scale farmers who rely on them for subsistence and the sale of produce. There is a growing interest in producing crops for income generation, thus the dependence on livestock waste as organic fertilizers which further promotes the notion of circular economy within the communities (Gamage et al., 2023). Crop farming activities in Africa, have relied on cattle for years, which are further used by crop farmers to plow and plant. The concept of a sustainable food system focuses on transforming agriculture and global food systems to end hunger and achieve food security by reshaping the productivity of both livestock and crop farming.

The aim is to ensure that food systems cater to the needs of poor and marginalized groups, while also being environmentally sustainable, resilient, and capable of delivering healthy and nutritious food for all (Nguyen, 2018). Insights from a focus group discussion with the Matiyani livestock farmers revealed that livestock herding and management have been instrumental in sustaining the livelihoods of local farmers. This has been achieved while simultaneously contributing to environmental conservation through community-enforced grazing patterns, despite ongoing challenges such as human-wildlife conflict.

The three pillars of a sustainable food system which are economic, social, and environmental sustainability, are already being practiced by the Matiyani community. Economic sustainability is evident through the sale of livestock for traditional celebrations, as well as the employment of local herders, which injects income into the community. Social sustainability is reflected in the way livestock ownership sustains livelihoods and enhances social status and wealth, contributing to community cohesion and resilience.

Lastly, environmental sustainability is promoted through controlled grazing patterns that prevent land degradation. Furthermore, there is an emerging interest in exploring carbon credit opportunities once the community is adequately capacitated, which could provide both environmental and financial benefits. Thus, these practices illustrate the ultimate goal of a sustainable food system, ensuring that food production not only feeds people but also empowers communities and protects the environment.

4.3 Understanding the challenges hindering sustainable food systems for livestock farmers in Matiyani village

Communities within the Vhembe Biosphere Reserve rely on livestock and crop farming as primary economic activities, influenced by both cultural traditions and climatic conditions. The farming practices within the region are successful and possess benefits for the communities; however, over time, there has been a shift from subsistence cattle farming to commercial livestock farming due to economic pressures and social challenges, including unemployment.

With this transition, livestock farmers in Matiyani Village are faced with numerous obstacles that hinder the development of sustainable food systems. These challenges include land degradation, limited grazing areas, disease outbreaks, inadequate veterinary services, extreme weather conditions, stock theft, and restricted market access. These factors contribute to poor livestock productivity, food insecurity, and economic instability (Mgomezulu et al., 2024). The practice of livestock in Matiyani village, is important in enabling food security. However, as mentioned above, the practice has its challenges. These challenges experienced in the communities have affected the achievement of establishing sustainable food systems and these challenges are discussed below, which are the findings from the focused group discussion with the farmers.

4.3.1 Land degradation and limited grazing areas

Communal land in Matiyani Village is collectively managed, making effective regulation of land use difficult. Increasing settlements and infrastructure development have reduced available grazing land. Overgrazing and bush encroachment have further deteriorated pasturelands, leading to poor livestock nutrition. According to (Mwale et al., 2021) communal land-use effectiveness is often questioned due to declining agricultural output, which exacerbates rural poverty and food insecurity. The scarcity of grazing land forces farmers to travel long distances in search of suitable pastures, increasing operational costs and reducing cattle productivity.

4.3.2 Veterinary challenges and disease outbreaks

Matiyani Village is located near the Kruger National Park (KNP) Punda Maria Gate, placing it in a designated Foot and Mouth Disease (FMD) red line zone. The proximity to the park increases the risk of disease transmission between wildlife and livestock, particularly from buffalo carrying FMD (Jori and Etter, 2016). In 2022, South Africa experienced a widespread outbreak of FMD, affecting six out of nine provinces and leading to temporary bans on certain exports (Sihlobo, 2023). The redline zone classification restricts farmers' ability to trade or sell cattle in formal markets, limiting their economic opportunities compared to farmers in non-restricted areas. Additionally, veterinary services in this remote area are scarce, making it difficult for farmers to access vaccinations and treatments. Farmers also struggle to administer correct dosages of veterinary medicine due to a lack of training and difficulty interpreting medication labels (Mwale et al., 2021).

4.3.3 Climate change and extreme weather conditions

Matiyani Village experiences high temperatures, often reaching up to 40°C, worsening drought conditions. A study by Mazibuko

et al. (2021) found that climate variability has led to increased livestock losses due to heatwaves, dry spells, and heat-related diseases. Droughts result in water shortages and poor-quality grazing pastures, forcing farmers to sell livestock at low prices to reduce losses. Farmers report high cattle mortality rates due to food and water scarcity, with extreme weather events causing severe economic losses (Cottrell et al., 2019). The impact of climate change on livestock farming threatens food security and complicates efforts to transition to sustainable agricultural practices.

4.3.4 Stock theft and human-wildlife conflict

Stock theft is a significant issue in Matiyani Village, with cattle frequently stolen and smuggled through KNP into Mozambique. According to Bunei and Kariaga (2016), stock theft negatively impacts food security and livelihoods, as farmers incur additional costs for security measures. The broken fence along the KNP boundary facilitates illegal activities, allowing both wildlife and criminals to move freely. Studies indicate that farmers attribute 11% of livestock losses to predation, 3% to theft, and 23% to diseases like FMD (Mapiye et al., 2018). Farmers rarely receive compensation for cattle lost to theft or predation, further discouraging livestock farming.

4.3.5 Invasive alien species and reduced forage availability

Invasive alien species (IAS) are non-native plants introduced through human activities, causing economic and ecological damage (Eschen et al., 2021). In the Vhembe Biosphere Reserve, bush encroachment and road development have increased the presence of IAS such as sickle bush and bikiboom (Vag'abikieboom), which reduce the availability of nutritious forage (Qwabe and Zantsi, 2024). The spread of these invasive plants negatively affects grazing land, forcing farmers to rely on expensive supplementary feed. The financial burden is intensified by the redline zone classification, which limits sales. African countries spend approximately USD 65.58 billion annually managing IAS (Eschen et al., 2021).

4.3.6 Restricted market access

Due to Matiyani Village's classification as a Foot and Mouth Disease red zone, cattle movement is highly restricted. Farmers cannot sell their livestock in formal markets, leading to lower income and limited economic opportunities. The absence of proper market linkages further exacerbates financial difficulties, as farmers must rely on informal sales at lower prices. Limited access to government-supported markets and agricultural subsidies prevents farmers from scaling up their businesses and improving their economic resilience.

In one Focus Group Discussion, farmers recognized the implementation of the Herding for Health model, facilitated by organizations such as Meat Naturally Africa and the Peace Parks Foundation. The model promotes improved grazing practices, including rotational grazing and controlled veld burning, and provides veterinary care through vaccination programs. Importantly, it links farmers to structured, formal markets where livestock can be sold at fairly competitive prices. This contributes to a more sustainable food system and reduces environmental degradation by maintaining healthy grazing lands. It also plays a critical role in mitigating human-wildlife conflict by encouraging the use of designated grazing zones and better herding practices.

4.3.7 Water access

One of the persistent major constraints within the Mhinga region is the availability of water, both for livestock and community members. These communities lack boreholes or reliable water points. This compels livestock to travel long distances, often into protected areas, where they may not return or may face predation. Additionally, it was highlighted that the farmers purchase water for their livestock on a daily basis as a way to tend to them, but this becomes an expensive running cost for the farmers, especially during the winter season.

4.3.8 Protect areas fence

The issue of broken or stolen park fencing was raised frequently. Without secure boundaries, cattle encroach on conservation land, escalating tensions between farmers and conservation authorities. The lack of clarity regarding who holds responsibility for fence maintenance between the government, park authorities, or communities further complicates resolution efforts. In most of the communities adjacent to the park, the fence has been vandalized both by wildlife and community members. In Matiyani, it was highlighted that near the Thulamela Mountain, there is a 5 km distance where the fence has fallen off and no repairs have been made this far. This increases the chances of predation and also livestock theft.

Traditional leaders and former park rangers voiced concerns about the decline in governance and accountability. Under previous political systems of the Apartheid Regime, clear rules and enforcement mechanisms ensured cooperation between communities and park officials. However, the current post-democratic landscape has seen a weakening of these relationships, marked by inconsistent engagement and diminished trust.

5 Recommendations

Livestock farming in these rural areas extends far beyond its role in food production. It embodies a deeply rooted socio-cultural system that supports livelihoods, promotes community identity, and sustains the rural economy. To fully harness its benefits while mitigating associated challenges, a collaborative approach is essential, which involves government entities, non-governmental organizations, traditional authorities, and the farmers themselves. Interventions such as Herding for Health have been presented by participants to provide a promising model, but long-term success will depend on inclusive decision-making, infrastructure investment, and the restoration of strong community-governance relationships. This further provided recommendations on the main challenges that livestock farmers within the region are currently facing.

To mitigate the impact of extreme weather events such as heatwaves and droughts, farmers should implement scheduled grazing periods, adjust livestock numbers, and conduct controlled veld burning. Additionally, they should administer livestock vaccinations and procure supplementary feed and protein supplements to enhance livestock resilience (Archer et al., 2021). Addressing FMD challenges requires collaboration between farmers, veterinarians, and animal health technicians to enhance surveillance, monitoring, and disease management. Farmers should receive guidance on increasing livestock productivity, optimal selling periods, and adopting sustainable farming practices to conserve the environment and improve animal wellbeing (Sihlobo, 2023).

Stock theft and human-wildlife conflict remain significant issues, particularly for communities near protected areas. Strengthening partnerships between local communities, South African National Parks (SANParks) crime prevention teams, and the South African Police Service (SAPS) within their anti-stock theft structure is essential in mitigating these challenges.

6 Conclusion

Agriculture is the backbone of rural economies in sub-Saharan Africa, with livestock farming playing a key role in food security, economic stability, and cultural identity. In Matiyani Village, livestock farming helps sustain livelihoods, provides nutritional benefits, and supports the local economy. However, challenges such as land degradation, climate change, restricted market access, and human-wildlife conflict limit its full potential in contributing to a sustainable food system.

This study highlights these challenges but also emphasizes the importance of developing solutions to help the community overcome them. Furthermore, collaboration between the government departments and nonprofit organizations is essential to supporting small-scale farmers in rural areas, particularly in indigenous communities. By providing resources and assistance, these partnerships can help farmers become more self-sufficient, with surplus production contributing to local economic growth. Strengthening these efforts will ensure that livestock farming continues to play a meaningful role in building a sustainable food system. The rich biodiversity in the Vhembe Biosphere Reserve is important for livestock farming activities. This does not make the VBR immune to challenges as presented above. However, the existence of challenges in this case presents an opportunity for collaboration between livestock farmers and various stakeholders.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Ethics statement

The studies involving humans were approved by the Vhembe Biosphere Reserve Board. The studies were conducted in accordance with the local legislation and institutional requirements. The

participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

MK: Visualization, Supervision, Formal analysis, Writing – original draft, Data curation, Software, Validation, Methodology, Conceptualization, Investigation, Writing – review & editing. AB: Investigation, Conceptualization, Software, Writing – original draft, Data curation, Formal analysis. RR: Funding acquisition, Resources, Data curation, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that Gen AI was used in the creation of this manuscript. We used ChatGPT for proofreading the work.

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