



# The Impact of Climate Change on Goat and Sheep Farming Systems in Southern Africa: A Narrative Review

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## ABSTRACT

Smallholder goat and sheep farming is a critical component of rural livelihoods in Southern Africa. Climate change has, however, aggravated the situations of drought, heat stress, and disease burdens, which threaten the productivity of small ruminants. The present review aimed to determine the multidimensional effects of climate change on goat and sheep farming in Southern Africa, to analyze existing adaptation measures, and identify policy measures to build resilience. The current review used Google Scholar, Scopus, and PubMed to cover peer-reviewed articles and grey literature published between 2014 and 2025. Based on the inclusion criteria, 102 articles were initially screened, and 51 articles were considered for the narrative review. The review focused on studies conducted in South Africa, Namibia, Botswana, Zimbabwe, and Lesotho. The results indicated a strong relationship between climate variability and decreased ruminant productivity, driven by pasture degradation, water shortages, heat stress, and limited access to veterinary services in Southern African countries. Additionally, the results showed that adaptive strategies include the use of indigenous breeds, drought-resistant feeding, and ethnoveterinary practices to cope with climate variations. The present narrative review highlights the importance of adaptive strategies and integrated policies in Southern African countries for sustaining the development of small ruminant farming amid climate variability.

**Keywords:** Climate change, Heat stress, Rangeland management, Small ruminant

## INTRODUCTION

Goat and sheep farming is a significant part of rural livelihoods and food systems in Southern Africa, supplying meat, milk, income, and cultural value to millions of smallholder farmers (Mapiye et al., 2020). Furthermore, studies revealed that goats and sheep are among the most climate-resilient livestock species, which are widely reared in arid and semi-arid regions where crop agriculture is often unsustainable due to climate variability (Joy et al., 2020; Nair et al., 2021). Hence, climate changes associated with rising temperatures, droughts, erratic rainfall patterns, and variations in the frequency of extreme weather events are regarded as a serious threat to the sustainability of goat and sheep production systems across the region (Ben Moula et al., 2024).

Climate-induced challenges negatively affect pasture availability, including access to water sources, thereby reducing reproductive performance and animal health, leading to decreased productivity and increased vulnerability, especially among small-scale farmers (Bahta et al., 2019; Zhou et al., 2022). Furthermore, climate change exacerbates socio-economic challenges by limiting access to veterinary care, undermining markets and infrastructure, and disrupting agricultural support services, which disproportionately impact marginalized rural communities (Stephen and Soos, 2021; Mthembu et al., 2025). In this context, the resilience of goat and sheep farming systems depends not only on the animals' inherent adaptability but also on the implementation of specific strategies that improve management practices and supportive policy frameworks. The current study aimed to investigate the effects of climate change on goat and sheep production in Southern Africa, including challenges, adaptation options, and policy implications for sustainable, climate-resilient livestock production systems.

## STUDY AREA

The present study focused on specific countries in the Southern African region, such as South Africa, Namibia, Botswana, Zimbabwe, and Lesotho, where goat and sheep production is vulnerable to climate change. Countries in this region experienced diverse agroecological conditions and shared challenges, including rising temperatures, rangeland degradation, irregular rainfall patterns, and prolonged drought. Several studies indicated that provinces such as Kgalagadi in Botswana (Mphale et al., 2014), the Eastern Cape in South Africa (Mahlalela et al., 2020; Mahlalela, 2023),

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and Kunene in Namibia (Mahlalela *et al.*, 2020; Mahlalela, 2023) are experiencing reduced annual rainfall and increased dry spells; this trend has impaired access to water and forage (Zhou *et al.*, 2022; Mutengwa *et al.*, 2023). Additionally, studies by Turpie *et al.* (2010) and Mutengwa *et al.* (2023) highlighted the impacts of climate change intensification, including heat stress, decreased pasture quality, water shortages, and increased disease prevalence in goat and sheep farming systems.

According to studies of Baleseng *et al.* (2016) and Bolowe *et al.* (2022) in Southern Africa, goat and sheep farming production differ from semi-intensive mixed production to extensive communal grazing, mostly influenced by local practices and resource availability. Notwithstanding these variations, climate-related hazards are a common occurrence in all the chosen regions, necessitating the development of regional adaptation plans. To improve the resilience and sustainability of goat and sheep farming in Southern Africa, policies and interventions must be guided by an understanding of the climatic context and regional vulnerabilities.

## STUDY DESIGN

A narrative review approach has been employed to synthesize the effects of climate change on goat and sheep production systems in Southern Africa. A comprehensive literature search was conducted between January and May 2025 using Google Scholar, Scopus, and PubMed databases. The search strategy incorporated Boolean operators (AND/OR) with keywords including “climate change”, “goat farming”, “sheep production”, “Southern Africa”, “drought resilience”, “adaptation strategies”, and “policy response”. Articles published between 2014 and 2025 were included in the studies, such as peer-reviewed articles and the grey literature. Geographical relevance (Southern Africa), thematic focus (climate impacts, adaptation, and policy), and publication language (English) were used as inclusion criteria.

One hundred and twenty-two records were found. Titles and abstracts were filtered after eliminating duplicates, and the full texts were finally filtered. Finally, 51 studies were included in the review, as they met the inclusion criteria. The thematic analysis was used to extract and synthesize data to determine common patterns in climate impacts, adaptation strategies, and policy responses in the region.

The narrative review considered publication titles and abstracts, obtained through a primary electronic search and was thoroughly examined for the possibility of inclusion. Duplicate articles were removed, and article titles and abstracts were thereafter screened for relevance, resulting in the exclusion of unrelated studies. Additionally, full texts were evaluated, and unrelated studies were excluded.

**Table 1.** The inclusion and exclusion criteria for the present study

Criteria type	Inclusion criteria	Exclusion criteria
Geographical scope	Studies conducted in South Africa, Namibia, Botswana, Lesotho, or Zimbabwe	Studies outside the Southern African region
Population	Studies focusing on goat and/or sheep farming systems in Southern African countries	Studies focused solely on cattle or poultry without mention of goats/sheep
Climate focus	Studies addressing climate change, variability, drought, temperature, or rainfall effects on farming	Articles with no reference to climate change impacts
Language	English	Non-English publication
Publication type	Peer-reviewed articles, governmental and non-governmental organization (NGO) reports, and credible grey literature	Opinion pieces, blogs, and non-scientific commentaries
Time range	2014-2025	Publications before 2010 (unless highly cited and foundational)
Themes covered	Climate impact, adaptation strategies, resilience, and policy implications	Studies not addressing at least one of the core themes of the review

## CONCEPTUAL FRAMEWORK

The narrative review was guided by the Intergovernmental Panel on Climate Change (IPCC) vulnerability framework, which describes climate risk as dependent on three fundamental components: exposure, sensitivity, and adaptive capacity. Farming systems for goats and sheep in Southern Africa are increasingly at risk due to rising temperatures, uneven rainfall distribution, and frequent droughts. Such climatic stresses are exacerbated by systemic issues in ecosystems and dependence on large-scale production systems. Adaptive capacity in farming communities is uneven and is attributed to social, economic, institutional, and knowledge-based factors. The present study assessed the interactions among climate stressors, vulnerability, and systemic weaknesses, highlighting the diversity of local responses that influence resilience and long-term sustainability.

## CLIMATE IMPACTS ON GOAT AND SHEEP FARMING

Climate change in Southern Africa has profound, multidimensional effects on livestock production, with goat and sheep farming systems appearing to be the most adversely affected (Zhou et al., 2022). Substantial stressors include the increasing frequency of extreme weather events, recurrent droughts, rainfall variability, and rising ambient temperatures (Nhara et al., 2020; Zhou et al., 2022). According to Mudau et al. (2022) and Zhou et al. (2022), climate fluctuations, such as droughts, rainfall variability, and the increase in extreme weather phenomena, decrease pasture availability, contribute to rangeland degradation, and reduce water sources, all of which are critical for the survival and productivity of small ruminants. Previous studies indicated that nutritional stress and elevated temperatures adversely influence reproductive performance, milk yield, and disease resistance in goats and sheep, particularly in low-input systems such as smallholder farms relying on minimal external resources (Mandleni and Anim, 2011; Kraai et al., 2022; Cooke et al., 2023). Furthermore, increased parasite infestation and reduced body weight gains have been linked to the intensity of climate-induced heat stress, thereby contributing to higher mortality rates among goats and sheep (Ben Moula et al., 2024). Studies by Ngaka (2012) and Inman et al. (2020) have demonstrated that regions such as the Eastern Cape and Free State in South Africa, as well as Kunene in Namibia, experienced substantial herd losses during periods of extreme drought.

Climate variations in Southern Africa have led to significant mortality among goats and sheep across several countries. For instance, in the KwaZulu-Natal Province of South Africa, the drought caused by El Niño during 2015-2016 led to a 29% mortality rate among goats due to insufficient food and water supply (Vetter et al., 2020). National herd assessments in Botswana documented 18.3% goat and 15% sheep mortality, which is significantly above the 2-5% (Ramabu et al., 2024). In Zimbabwe, the official report from the Ministry of Lands, Agriculture, Water, and Rural Resettlement (2020) indicated that the mortality rates of goats (23%) and sheep (17%) were directly linked to the drought-affected season (Risk, 2020). Meanwhile, in Namibia, the study by Marius et al. (2021) indicated that numerous reports of losses in goats and sheep have been documented due to drought. Furthermore, smallholder farmers in Lesotho regularly report livestock deaths due to drought, but quantifiable mortality statistics have not been recorded (Mojaki et al., 2025).

Studies conducted in Southern Africa showed that climate change exerts diverse and interconnected stressors on goat and sheep production systems (Zhou et al., 2022). The impact of climate change in Southern Africa has been observed in countries such as South Africa (Mahlalela et al., 2020; Kraai et al., 2022), Namibia (Inman et al., 2020), Botswana (Seleka, 2001; Kgosikoma and Batisani, 2014), Zimbabwe (Mhlanga et al., 2018; Bvirwa et al., 2023) and Lesotho (Gwimbi, 2015; Tsese, 2023), whereby stressors such as erratic rainfall patterns, prolonged droughts, increased temperatures as well as the intensification of extreme weather events within the region has impact negatively the goat and sheep production systems. Several studies of Halimani et al. (2021), Slayi et al. (2022), and Letsoalo et al. (2023) on the Eastern Cape in South Africa revealed that climate-induced droughts in this province have led to widespread rangeland degradation and negatively impacted herd sizes of small ruminants due to poor pasture availability and water access scarcity. In addition, the impact of heat and water stress in the Eastern Cape province of South Africa has been reported to reduce fertility and increase fertility problems in goats and sheep, resulting in decreased productivity (Halimani et al., 2021). Meanwhile, in the Kunene region of Namibia, a study by Kwembeya and Shikangalah (2023) reported a declining rainfall trend over the past decade, contributing to increased drought intensity. The effects of climate change have led to a decline in grazing lands, nutritional deficiencies, and rising mortality in goat and sheep herds, particularly among resource-poor communal farmers (Kwembeya and Shikangalah, 2023).

In Botswana, particularly in the Kgalagadi region, small farmers experiencing a prolonged dry season should consider seasonal migration as an essential strategy for securing water and forage (Kgosikoma and Batisani, 2014). Furthermore, studies by Mosalagae and Mogotsi (2013) and Kgosikoma and Batisani (2014) indicated that these conditions disrupt traditional grazing patterns and intensify competition for limited resources among cattle, goats, and sheep. In Zimbabwe, farmers in the southern provinces of Masvingo and Matabeleland South face persistent climate threats, including rising temperatures, a higher incidence of tick-borne diseases, and a significant reduction in birth rates (20-35%) during periods of climatic stress such as drought and extreme heat.

On the other hand, the high levels of climate-induced food insecurity have been reported among goat-reliant households in these two provinces, Masvingo and Matabeleland South (Homann et al., 2007; Ndlovu et al., 2020). Previous studies conducted indicated that people in the Lesotho highland primarily depend on small ruminants for food and income for their communities (Gwimbi, 2015; Grab et al., 2017; Matsepe et al., 2021). However, extreme cold events followed by warmer winter temperatures have affected the incidence of animal diseases. Furthermore, erratic snowfall and changing grazing cycles impair herd movement and health, thereby contributing to increasing helminth and ectoparasite burdens (Zhou et al., 2022). Additionally, the study of Zhou et al. (2022) demonstrated that in Southern African states, effects of climate change, such as decreased pasture quality, heat stress, water shortage, and the increased

risks of diseases, have all led to the decline in the production of goats and sheep and threaten the sustainability of such systems in the long run.

### **SOCIO-ECONOMIC AND INSTITUTIONAL CONSTRAINTS**

Socio-economic and institutional constraints influence the degree of adaptation of goat and sheep farmers to climatic challenges in Southern African countries. These barriers differ across countries but share a number of features across the region (Mutengwa *et al.*, 2023). In South Africa, particularly in the Eastern Cape and Limpopo provinces, the lack of access to veterinary services and extension support is sparse in remote rural areas (Zhou *et al.*, 2022). The situation is thought to be associated with poor road infrastructure, limiting market access and disease surveillance coverage. Different studies conducted in Namibia have demonstrated that the government has been interfering with drought relief programs but has taken inadequate action (Inman *et al.*, 2020; Treichel *et al.*, 2021; Menestrey Schwieger, 2023). For instance, Smallholders in Kunene and Otjozondjupa regions have indicated that access to supplementary feeds and vaccines is difficult due to costly transportation and disruption in the supply chains (Treichel *et al.*, 2021). Meanwhile, in Botswana, despite the government's efforts to provide veterinary medications, bureaucratic delays, insufficient policies, and poor planning regarding climate sensitivity undermined the overall quality of the programs in the country (Kgosikoma and Malope, 2016; Motsumi *et al.*, 2023). Furthermore, the studies of Kgosikoma and Malope (2016) and Motsumi *et al.* (2023) concluded that marginalisation of small producers involved in goat and sheep production, who are majority women and youth, is regarded as a factor limiting the distribution of resources and participation in decision-making processes. While in Zimbabwe, the recurrent economic instability and hyperinflation have contributed drastically to the affordability of livestock inputs across the country, making it difficult for farmers to maintain feeding regimes for their livestock properly (Ndlovu *et al.*, 2020). On the other hand, the majority of farmers were found to be not able to afford the implementation of climate-smart technologies. Moreover, market volatility discourages investment in small stock farming across the country due to poverty (Ndlovu *et al.*, 2020). Land tenure insecurity, more particularly in communal grazing systems, is pointed out as a factor restricting sustainable pasture management and long-term investment in climate adaptation practices in countries such as Lesotho (Gwimbi, 2015). In addition, in mountainous regions, veterinary services were underdeveloped, which increased disease incidence, and interventions were minimal (Stephen and Soos, 2021). These issues explain why goat and sheep production systems in the Southern African region are adverse due to weak institutional support, socio-economic marginalization, and policy coordination failure.

### **FARMER ADAPTATION STRATEGIES**

Farmers in Southern Africa have implemented localized adaptation policies, depending on the environment and the capacity of available resources. For instance, the study by Mapiye *et al.* (2020) revealed that in Southern Africa, communal farmers have adopted supplementary feeding systems or practices relying on crop residues and drought-tolerant forage such as lucerne and Moringa. Small-scale farmers are increasingly focusing on breeding indigenous livestock, such as Nguni and Boer goats, which are valued for their resilience to heat and disease (Mapiye *et al.*, 2020). Concurrently, in water-scarce regions such as Kunene in Namibia, communities depend on boreholes and community-managed water systems. Additionally, as noted by Schnegg (2016) and Schwieger *et al.* (2022), many farmers practice seasonal transhumance, moving their herds to higher altitudes during periods of extreme heat.

Indigenous knowledge-based seasonal calendars and rotational grazing practices have been adopted in Botswana to manage pasture usage (Kgosikoma and Batisani, 2014). Furthermore, in Botswana, an agroforestry-based intervention, including the planting of trees that provide both fodder and shade, has been implemented in this area as part of an experimental study with promising results (Cooke *et al.*, 2023). In the study by Maroyi (2012), it was shown that some smallholders have turned to zero-grazing systems for sheep and goats, especially in peri-urban zones of Zimbabwe, while others rely on alternative feeding practices such as herbal remedies and ethnoveterinary knowledge as affordable alternatives to scarce formal veterinary services or care. In Lesotho, roofed kraals, windbreak structures, and feed blocks produced by using crop residues are small-scale interventions that are being experimented with the aim of helping in improving animal welfare in situations of extreme cold and feed deficit (Mahlehlhla *et al.*, 2021). The knowledge-based practices have the potential; however, they are frequently adopted without institutional resources or financial constraints, making it difficult to expand them and achieve long-term results.

### **POLICY AND GOVERNANCE RESPONSES**

There is still insufficient and unequal policy support for the adaptation of small ruminants among the countries in Southern Africa. In South Africa, livestock is not explicitly mentioned in national climate plans. Budgetary allocation is limited, and there is no specific plan for small ruminants. Policies such as the Agriculture and Agro-processing Master Plan (AAMP) hold promise, but the execution is lagging (Zhou *et al.*, 2022). Namibia's national drought policy and

strategy provide a framework for livestock relief, although it does not make special considerations for goats and sheep (Turpie et al., 2010). It is imperative to align financial assistance, veterinary accessibility, and training to the requirements of communal farmers (Mutengwa et al., 2023). Meanwhile, in Botswana, the Integrated Support Program for Arable Agriculture Development (ISPAAD) has shown some success, but it mainly supports crop production rather than livestock (Mosalagae and Mogotsi 2013; Kgosikoma and Malope 2016). Moreover, dryland areas still lack a regionally coordinated framework to guide climate adaptation in the livestock sector (Motsumi et al., 2023).

The National Climate Policy in Zimbabwe highlighted the vulnerability of the agricultural sector; however, persistent institutional instability hinders interventions aimed at livestock. The majority of farmers rely on non-governmental organizations for assistance in climate-resilient practices. In Lesotho, the national adaptation program of action includes livestock-related activities; however, their implementation has been considerably constrained due to insufficient funding and a shortage of extension personnel.

## CONCLUSION

The production systems of goats and sheep in Southern Africa are particularly sensitive to the effects of climate change, with losses primarily caused by degraded pasture, water shortages, and shifts in disease patterns. Even though farmers have implemented various localized and indigenous-level adaptations, these measures are poorly organized and lack financial support for their long-term sustainability. Hence, integrating small ruminants into climate frameworks and nationally determined contributions (NDCs) will strengthen regional collaboration. Additionally, funding gender-sensitive climate-smart livestock for communal farmers, incorporating Indigenous knowledge into planning, and investing in climate-veterinary data systems to improve risk management will contribute to sustainable small ruminant production.

## DECLARATIONS

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### Authors' contributions

This review was conceptualized and designed by Baitshoetsi Gloria Mokolopi and Mpinda Edoaurd Tshipamba, who conducted the search and wrote the review. All authors reviewed and approved the final edition of the manuscript.

### Availability of data and materials

All data related to this study are prepared and presented in this manuscript.

### Competing interests

The authors declared no conflict of interest.

### Ethical considerations

The authors have verified potential ethical concerns, including plagiarism, agreement to publish, misconduct, and/or duplicate publication and/or submission, and redundancy. The authors confirm that no AI tools were used to prepare this study.

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