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Climate change impacts and mitigation strategies in Sub-Saharan Africa's livestock production sector. A brief review

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Climate change poses significant challenges to Sub-Saharan Africa's livestock production sector, threatening the livelihoods of millions and exacerbating food insecurity and poverty. This review paper comprehensively examines the impacts of climate change on livestock farming systems in the region, including changes in temperature, precipitation patterns, and the spread of diseases and pests. Additionally, it explores mitigation strategies to enhance the resilience and sustainability of Sub-Saharan Africa's livestock production sector, considering adaptation measures, sustainable livestock management practices, and policy interventions. By synthesizing existing research and identifying gaps in knowledge, this paper provides valuable insights for policymakers, researchers, and practitioners seeking to address the complex challenges posed by climate change in Sub-Saharan Africa's livestock production sector. Effective mitigation strategies are crucial for safeguarding livelihoods, promoting food security, and ensuring the long-term sustainability of livestock farming in the region.

KEYWORDS

sustainable agriculture, vulnerability, resilience, smallholder farmers, adaptation

Introduction

Sub-Saharan Africa's livestock production sector stands as a cornerstone of its agricultural economy, providing livelihoods for millions and serving as a vital source of food security and economic stability. For instance, A study from south Africa revealed the benefits from livestock to include; Food Clothing Work Monetary Social Manure Other benefits (Ngongolo et al., 2021; Stroebel, 2004). However, this sector faces escalating challenges due to the impacts of climate change. The region is particularly vulnerable to the adverse effects of climate change, with increasing temperatures, erratic rainfall patterns, and extreme weather events posing significant threats to livestock farming systems. For instance, a study by Thornton et al (2009) revealed that, climate change has impacts on the feed's availability, quality and quantity to livestock water and alters the transmission and epidemiology livestock diseases and their disease vectors. As global temperatures continue to rise, it is imperative to understand the specific impacts of climate change on Sub-Saharan Africa's livestock production sector and to develop

effective mitigation strategies to ensure its resilience and sustainability. Smallholders face constraints like farm size, market access, and knowledge gaps. Integrated assessments are needed for effective adaptation strategies. African mixed crop–livestock systems confront climate vulnerabilities, requiring vital adaptation for livelihoods. Smallholders face constraints, impeding resilience despite available solutions. Integrated assessments essential for effective strategies (Descheemaeker et al., 2016).

Sub-Saharan Africa's livestock production sector encompasses a diverse range of livestock species, including cattle, sheep, goats, poultry, and pigs, which are raised under various production systems ranging from extensive pastoralism to intensive commercial farming (Pandey and Upadhyay, 2022; Kaasschieter, et al., 1992). These livestock systems play a critical role in the livelihoods of rural communities, providing income, nutrition, and social capital (Sekaran, et al., 2021). However, they are highly susceptible to the adverse impacts of climate change, which manifest in multiple ways, including reduced forage availability, increased heat stress, heightened disease prevalence, and water scarcity.

In the Southern African Development Community (SADC), 30.6% face severe food insecurity, 8% are malnourished, and 50% live below $1/day (Mapiye et al., 2020). Agriculture, particularly cattle, plays a vital role. However, in Sub-Saharan Africa's livestock production sector is highly vulnerable to the adverse effects of climate change, including shifts in temperature and precipitation patterns, increased incidence of droughts and floods, and the spread of diseases and pests. These impacts jeopardize the health, productivity, and livelihoods of millions of smallholder farmers who depend on livestock for food, income, and assets (Baumgard et al., 2012). Urgent action is needed to address these challenges and safeguard the future of livestock farming in the region. In this case the paper focused on answering the following questions "How do climate change-induced stresses, such as altered precipitation patterns and temperature fluctuations, impact the productivity and resilience of Sub-Saharan Africa's diverse livestock species, considering both indigenous and introduced breeds? What are the most effective and contextually appropriate mitigation strategies for reducing the vulnerability of Sub-Saharan Africa's livestock production sector to climate change, taking into account socio-economic factors, cultural practices, and regional variations? How can sustainable land management practices, including agroforestry, rotational grazing, and soil conservation techniques, be integrated into livestock production systems in Sub-Saharan Africa to enhance resilience to climate change while promoting long-term environmental sustainability and food security?"

Justification

This review paper is justified by the urgent need to understand and subsequently address such complex interactions between climate change and livestock production in sub-Saharan Africa. Climate change impacts such as droughts and heavy rainfall have already affected the livestock sector and will cause further problems in the future. For example, research in Kenya suggests that an additional 1.8 million cattle could be lost by 2030 due to more frequent droughts. The estimated value of these lost animals, together with the production that will not take place, is around USD 630 million (Ericksen et al., 2013). The 2014 IPCC report provided little information on the expected impacts of climate change on livestock and livestock systems, for which much more detailed and comprehensive data is urgently needed (Thornton, et al., 2015). By analysing the impacts of climate change on this sector, as well as mitigation strategies, it aims to provide insights that will be useful to policymakers, researchers and practitioners. This review can provide valuable insights for evidence-based decision making and inform the design of targeted interventions aimed at enhancing the resilience and ensuring the sustainability of the livestock sector in sub-Saharan Africa in the face of the challenges posed by climate change.

Materials and methods

Literature review

A comprehensive review of peer-reviewed scientific literature was conducted using online databases such as PubMed, Web of Science, Scopus, and Google Scholar. Search terms included combinations of keywords related to climate change, livestock production, Sub-Saharan Africa, impacts, and mitigation strategies. Relevant studies, review articles, reports, and policy documents published between 2000 and 2023 were identified and analyzed.

Data collection

Data pertaining to climate change impacts on Sub-Saharan Africa's livestock production sector were extracted from selected studies, focusing on key variables such as temperature trends, precipitation patterns, livestock health, productivity, and socio-economic impacts. Data were organized and synthesized to identify trends, patterns, and gaps in knowledge.

Key findings from the review of the information

Impacts of climate change on the productivity and resilience of Sub-Saharan Africa's diverse livestock species

Climate change-induced stresses, including altered precipitation patterns and temperature fluctuations,

TABLE 1 Impacts of climate change in livestock production in Sub-Saharan Africa.

Sn	Impacts	Description	References
1	Altered Forage Availability	Changes in temperature and precipitation patterns affect vegetation growth, leading to fluctuations in forage availability and quality for livestock	Giridhar and Samireddypalle (2015)
2	Heat Stress	Rising temperatures result in heat stress among livestock, reducing feed intake, growth rates, and reproductive efficiency	Savsani et al. (2015)
3	Water Scarcity	Shifts in precipitation patterns can cause water scarcity, affecting drinking water availability for livestock and leading to dehydration and health issues	Naqvi et al. (2015)
4	Disease Spread	Climate change alters the distribution and prevalence of diseases and parasites affecting livestock, increasing the risk of disease outbreaks and requiring additional disease management measures	Bett et al. (2017)
5	Reduced Reproductive Performance	Heat stress and environmental changes negatively impact reproductive performance in livestock, leading to decreased fertility rates and lower productivity	Savsani et al. (2015)
6	Food Insecurity	Climate-related disruptions to agriculture can lead to food insecurity for both livestock and humans, impacting the availability and affordability of feed and fodder	Godde et al. (2021)
7	Economic Impacts	Climate-related challenges in livestock production can result in economic losses for farmers, affecting their livelihoods and contributing to broader economic instability in rural communities	Bogale and Erena (2022)

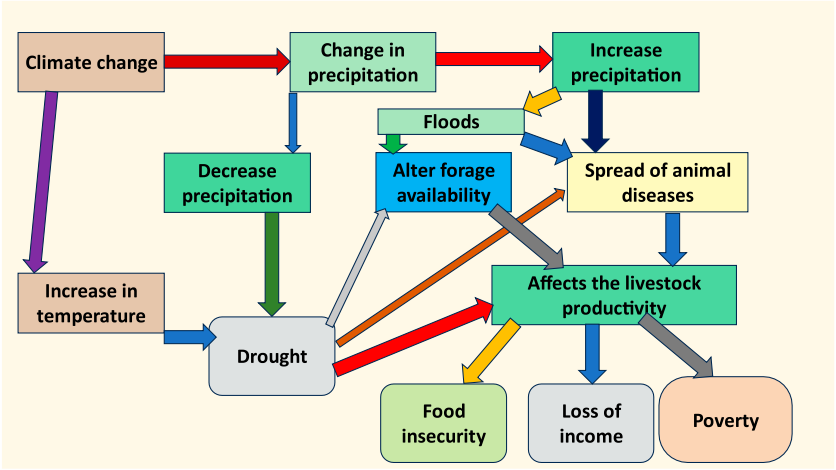

FIGURE 1
The diagrammatic summary of the impact of climate change on the livestock production.

profoundly affect the productivity and resilience of Sub-Saharan Africa's diverse livestock species, encompassing both indigenous and introduced breeds (Saikanth et al., 2023). Understanding these impacts is crucial for devising effective adaptation and mitigation strategies in the region (Table 1; Figure 1). Climate change impacts livestock production through altered forage availability, heat stress, water scarcity, disease spread, reduced reproductive performance, food insecurity, migration, mortality, distribution changes, and economic losses (Baumgard et al., 2012). A study in Ethiopia revealed that, Drought imposes significant economic hardships, causing lost productivity, population reductions, and damage to livestock, crops, soil, and vegetation (Bogale and Erena, 2022). In the Somali region, drought-related animal death rates increased by 60%–80% between 1990–2000 and 2001–2002/03, leading to water depletion, crop failure, and food price hikes (Amerino et al., 2024). In overall the impacts of climate change in livestock production leads to food insecurity, loss of income and poverty (Figure 1).

Mitigation strategies for reducing the vulnerability of Sub-Saharan Africa's livestock production sector to climate change

Mitigation strategies for Sub-Saharan Africa's livestock production sector against climate change involve considering socio-economic factors, cultural practices, and regional

variations (Descheemaeker et al., 2016). Addressing issues such as access to resources, integrating traditional knowledge, and tailoring strategies to diverse contexts can enhance resilience and sustainability amidst climate challenges. Socio-economic factors, encompassing farmers' economic status and resource accessibility, significantly influence vulnerability to climate impacts. Strategies should facilitate access to credit for climate-resilient infrastructure, insurance schemes for climate-related losses, and capacity-building programs to enhance adaptive skills among livestock producers. Climate change is transforming agricultural and food systems, threatening livelihoods, particularly among the world's poor. Transformative adaptation is crucial to mitigate risks and vulnerabilities, necessitating adequate, accessible, and appropriate financing. While Multilateral Development Banks play a critical role, expanding public sector climate finance and incentivizing private investments are essential for effective adaptation, thereby improving capacity-building programs and climate resilience infrastructure (Lipper et al., 2021).

Cultural practices also significantly contribute to livestock systems' resilience. Strategies should integrate indigenous knowledge, promote local breeds adapted to climate conditions, and support traditional herding and grazing practices. Community-based management approaches for shared grazing lands can further enhance resilience. Indigenous knowledge of rangeland management in East and the Horn of Africa supports drought-resilient livelihoods. Advocating participatory research that integrates herders' knowledge into policy-making is crucial (Oba, 2009). Herders' selected indicators inform decision-making, shaping resource governance and coping strategies across space and time. Integrated frameworks enhance sustainable management.

Sub-Saharan Africa's diverse climates and ecosystems necessitate customized mitigation approaches (Descheemaeker et al., 2016). Adaptation strategies must acknowledge regional vulnerabilities, available resources, and cultural norms. Stakeholders' active engagement is crucial to overcoming barriers to success, which are diverse and often revolve around biophysical, knowledge, and financial constraints, as indicated by Shackleton (2015). However, deeper exploration is needed to understand the compounded impacts and interactions of these barriers, including the less recognized political, social, and psychological factors (Shackleton, 2015). These are often overlooked unless specifically targeted by research efforts. Water management may be prioritized in arid regions, while disease control and pasture management are critical in humid areas. Future climate projections for Southern Africa indicate decreased rainfall, rising temperatures, and heightened variability, particularly affecting the drier western regions (Nhemachena et al., 2020). This poses significant challenges for agriculture, with projected productivity reductions of 15%–50%, exacerbating food insecurity (Nhemachena et al., 2020). Addressing this requires sustainable water and energy management, alongside accessible adaptation measures, to ensure sustainable development and livelihoods (Nhemachena et al., 2020).

A holistic approach, addressing socio-economic, cultural, and regional factors, ensures targeted, sustainable, and impactful mitigation efforts against climate change's adverse effects on livestock production. For instance, the concern arises from the projection that 80% of global meat production growth will occur in LMICs (low- and middle-income countries). Studies often overlook the triple-bottom line of social, economic, and environmental aspects in mitigation efforts. While strategies combining emissions reduction and carbon sequestration offer optimal mitigation, the focus should shift towards holistic, multi-metric approaches considering the broader purpose of livestock systems (Harrison et al., 2024). Consequential life cycle assessments and socio-economic planetary boundaries can guide sustainability metrics, necessitating collaborative dialogue among stakeholders for globally reconciled metrics to avoid maladaptive outcomes (Harrison et al., 2024).

Importance of sustainable land management practices to enhance resilience to climate change

Integrating sustainable land management practices into livestock production systems in Sub-Saharan Africa can significantly enhance resilience to climate change and promote long-term environmental sustainability and food security (Were et al., 2016). Agroforestry, rotational grazing, and soil conservation techniques are key components of this approach (Figure 2) (Amede et al., 2023).

Agroforestry involves planting trees alongside crops or pastures, which can provide multiple benefits such as improved soil fertility, enhanced biodiversity, and increased carbon sequestration (Mbow et al., 2014). Incorporating agroforestry into livestock production systems can offer shade and shelter for animals, while also diversifying income sources through the production of timber, fruits, and other non-timber forest products (Were et al., 2016). A study, have showed that, Agroforestry holds promise for enhancing food security, climate resilience, and environmental sustainability in Africa's rural areas. It plays a vital role in large-scale mitigation efforts like REDD+ and AFOLU, offering a pathway to resilience for farmers facing climate and land challenges (Mbow et al., 2014).

Rotational grazing involves moving livestock between different grazing areas to prevent overgrazing and allow vegetation to regenerate (Teague and Barnes, 2017). This practice helps maintain soil health, preserve biodiversity, and mitigate erosion. Implementing rotational grazing systems can also improve forage quality and quantity, leading to better livestock nutrition and productivity (Teague and Barnes, 2017). A study that looked at climate smart grazing system, revealed that, traditional rotational stocking (RT) and

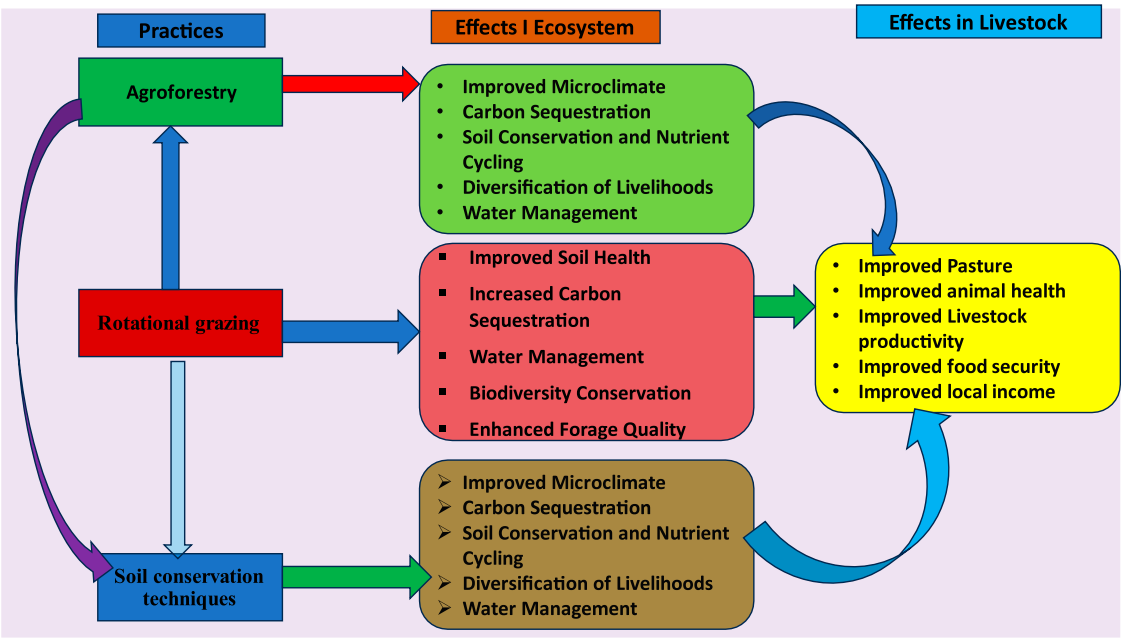

FIGURE 2
Sustainable land management practices to enhance resilience to climate change.

"Rotatinuous" stocking (RN) both contributed on the productivity of pasture and animal in different level, such suggest that, their practices are essential in livestock management system specifically when looking climate resiliency system (Savian et al., 2021).

Soil conservation techniques, including terracing, contour plowing, and cover cropping, aim to prevent soil erosion and enhance soil moisture retention (Figure 2). By reducing soil degradation and improving soil structure, these practices contribute to increased agricultural productivity and resilience to climate change impacts such as droughts and floods (Wolka et al., 2018).

To effectively integrate these sustainable land management practices into livestock production systems in Sub-Saharan Africa, it is essential to provide training and extension services to farmers, access to appropriate technologies and inputs, and incentives for adoption. Additionally, supportive policies and institutional frameworks that promote sustainable land management and provide incentives for conservation efforts are crucial for scaling up these practices across the region. By promoting the adoption of agroforestry, rotational grazing, and soil conservation techniques, Sub-Saharan Africa can build more resilient and sustainable livestock production systems that contribute to food security, mitigate climate change impacts, and conserve natural resources for future generations (Wolka et al., 2018; Wolka et al., 2018; Savian et al., 2021).

Discussion

Sub-Saharan Africa's livestock production sector confronts daunting challenges from climate change, including altered precipitation patterns, temperature fluctuations, water scarcity, disease proliferation, and diminished reproductive performance. These adversities reverberate across food security, economic stability, and livelihoods. Nevertheless, avenues exist to bolster resilience and sustainability through adept mitigation strategies.

Integrated adaptation strategies tailored to Sub-Saharan Africa's diverse livestock species are imperative. These strategies must encompass socio-economic factors, cultural practices, and regional disparities for maximum efficacy and inclusivity. Sustainable land management practices such as agroforestry, rotational grazing, and soil conservation should be mainstreamed to fortify livestock production systems against climate vagaries. These practices hold promise in conserving natural resources, mitigating environmental degradation, and fostering long-term food security.

Securing adequate, accessible, and appropriate climate finance is paramount to execute mitigation and adaptation initiatives. Public sector climate finance expansion and incentivizing private sector investments are pivotal for fortifying climate-resilient infrastructure and enhancing capacity-building programs. Stakeholder engagement, inclusive of local communities, farmers, policymakers, researchers, and development agencies, is pivotal. Their involvement ensures contextually relevant and sustainable strategies. Moreover, prioritizing research and fostering knowledge

sharing platforms are essential for unraveling complex climate-livestock-livelihood interactions and disseminating best practices across Sub-Saharan Africa's diverse regions and stakeholders.

Author contributions

KN conceived the idea, penned the initial draft, and conducted literature searches. LG undertook a comprehensive analysis, restructured the content, and meticulously edited and proofread the document.

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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 author(s) declare that no Generative AI was used in the creation of this manuscript.

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