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RESEARCH ARTICLE

Perceptions of climate change impacts on subsistence cattle production

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Abstract

Despite the adverse effects of fluctuating rainfall and temperature on their productivity, cattle continue to be highly esteemed and raised for their cultural significance. This study delineates the ramifications of climate change on subsistence cattle production in South Africa's Limpopo Province. The study employed a qualitative approach and employed random sampling to select 23 cattle ranchers in the Waterberg District Municipality of Limpopo Province. The interviews were conducted using a semi-structured questionnaire. The collected data were analyzed through thematic content method. The research found that rising temperatures, erratic rainfall, and intermittent drought compromise the cultural value of cattle as sources of food, household products, and ritual purposes. The primary impacts of these climate fluctuations are the decrease and limited availability of cattle fodder in the form of grass, leaves, shoots, pods, and crop residues, as well as the depletion of water resources. The adaptation practices reported in the study are a reduction in cattle numbers by selling, the provision of supplementary feed, and alternative water sources. The study suggests that agricultural extension officers should provide intervention and support to small-scale cattle farmers to help them reduce and adapt to the effects of climate change. This will ensure sustained food security at the household level. In addition, the study suggests implementing a dual strategy to reduce the impact, which involves implementing a combination of crop and cattle farming systems. This approach could be helpful in ensuring both food security and livelihood opportunities for rural communities that rely on natural resources to fulfill their essential requirements.

Keywords: Small-scale farming; Subsistence cattle production; Climate change; Climate change adaptation; Cultural heritage.

1. Introduction

Extensive research exists on the impacts of climate change on small-scale crop production, whereas not much has been researched on the impacts of climate change on subsistence livestock production. However, the present study examines the perceptions of climate change impacts on cattle production. The research is primarily centered on the production of cattle due to their significant cultural contributions, including their importance such as a source of sustenance (milk and meat), ornamentation (from dung), and entertainment and ceremonial purposes (using skin and horn), and their role in providing kraal manure. The United Nations Sustainable Development Goals seek to establish a global society that is free from poverty, hunger, disease, and scarcity by guaranteeing an adequate, safe, economically viable, and nutritious food. To eradicate poverty, hunger, and malnutrition while promoting sustainable agriculture, it may be essential to employ local resources for livelihood, such as cattle production. However, it is crucial to address the adverse effects of climate change on cattle farming to improve household food security to eradicate hunger, poverty, and malnutrition.

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Cattle play a significant role in the social, cultural, and economic fabric of numerous rural communities in low-income cultures, namely those residing in marginal, semi-arid, and desert regions (de Glanville *et al.,* 2020). In addition, it is worth noting that cattle have a significant socio-economic impact on enhancing the well-being of marginalised individuals residing in rural areas, particularly those who lack land ownership and rely on manual labour for their livelihood (Vetter *et al.,* 2020). Cheteni and Mokhele (2019) acknowledge that livestock production, specifically cattle, plays a significant role in food provision in South Africa. According to Thorton (2020), livestock bears significant importance in the livelihoods of numerous households residing in low-income societies, contributing to informal household insurance, and financing as well as soil fertility and household nutrition. The findings of Zhou *et al.* (2022) show that the incorporation of livestock into agricultural practices presents significant prospects for enhancing food security and promoting sustainable development, provided that suitable measures are taken to adapt to the challenges posed by climate change.

Subsistence livestock production holds significant importance within the agricultural industry, as it plays a crucial role in enhancing the livelihood of impoverished rural communities. The production experiences adverse effects due to alterations in temperature and rainfall patterns, resulting in the limited availability and exhaustion of water and feed resources that are crucial for the sustenance of cattle (de Glanville *et al.,* 2020). The impacts of climate change on pastoralism include changes in growing conditions associated with warming temperatures and declining precipitation, which in turn lead to negative impacts on livestock productivity, food security, and livelihoods of pastoralist communities, including drought-induced degradation of rangelands (IPCC, 2022). Drought is responsible for economic damage to livestock enterprises, with the impacts on animal health and the livelihoods of pastoralists contributing to land degradation, reduced growth rates, and reproduction, particularly in cattle production (IPCC, 2022).

Vetter *et al.* (2020) acknowledge that communal livestock farmers are highly susceptible to climate variation, as it poses a significant challenge for poor rural populations that rely heavily on cattle as a means of sustenance (Thorton, 2020). The potential ramifications of climate change on livestock and the livelihoods of local communities in arid and semi-arid areas are of significant concern (Vetter *et al.,* 2020). Maluleke and Mokoena (2017), who discovered that the expansion of agricultural production areas may experience a decline of more than 50% by 2050 due to the escalating heat and aridity associated with climate change, support this assertion. These adverse conditions pose significant risks to both food security and the sustenance of livelihoods. The livestock agricultural industry is now experiencing a significant decrease in productivity due to the adverse effects of drought and a limited supply of potable water for cattle (Cheteni and Mokhele, 2019). The IPCC (2022) confirms that livelihood sustainability in the drylands, which cover more than 40% of the land surface area, are home to roughly 2.5 billion people, and support approximately 50% of the livestock and 45% of the food production, is threatened by a complex and inter-related range of social, economic, and environmental changes that present significant challenges to rural communities. However, agricultural climate-adaptation policy targeting livestock farmers in rural areas is very likely to benefit from better education and awareness as well as increased access to extension services among livestock farmers on climate risk-coping choices and strategies (Rahut and Ali, 2018).

Theoretical framework

Climate change is continuing to negatively affect all aspects of human life, most importantly subsistence production to ensure household food security. The negative impacts of unpredictable

rainfall, intermittent drought, and bad weather patterns are mostly felt by subsistence farmers, who rely on rain-fed production of livestock to satisfy basic needs. South African rural community members engage in a range of livelihoods, but livestock are at the centre of traditional subsistence and transitional, mixed household economies. Livestock farmers have been increasingly confronted with a range of challenges resulting from climate change, including elevated mortality rates, sluggish growth rates, and diminished milk output, among other notable effects (Cheteni and Mokhele, 2019; Maluleke *et al.*, 2020). These observations are supported by the IPCC (2022) that livestock production is the most affected area of human livelihood in developing countries where subsistence livelihood is still prevalent.

2. Materials and methods

2.1. Study Area

This research is grounded in fieldwork that was carried out within the Mogalakwena community, located in the Limpopo Province of South Africa (Figure 1). The community is located within the administrative boundaries of the Mogalakwena Local Municipality, which falls under the jurisdiction of the Waterberg District Municipality. The annual precipitation varies between 600 and 650 millimetres, with the highest encounters in January and December. There has been a discernible decline in average precipitation recently. The occurrence of thunderstorms accompanied by hail and fog is most prevalent. The summer season is characterised by elevated temperatures that may escalate up to 34°C. Aberrant variations in temperature and precipitation patterns have engendered an escalation in the frequency and intensity of drought events (Statistics South Africa, 2017). The climatic fluctuations have had a substantial and long-lasting impacts on the viability and effectiveness of subsistence agricultural production.

2.2. Study Design

2.2.1. Participant selection

A qualitative investigation was conducted between 2019 and 2021 to explore the small-scale cattle farmers' understanding of the effects of climate change on cattle production. The data was obtained through semi-structured interviews conducted with 23 small-scale cattle farmers who were selected purposely from the Mogalakwena community. They were identification through transact walks across the residential area to detect households with cattle kraals. Only households that have cattle were selected for the study. The age of the participants in the sample ranged from 38 to 71 years with a total of eighteen males and five females. All participants provided their agreement to partake in the study by affixing their signature to the consent form. Anonymity and confidentiality were maintained using fictitious names and the restriction of discussions regarding the study findings solely to the participants.

2.2.2. Data collection

Data was gathered through direct interaction with the farmers. Each farmer was interviewed for around 45 minutes to one hour. Face-to-face semi-structured interviews were done in the local dialect and thereafter translated into English to ensure that the farmers could freely and confidently participate in the study. However, a skilled linguist assisted in translating and editing the responses.

2.2.3. Data analysis

Data analysis was effected through content analysis. Data were processed through transcription of the interviews, followed by classification of data into common themes. The application of this analytical method was advantageous as it measured the frequency, importance, and interrelation of particular words and phrases useful to describe the perceptions of climate change and its impacts on cattle production, and the types of adaptation measures. A data verification was undertaken with the farmers to ensure the completeness and trustworthiness of the gathered data. Follow-up

investigations and informal discussions with the farmers were arranged to elucidate and authenticate the findings.

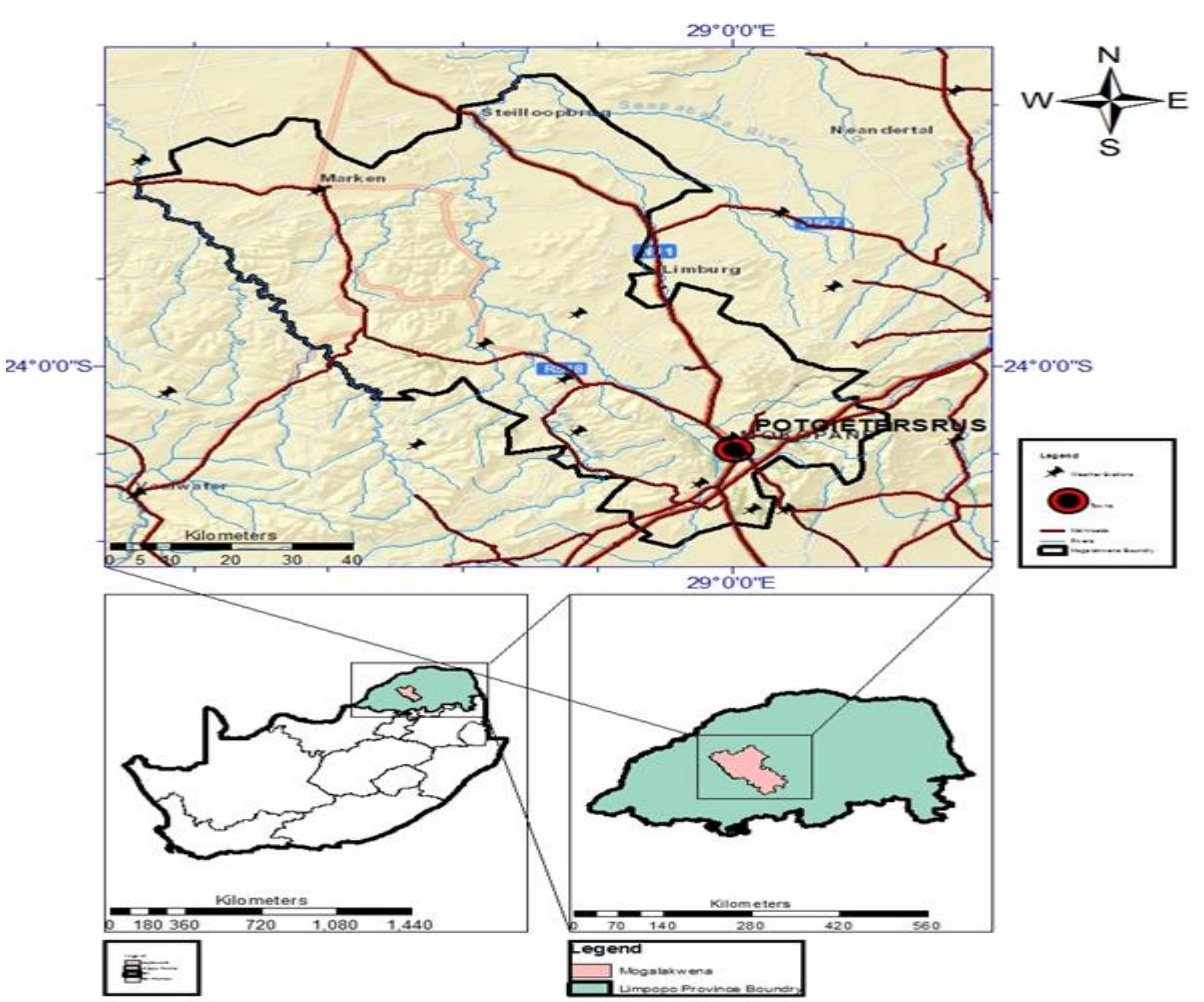

Figure 1. Study Area

3. Results and discussion

3.1. Profile of Cattle Farmers

Many cattle farmers (91%) were men aged between 35 and 71 years. Fewer women (4%) aged between 46 and 55 years were farming the cattle left behind by their late husbands. This situation was so because they did not have anyone to look after the cattle as their sons were schooling. Despite their educational qualifications, household size and income, 87% of community members still value their cultural traditions to sustain livelihood by raising larger herds of cattle of more than ten herds per household.

3.2. Cultural Value of Cattle

The farmers acknowledged that they continued to place significant cultural value on cattle, as they serve as essential means of sustenance, providing food, entertainment, ornamentation, draught power, and facilitating religious celebrations.

The farmers conceded that:

"Cattle play a crucial role in fulfilling our diverse livelihood needs such as food, social and ritual purposes. Cattle are our wealth".

Despite this notable importance of cattle and the deep affection harboured by the owners towards their livestock, the farmers displayed great

concern for the overall condition of their livestock.

All the farmers mentioned that:

"Due to the relatively low economic relevance of cattle, particularly in terms of their limited usefulness as a food source compared to their substantial social, ceremonial, and ritual importance, farmers prioritise the number of cattle owned over other factors".

Table 1. Profile of Cattle Farmers

Socio-economic characteristics		Number of farmers	Percentage	
			Male	Female
Age	38-45 years	6	22	4
	46-55	4	14	4
	56-65	5	21	-
	66-75	8	35	-
Gender	Men	21	91	-
	Women	2	-	9
Marital status	Single	-	-	-
	Married	21	91	-
	Widow	2	-	4
	Divorced	-	-	-
Educational achievement	No formal education	-	-	-
	Primary education	5	21	-
	Secondary education	9	30	4
	Tertiary education	9	39	-
Household income	Less than R1000	1	-	4
	R1500	4	13	4
	R2000	6	22	-
	R3000	5	21	-
	R4000	3	13	-
	<R5000	3	13	-
	>R5000	1	4	-
Household size	Less than 5	8	22	4
	Less than 10	15	65	-
Herd size	Less than 10	3	4	9
	More than 10	20	87	-

Cattle production can mitigate poverty levels and enhance the overall quality of life for poor people residing in the rural areas (Dovie *et al.,* 2006; Calvosa *et al.,* 2010), as it has a crucial role as a valuable resource for those with little financial means. Livestock products play a crucial role in ensuring global food security as they contribute significantly to worldwide kilocalorie and protein consumption (Rosegrant *et al.,* 2009). According to Vetter *et al.* (2020), the enhancement of livelihoods for marginalised rural populations, such as landless labourers, is a significant socio-economic function. Additionally, cattle present large prospects for sustainable development (Escarcha *et al.,* 2018). The significance of cattle in a nation's development plan is contingent upon its diverse socio-economic contributions and the cultural advantages it offers (Maponya and Mpandeli, 2013). An outstanding observation in this study was that the farmers believed that the possession of a larger number of cattle was directly correlated with increased wealth and the enhanced capacity to fulfil the fundamental requirements of a household. There is evidence to suggest that the number of livestock produced and owned plays a crucial role (Prasad *et al.,* 2022).

3.3. Climate Change Impacts on Cattle Production

The farmers reported two main resources impacted by climate change. These embrace the following:

Scarcity and decline of forage resources

The consensus among the farmers was that:

"Natural grazing grounds serve as the primary source of feed for cattle. We drive cattle to the veld every morning for cattle to consume autochthonous botanical resources, including grasses, shoots, foliage, and pods. The farmers demise of the cattle was a result of the depletion of grazing resources and the loss of foliage on the trees. There was a notable degradation of pastures and arable areas in livestock farming areas due to unpredictable rainfall and temperature variations. These led to a reduction in the availability of pasture, rangelands, crops, and forage, which are crucial for sustaining cattle feed. These species are rarely observed in their natural habitat, where the cattle have historically engaged in seasonal browsing activities. Crop remains in the ploughing fields and gardens serve as a supplementary source of cattle feed. During the winter season, following the completion of the harvest, cattle are permitted to consume the remaining stalks in the fields. These agricultural residues exhibit substandard characteristics in terms of both quality and quantity due to the limited crop output resulting from the adverse effects of unpredictable precipitation patterns, sporadic drought occurrences, and increasing temperatures. However, once this resource is depleted, it becomes necessary to search for winter grass at locations distant from their place of residence. The reliance of cattle production on climate-sensitive natural resources poses a significant challenge. The fluctuating patterns of precipitation and elevated levels of thermal stress have a detrimental impact on the general well-being of cattle, leading to a rise in livestock mortality rates and a decline in birth rates".

The cattle feed resources reported by the farmers align with the categorization of East Ethiopian cattle pastures as natural pasture grazing, crop residues, and browsing plants proposed by Gilo and Bertha (2017). The study by Saka *et al.* (2021) found that climate change presents a significant challenge to cattle production due to its negative effects on feed quality, forage, crop productivity, and water availability. These climatic conditions have been identified as the primary factors contributing to the drop in forage accessibility. The detrimental implications on cattle productivity resulting from a rise in atmospheric temperatures were forecasted by the International Panel on Climate Change (IPCC, 1996) attributed to a decline in fodder quality and an elevation in ambient temperature. According to Musemwa *et al*. (2021) and Zhou *et al.* (2022), one of the contributing factors leading to substantial livestock losses is the presence of inadequate grazing conditions (Erasmus, 2018). It is widely acknowledged that the increase in temperatures and occurrence of droughts have led to a decrease in the production of pasture, rangeland, and forage crops (Wheeler *et al.*, 2013). The negative impacts of temperature and rainfall variations on pasture quality and quantity have been observed to disrupt the food resource availability cycle for livestock throughout the year (Fereja, 2016). The effects of climate change on feed are frequently discussed in terms of both quantity and quality. According to research by Vetter *et al.* (2020), livestock farmers who live in semi-arid regions suffer negative effects as a result of decreased and fluctuating precipitation levels as well as frequent droughts, which supports the claim that cattle pasture is scarce.

3.3.1. Decline in water resources

The primary water sources utilised by livestock were identified as the Mogalakwena River and ponds. The issue of diminishing quantity and deteriorating quality of drinking water from these sources has been identified as a significant concern. The limited supply of water for cattle production and the growing demand for drinking water have been identified as significant

challenges that impede the efficiency of cattle production.

The consensus among farmers was that:

"The escalating losses in pastoral systems pose a growing threat to the livelihoods and food security of households heavily reliant on cattle farming". The decline in water levels in the river and ponds can be attributed to the increasing temperatures and unpredictable precipitation patterns".

Water and land resources play a crucial role as essential inputs in livestock production systems, particularly in the production of feed crops (Escarcha *et al.*, 2018). Abdurehman and Ameha (2018) concede that prolonged exposure to elevated ambient temperatures or drought can result in a decrease in water availability and a decline in the water content and quality of fodder. Furthermore, the study conducted by Rojas-Downing *et al.* (2017) demonstrates that water scarcity and depletion have been found to have a significant negative impact on livestock productivity. Higgins *et al.* (2008) suggest that drinking water for cattle should be enough and that when the ambient temperature is above 27°C, both water and feed consumption decline, leading to detrimental effects on bovine output. According to Kgakatsi *et al.* (2006), a major factor in cattle production vulnerability to climate extremes is the presence of uncertainty in drought prediction, which makes the situation even worse. Moreover, the authors emphasise that the success of rural livestock farming practices is heavily contingent upon the reliability and quality of continuous rainy seasons. According to Saka *et al.* (2021), a significant portion of the output occurs over broad rangelands characterised by limited inputs and fluctuating water availability influenced by seasonal climatic conditions. Production systems, particularly in the production of feed crops (Escarcha *et al.*, 2018). Abdurehman and Ameha (2018) concede that prolonged exposure to elevated ambient temperatures or drought can result in a decrease in water availability and a decline in the water content and quality of fodder. Furthermore, the study conducted by Rojas-Downing *et al.* (2017) demonstrates that water scarcity and depletion have been found to have a significant negative impact on livestock productivity. Higgins *et al.* (2008) suggest that drinking water for cattle should be enough and that when the ambient temperature is above 27°C, both water and feed consumption decline, leading to detrimental effects on bovine output. According to Kgakatsi *et al.* (2006), a major factor in cattle production vulnerability to climate extremes is the presence of uncertainty in drought prediction, which makes the situation even worse. Moreover, the authors emphasise that the success of rural livestock farming practices is heavily contingent upon the reliability and quality of continuous rainy seasons. According to Saka *et al.* (2021), a significant portion of the output occurs over broad rangelands characterised by limited inputs and fluctuating water availability influnced by seasonal climatic conditions.

3.3.2. Declining numbers of cattle

Observations from the study are that many households (87%) own about 20 herds of cattle each. The farmers reported the following:

"We used to raise large herds of cattle. The numbers decreased as we started experiencing less and late rainfall, which compromised the quality and availability of foreage materials. The water levels in the rivers and ponds aldo declined due to rainfall scarcity and rising temperatures. We struggle to raise cattle because they die of hunger and thirst".

The farmers' experiences of loss of cattle is a common challenge in other parts of the Limpopo Province and South Africa as a whole. For instance, Previous literature provides various observations that confirm the farmers' opinions of the implications of climate change on cattle production, which in turn compromises the cultural value associated with cattle. For instance, Shongwe *et al.* (2011) report that multiple climatic model projections for South Africa show that the country will undergo a rise in

temperatures, with anticipated increments ranging from 5°C to 8°C by the year 2050 (Zhou *et al.*, 2022). The variances provide evidence that cattle production occurs in climatic settings that are characterised by hard and challenging circumstances (Mthembu and Zwane, 2017; Popoola *et al.*, 2019). According to Archer et al. (2021), it is anticipated that climate change will have a growing influence on rural areas, particularly in terms of exacerbating challenges faced by economic activities such as livestock raising. Livestock production, despite its significant socio-economic impact on poverty alleviation, appears to function under diverse and challenging environmental circumstances, leading to diminished production outcomes (Musemwa *et al.*, 2012). According to Popoola *et al.* (2019), the production of cattle in rural areas is a very precarious endeavour in terms of its susceptibility to climate change, despite its significant contribution to the socio-economic well-being of rural populations. The possible effects of climate change on livestock production involve various aspects, including alterations in water availability, animal development, milk production, quality of feed crops and pasture, illnesses, animal reproduction, and biodiversity (Abdurehman and Ameha, 2018). According to Battisti and Naylor (2009), people who rely on crop and livestock production for their overall household food security face heightened risks due to climate change. Shikuku *et al*. (2015) have conducted an observation indicating that smallholder cattle production is susceptible to the detrimental effects of climate change.

3.4. Adaptation Practices

Adaptation and mitigation practices are crucial in addressing the adverse effects of climate change on cattle, as highlighted by Sejian *et al*. (2015). If left unattended, the susceptibility of livestock production will persistently escalate, engendering adverse ramifications for rural populations. The loss of cattle will engender impoverishment and imperil their means of subsistence. According to Myeki and Bahta (2021), historical evidence suggests that smallholder livestock producers have effectively responded to ecological and climatic changes by leveraging their understanding of the environment in their livestock rearing practices. Nevertheless, farmers employ several strategies to alter and improve their existing cattle production practices, which include the following approaches:

Reducing the number of livestock by selling

3.4.1. The farmers reported that:

"We sell our cattle as a proactive measure to mitigate additional production losses caused by the depletion of fodder and water resources resulting from unpredictable rainfall patterns and increasing temperatures".

Zhou et al. (2022) support that the most common adaptation measure for preventing cattle loss is destocking or selling a specific section of the herd. Slayi et al. (2021) support the idea that many rural areas are experiencing a rise in mortality rates and unanticipated sales as farmers are pushed to sell a portion of their livestock during periods of drought.

3.4.2. Supplementary feed

The farmers agreed that:

"We reduce the poor growth of cattle by providing additional sources of nourishment to complement their regular diet".

It was observed that only farmers who had achieved an enhanced socio-economic level were inclined to acquire additional feed, such as yellow maize and lucerne, at an approximate cost of $26 (R500) per pack. Farmers opt to purchase supplementary feed for their stock during periods of drought and dry weather to mitigate additional losses in output and financial resources (Zhou et al., 2022). Vetter et al. (2020) acknowledge that cattle herds that are provided with supplementary feed had decreased mortality rates compared to herds that did not receive such inputs; however, the mortality rates varied significantly.

3.4.3. Alternative water provision

Alternative water provision is implemented by non-traditional methods or sources for supplying

water for cattle drinking. The common methods used by cattle farmers for obtaining and conserving water for cow consumption include borehole drilling, rainwater harvesting, and the acquisition of water tanks to store water. A potential cost-effective approach to improving water resource management for livestock is the use of localised methods by establishing rainwater collection infrastructure and storage facilities (Prasad et al. 2022).

4. Conclusion

It is clear from the study that subsistence farmers possess knowledge regarding the adverse impact of unpredictable precipitation patterns, sporadic drought occurrences, and fluctuations in temperature on the productivity of cattle. The primary consequences of these phenomenona are the reduced availability of hay and pasture, as well as the depletion of water supplies. Additionally, there is a notable decline in water levels within the local resources from which the farmers drive cattle to drink. These circumstances have resulted in mortality and suboptimal cattle productivity. However, the farmers use local adaptation strategies such as the decrease of livestock populations through sales, the provision of supplementary feed, and the establishment of alternate water sources, to maintain sustainable cattle production. The study suggests that small-scale cattle farmers should receive assistance from agricultural extension officers to effectively address the challenges posed by climate change on cattle production. Additionally, a dual mitigation practice such as the adoption of a mixed crop and livestock system, to provide food security and livelihood options for rural communities that depend on natural resources to meet basic needs is proosed.

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Declaration of Competing Interest

The author declares there are no conflicts of interest.

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