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Back to Basics: Mitigating the Harmful Effects of Droughts for Efficient Livestock Productivity in the Grasslands of the Central Free State in South Africa

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ABSTRACT

Extensive livestock production in South Africa depends on rangeland productivity and effective livestock management practices. This study aims to identify various processes to mitigate the adverse effects of droughts on livestock farming in Bloemfontein, South Africa. Stocking rates on land-reform farms during drought, rangeland management impacts on the reproduction performance of beef cattle and rangeland condition and soil data were investigated. The results showed a significant difference between rangeland condition and soil carbon, demonstrating the essential role of rangeland management in carbon sequestration. In conclusion, knowledge regarding stocking rates and prudent rangeland management practices (condition and carbon sequestration) is paramount for sustainable livestock farming during climate change. Intensive training of farmers in sustainable rangeland management is recommended to mitigate the effect of droughts and to ensure sustainable livestock production with a minimised carbon footprint.

Keywords: Mitigating Droughts Effects, Efficient Livestock Productivity, Grasslands

1. INTRODUCTION

The profitability and sustainability of extensive livestock farming enterprises are determined by various factors, including the health of rangelands and livestock reproductive performance

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(Van der Westhuizen *et al*., 2020). A recent report by Avenant (2019) stated that the grassland biome of South Africa covers a total area of 32 534 079 ha (hectares), of which the available livestock grazing area is 21 560 559 ha currently being grazed by 3 934 838 large stock unit (LSU) heads. According to Meissner *et al*. (1983), a large stock unit is the equivalent of an animal weighing 450kg, gaining 500g per day in weight on the pasture with a digestible energy (DE) concentration of 55%.

In the Free State Province, the total grasslands area is 12 982 516 ha, with an available grazing area of 8 538 734 ha grazed by 1 333 815 LSU heads (Avenant, 2019), indicating an average stocking rate of 6.4 ha/LSU. According to Mokhesengoane *et al*. (2021), rangeland resource planning and management depends on climatic variations such as rainfall and temperature, influencing the stocking rate adjustments. However, over the past four consecutive decades, several research projects have highlighted weather events, such as El Nino induced droughts, to have had detrimental implications on livestock productivity and continue in the future (Thornton *et al.,* 2009).

A study by Van der Westhuizen *et al*. (2020) emphasised that increased climate variability and climate change significantly threaten essential grassland ecosystems with increased droughts, especially in semi-arid areas with unpredictable rainfall. Additionally, poor rangeland management and overstocking can lead to financial and livelihood losses due to livestock mortalities in extensive livestock farming systems (Mokhesengoane *et al*., 2021). Natural rangeland management methods based on scientific research promote sustainable beef productivity and can decrease the adverse effects of droughts (Van der Westhuizen *et al*., 2020).

The sustainability of livestock farming enterprises and grazing resources contributes to global food security. The Food and Agriculture Organisation (FAO, 2014) predicts an increase in the world's population growth from 7.2 billion to 9.3 billion by 2050. The degradation of grasslands is a global concern. At the same time, ecosystem health also plays a role in hydrological disturbances, water quality, dust storm occurrence and severity, food security, poverty, rural development and the social consequences of uprooted people (Van der Westhuizen *et al*., 2022). Previous studies have identified a negative relationship between soil organic carbon (SOC) content, soil organic matter (SOM) and low rainfall occurrences (Fynn *et al*., 2009).

Therefore, sustainable rangeland management practices should be implemented to reduce the carbon footprint. Agricultural extension can be essential to incentivise and support farmers in adopting sustainable livestock production systems. This study aims to present extension personnel with information to guide them in this process, concentrating on recent research results for the Bloemfontein area. Data collection included: (1) stocking rates of LSU on land-reform farms during droughts (Mokhesengoane *et al*., 2021); (2) rangeland management and reproduction performance of beef cattle (Van der Westhuizen *et al.*, 2020), and (3) recent assessment of rangelands condition and associated soil health collected on nine land reform farms.

2. MATERIALS AND METHODS

2.1. Study Area

The three studies evaluated in the current study were conducted in the semi-arid grassland biome of the Bloemfontein area (1320 m to 1420 m above sea level) in the Free State Province of South Africa. According to Van der Westhuizen (2003), the vegetation type can be described as sweet grass-veld, often dominated by perennial *Themeda triandra* (red grass) species when grasslands are in a pristine maintained condition. The average rainfall reported from the last 95 years for this area by ISCW-databank (2018) is ± 556 mm per annum. The most precipitation occurs in the summer months (November to March), resulting in a 62% increase in vegetation growth (Van der Westhuizen, 2006). The Department of Agriculture's (2003) grazing capacity map recommends the grazing capacity norm of 6 ha per LSU for veld in good condition in this area.

2.2. Methods

Purposive sampling was utilised to select three recent research trials supporting ecological sustainability approaches in livestock management in the Bloemfontein area during drought periods. Previous studies reviewed based on their theoretical framework include:

i. Stocking rates of LSUs on land-reform farms during droughts (Mokhesengoane *et al*., 2021);
ii. Rangelands management and reproduction performance of beef cattle (Van der Westhuizen *et al.*, 2020) and
iii. Recent assessment of rangeland's condition and associated soil health collected on nine land-reform farms.

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According to Mokhesengoane *et al*. (2021), twenty-nine livestock farmers reported a loss of 176.8 LSU's during the 2018 and 2019 mid-summer drought period. In comparison, Van der Westhuizen *et al*. (2020) described increased livestock production during drought with minimal rangeland management input in the same district. Furthermore, the recent assessment quantified the benefits and limitations of sustainable rangeland management practices during droughts and climate change mitigation by comparing soil carbon content with rangeland conditions.

Soil analyses were performed according to The Non-Affiliated Soil Analysis Work Committee (1990). Rangeland condition scores were determined for every site using the indicator species technique, developed and tested against a degradation gradient technique specifically for central Free State vegetation type (Van Der Westhuizen, 2003).

3. RESULTS AND DISCUSSIONS

Literature studies indicated the influence of stocking rate, rangeland management and condition assessment on sustainable livestock production while mitigating the harmful effects of droughts and climate change.

3.1. Stocking Rate

According to Mokhesengoane *et al*. (2021), the average stocking rate implemented by farmers representing land-reform projects in the Bloemfontein district during the 2018 and 2019 drought was 5.9 ha per LSU. Overstocking occurred on 31% of the farms, and 38% of farmers reported fodder shortages. Despite the low feed resources, overstocking rates of over 300% (above the recommended 6 ha/LSU) and high mortalities were reported (Table 1). Total livestock mortalities reported for this trial were 176.8 LSU, equal to R 1 760 920.87 at R42.39/kg for an average B2/B3 carcass for November 2018.

TABLE 1: Mean Mortality Rate as a Percentage of the Stocking Rate at 6 ha/LSU (± Standard Deviation) (Mokhesengoane et al., 2021)

Stocking rate	Mortality %
More than 130 % overstocked	32.7 ± 50^{a}
Rest of farmers	5.7 ± 7.6^{b}

$^{A\ \&\ b}$ – Values in columns with different superscripts differ significantly

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In the study of Mokhesengoane *et al*. (2021), respondents were requested to compare the availability of natural fodder with that of their neighbours. Table 2 shows a positive relationship between available fodder and stocking rate and a negative relationship between available fodder and mortality rate (Table 2). The stocking rate of the farms with less fodder available than their neighbours (stocking rate of 378%) contributed to forage shortages and higher mortality rates (22.4%).

TABLE 2: Fodder Availability Compared to Neighbouring Farms With Average Stocking Rate and Average Mortality Rate During the Drought of 2018-2019 (Mokhesengoane *et al*., 2021)

Forage availability in comparison with neighbours	Frequency	Percent (%)	Stocking rate (%)	Mortality rate (%)
Better	12	41.4	88	6.5
Same	6	20.7	147	14.0
Worse	11	37.9	378	22.4
Total	29	100.0		

Furthermore**,** the influence of stocking rates during drought on beef production and reproduction is also emphasised by Van der Westhuizen *et al*. (2020). Reduced stocking and calving rates (not reduced lower than 18%) during drought outperformed the 6 ha/LSU for the study area with R 1 534 per cow (Table 3). Future studies could further investigate the practical implementation of the variable stocking rate. Due to the impact of climate variability on sustainable beef production, stocking rates should be determined according to assessments of rangeland potential.

TABLE 3: Comparison of Reproduction Performance Between Fixed and Variable Stocking Rate (%) (Van der Westhuizen *et al*., 2020)

Years after the implementation of rangeland management	Fixed stocking rate	Reduced stocking rate due to drought
Calving rate (%)	58	76
Weaning weight (kg)	188	198

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Income per cow mated *	R 4 034	R 5 568

* = Based on a weaner price of R37/kg

3.2. Rangeland Management

Van der Westhuizen *et al.* (2020) recorded a 32% calving rate without implementing rangeland management during the first year of the trial. In contrast, after a year of rangeland management implementation, the calving rate almost doubled to 59%, reaching the maximum of 82% in year four. These calving rates are more profitable than the lower calving rate of 34% reported for commonage farmers, 60% reported for commercial farmers (Scholtz & Bester, 2010) and 32% reported for Bloemfontein land-reform farms studied during drought (Mokhesengoane *et al.*, 2021). Commonage and land reform small-holder farmers generally report lower calving rates due to their communal livestock farming background, where rangeland management and sustainable beef production practices are not usually implemented (Van der Westhuizen *et al.*, 2020). Additionally, poor livestock performance and degradation of natural resources are more evident in these systems (Van der Westhuizen *et al.*, 2020). Weaning calf weights of 156 kg with no rangeland management inputs and 229 kg during production year four of rangeland management implementation were recorded (Table 4). Implementing a reduced stocking rate resulted in an increased calving rate, improved environmental health and potential income per cow, further emphasising the importance of a balance between natural fodder availability and livestock numbers (Forbes, 1988).

3.3. Rangelands Condition

Rangelands condition assessment is crucial to ensure the sustainability and profitability of extensive livestock farming systems. The condition status of grazing resources indicates ecosystem health, production ability and carrying capacity during drought (Van der Westhuizen *et al.*, 2018). The risks associated with droughts escalate if rangeland conditions deteriorate; for example, fodder shortage can increase to 48% for rangelands of average condition (50%) compared to only 5% for rangelands classified as an optimum condition in the Bloemfontein area (Van der Westhuizen, 2006).

TABLE 4: Reproduction Performance (Calving Rate % and Weaning Weight in Kg) and Rangeland Condition Over Four Production Years (Van der Westhuizen *et al.*, 2020)

Years after implementation	**Calving % ± SD**	**Weaning weight (kg) 205 days ± SD**	**Simulated seasonal production**
No rangeland management inputs	$32^{a} \pm 10$	$155.8^{a} \pm 11.1$	Normal
Year 1	$59^{b} \pm 19$	$215.8^{c} \pm 6.7$	Below normal
Year 2	$60^{b} \pm 12$	$214.4^{c} \pm 10.1$	Very high
Year 3	$62^{b} \pm 15$	$190.0^{b} \pm 9.6$	Very low Drought
Year 4	$82^{c} \pm 7$	$228.6^{d} \pm 6.7$	Normal

$^{a, b, c, d}$ – Values (mean ± SD) within a column followed by different superscript letters are significantly different ($p < 0.05$), SD = Standard deviation.

Where poor rangeland conditions are identified, the probability of forage shortages increases to more than 90%. Results from Trial Three indicated significant differences ($p < 0.05$) between rangelands condition (minimum = 14%, maximum = 81%, average = 50%) and topsoil carbon content (Table 5) of land-reforms farms at 20 cm depth (for rangelands in very poor condition, 1% topsoil carbon content was recorded and for rangelands in good condition, 3.1% topsoil carbon content was recorded). Rangelands in good condition can sequestrate three times more carbon than rangelands in poor conditions.

The grasslands biome covers approximately 50% of the global surface area (Mitchell, 2000), mainly utilised for livestock grazing. Grasslands are essential in carbon sequestration, absorbing atmospheric carbon dioxide during photosynthesis and transporting it through the root systems to be stored in the soil.

TABLE 5: Topsoil's Carbon Content (%) for Different Rangelands Condition Classes

Rangelands condition	**Very poor (≤ 20 %)**	**Poor to Moderate (21 - 60 %)**	**Good (> 60 %)**

Carbon content ± SD (%)	1.0[a] ± 0.43	1.9[a] ± 0.73	3.1[b] ± 1.08

a, b, c, d – Values (mean ± SD) within a column followed by different superscript letters are significantly different ($p < 0.05$), SD = Standard deviation.

Carbon (C) then strengthens the soil structure by increasing macro soil pores, substrate and energy to support soil microbial activity, further promoting the storage of organic nitrogen (N), phosphorous (P) and other related soil nutrients. Therefore, grassland maintenance through the implementation of management practices and adequate stocking rates increases the potential of the soil to store more C and, as a result, mitigate the effects of climate change (Fynn *et al.*, 2009).

4. CONCLUSIONS

The collective findings of this comparison study illustrate that proper animal stocking rates and prudent rangeland management lead to ecological sustainability, high investment returns, and sustainable extensive livestock farming enterprises. These findings can further be summarised as follows to mitigate the adverse effects of droughts and climate change:

i. Overgrazing leads to higher livestock mortalities during droughts.
ii. Reduced livestock numbers during droughts decrease livestock mortalities.
iii. Reduced livestock numbers during droughts increase the production and reproduction rate of livestock.
iv. Production planning for sustainable rangeland utilisation increases livestock production and profitability.
v. With a sustainable grazing system, livestock production can be higher even during drought periods.
vi. Carbon sequestration for good-condition grasslands is three times higher than for poor-condition grasslands.

In conclusion, properly managed grasslands and grazing resources, including controlled stocking rates, are effective tools for livestock farmers to mitigate the harmful influence of climate change on the environment. No mortalities were reported during Trial Two, with similar environmental parameters to Trial One, reiterating the significance of implementing rangeland management practices and production planning based on scientific research. Trail

Three results illustrate that SOC and SOM increase as rangeland's condition improves, highlighting the importance of grassland health for carbon sequestration and mitigating climate change impacts and a reduced carbon footprint.

5. RECOMMENDATIONS

The study recommends a paradigm shift to extension personnel by highlighting the significance of proper rangeland management and animal stocking rates in carbon sequestration to reduce climate change effects. Furthermore, the study recommends that the balanced application of stocking rates, in line with seasonal fodder availability fluctuations, is paramount for sustainable livestock productivity during variable climatic conditions. Knowledge of stocking rates and rangeland management is critical for profitability and environmental sustainability.

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