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Developing an Extension Strategy for the Management and Eradication of Bush Encroachment in Communal Livestock Lands in Mopani District, Limpopo Province of South Africa

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ABSTRACT

Bush encroachment poses a multifaceted challenge, driven by critical socio-economic, environmental, and governance factors within the communal livestock system. The article aimed to identify practical agricultural extension methods for combating bush encroachment on communal land. The study presents practical agricultural extension strategies for livestock farmers to address bush encroachment within the communal system. The study was conducted in the Mopani District with a sample of 300 communal livestock farmers. Quantitative data were analyzed using SPSS version 27, while qualitative data were analyzed using a thematic analysis framework. The findings highlight varied perspectives among livestock farmers, emphasizing the complexity of managing bush encroachment and the need for community-driven strategies. The study findings indicate that, while farmers possess relevant indigenous knowledge, the lack of structured extension support and technical training hinders the effective control of encroaching species. The study recommends integrating climate-smart agricultural practices, such as adaptive grazing, rangeland restoration, and climate-resilient land use. Additionally, it suggests creating a framework to formalize extension programs, define stakeholder roles, and improve land governance. This research enhances sustainable rangeland management by presenting a strategy for extension that is both context-sensitive and centered on communal livestock farmers.

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Introduction

Communal livestock systems, characterized by shared ownership and utilization of livestock among specific groups or communities, are fundamental to rural livelihoods and local agrarian economies (Robinson, 2019; Falayi *et al*., 2022). These systems are at risk from non-native plant invasions and the rapid growth of woody plants in communal rangelands, known as bush encroachment (Soubry & Guo, 2021; Wiethase *et al*., 2023; Skhosana et al., 2025). As the bush cover spreads, it reduces grass growth (Soto-Shoender *et al*., 2018) and the availability of food for livestock, resulting in reduced grazing capacity and lower livestock productivity (Dong *et al*., 2017). In South Africa, bush encroachment worsens due to overgrazing, fire suppression, climate variations, and inadequate communal governance, affecting grazing and soil quality (Mudau *et al.,* 2022). These combined pressures have altered savanna and grassland environments, posing greater challenges for managing livestock (Archer *et al*., 2017). The Mopani District of Limpopo intricately links communal livestock production to food security, household income, and cultural identity (Masiza *et al*., 2023). The incursion of shrubs and trees has exacerbated feed shortages during the dry season, heightened competition for scarce resources, and increased production risks for small-scale farmers (Aweto, 2024). There are several definitions of bush encroachment; for this study, it is defined as instances in which woody plant species grow in areas where they did not previously occur (O'Connor et al., 2014; Esterhuizen, 2019). In this study, the terms 'bush encroachment', 'bush infestation', and 'woody invasion' interchangeably to denote the proliferation and impacts of woody plants in communal farming regions. Previous studies have mainly focused on the symptoms and wider effects of bush encroachment, overlooking the essential daily agricultural practices and decision-making processes crucial for its control in communal systems. Research indicates that bush encroachment is influenced by multiple interacting factors, including invasive plant species (Lesoli et al., 2013), overgrazing (Belayneh, 2017), climate change (Sebitloane et al., 2017), and altered fire regimes (Hassan & Louhaichi, 2023).

The scale of the problem is substantial, with bush encroachment being identified as the second most critical threat to ecosystems worldwide (Hui *et al*., 2017). Community rangelands are characterized by weak institutions, misaligned incentives, poverty, poor governance, and limited access to productive resources, which collectively perpetuate cycles of livelihood decline and ecological degradation (Kashandula *et al*., 2024; Newete *et al*., 2025 & Adams *et al*., 2019). The expansion of woody thickets reduces grazing capacity, reduces animal productivity, and increases income losses and food insecurity for small-scale farmers (Kgapola *et al*., 2023). Furthermore, livestock can facilitate the spread of encroacher species through seed dispersal, especially when goats transport seeds through their digestive systems, thereby increasing the cost and duration of ecological restoration efforts (Manganyi *et al*., 2023).

Agricultural extension plays a crucial role in addressing bush encroachment by aligning interventions with local socio-economic conditions and communal governance (Sebitloane *et al*., 2020). Extension strategies in communal contexts must consider the socio-cultural dynamics that influence innovation adoption, such as

traditional authority, local norms, and collective decision-making (Ezeudu *et al.,* 2023). Current strategies primarily focus on education and community engagement to shape farmer perceptions and practices (Baloyi, 2023), employing methods such as workshops, pamphlets, and community meetings (Norton & Alwang, 2020). The effectiveness of these interventions varies significantly based on community involvement, cultural acceptance, and the adaptation of proposed practices to local conditions, which can be influenced by factors such as the level of trust in extension agents and the integration of indigenous knowledge into the strategies. Effective agricultural extension services are characterised not only by the dissemination of information but also by adaptability, a participatory approach, and the capacity to enhance farmers' ownership of sustainable management strategies (Marquart *et al*., 2023; Antwi-Agyei & Stringer, 2021).

Acknowledging the valuable indigenous knowledge of communal farmers is crucial, as it can guide rangeland management strategies. In developing countries, communal livestock keepers exhibit significant ecological knowledge that can aid in poverty alleviation, enhance food security, and promote sustainable livestock development (Baloyi *et al*., 2024; Kitole & Sesabo, 2022; Beyene *et al*., 2014). In South Africa, this knowledge has informed practical initiatives, such as the development of fodder flow programs that provide year-round feeding options (Monkwe *et al*., 2023). This regional ecological knowledge demonstrates extensive experience in managing limited natural resources under challenging environmental conditions (Rani *et al*., 2025). Agricultural extension should serve as both a technical advisory service and a facilitative platform that integrates local knowledge with scientific evidence to promote sustainable agricultural practices through education and co-learning (Prajapati *et al*., 2025).

Despite growing research on bush encroachment and rangeland management, there is still a significant gap in understanding how agricultural extension can effectively support farmer-led management in communal livestock systems, particularly in Mopani District, Limpopo Province. Current extension methods often fail to integrate local social and economic realities, traditional knowledge, and scientific evidence effectively, leading to strategies that do not align well with local customs, social systems, and financial constraints. Furthermore, policy integration is frequently undermined by a lack of alignment with existing administrative traditions and political culture, while the literature tends to favour technical and ecological interventions over participatory approaches for communal livestock keepers. Farmers often face challenges in obtaining the knowledge and institutional support needed to assess and adopt appropriate management strategies. Indigenous and traditional practices, while acknowledged, often lack formality, exhibit inconsistent application, and receive insufficient support from formal institutions, hindering their effectiveness in addressing the challenges posed by bush encroachment and in supporting sustainable communal livestock management.

Bush encroachment poses both an ecological threat and a direct challenge to the sustainability of communal livestock livelihoods and the resilience of the ecosystems that support them. The continued spread, despite multiple interventions, suggests that the problem persists due to complex interactions among environmental, socio-economic, and institutional factors, including inadequate policy enforcement, lack of community engagement, and insufficient funding for sustainable practices. The identification of effective

agricultural extension strategies is thus particularly urgent. It is important to implement an innovative and community-focused extension strategy to promote sustainable land management, empower farmers, and ensure the long-term viability of communal livestock production. This study is important because it demonstrates how agricultural extension can promote local, community-based, and sustainable approaches to addressing bush encroachment, particularly given the vital role of communal lands in rural livelihoods in Mopani District and similar regions.

Conceptual framework for Bush encroachment drivers

Drawing on insights from the examined literature on rangeland degradation, bush encroachment, and rural extension strategies, Figure 1 presents a conceptual framework. This framework shows how different factors influence bush encroachment and how agricultural extension can help reduce its impact. The framework is built on the idea that bush encroachment is not just about ecology; it also involves a mix of ecological, socio-economic, and institutional factors in communal rangelands. Continuous grazing, fire suppression, and soil degradation significantly influence bush encroachment in ecosystems. Overgrazing diminishes the biomass and ground cover of grasses, reducing their ability to compete with woody species (Zuo *et al*., 2023). The suppression of natural fire regimes eliminates an essential control mechanism for the ecosystem (Russell-Smith *et al*., 2021). Soil degradation, characterised by compaction and nutrient depletion, promotes the development of woody species with deeper root systems (Osman, 2014).

The encroachment of bushes is directly impacted by socio-economic dynamics, particularly the heavy reliance on livestock for livelihoods. In communal areas, livestock serves as a source of food and income, holds cultural significance, enhances household security, and supports traditional practices (Mapiye *et al*., 2020). Livelihood pressures and limited income-generation alternatives drive high stocking rates, which, in turn, consistently strain rangeland resources (Rapiya *et al.,* 2025). Encroachment reduces forage availability, leading to a decline in livestock productivity and adversely affecting household income and food security (Twine *et al.,* 2016). This condition often leads to a detrimental cycle in which households respond to declining productivity by maintaining or increasing herd sizes, thereby exacerbating ecological degradation.

Institutional factors significantly influence the trajectory of bush encroachment. Weak agricultural extension services, inadequate policy frameworks, and insufficient resource allocation each independently impede collective action and sustainable rangeland management (Dong *et al*., 2017). Institutional shortcomings impede the dissemination of indigenous and scientific ecological knowledge, resulting in fragmented information for farmers that is challenging to apply in practice (Radcliffe *et al.,* 2021). Weak or fragmented governance structures lead to inconsistent enforcement of rangeland management policies, such as grazing controls, bush-clearing programs, and fire management, thereby allowing the persistence of unsustainable practices. The institutional gap reinforces ecological and socio-economic factors, thereby entrenching bush encroachment within communal systems (Baloyi *et al*., 2024).

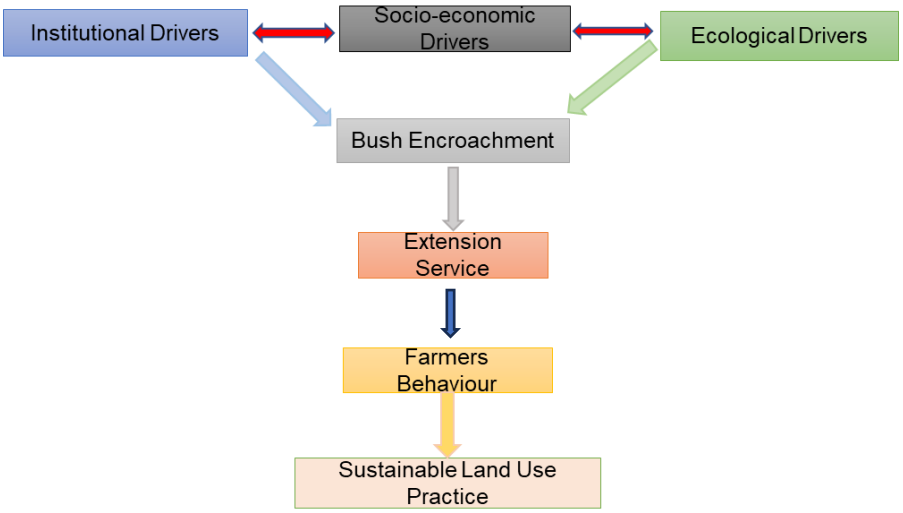

Figure 1. Conceptual framework for Bush encroachment drives. Source: Author's own work

Agricultural extension serves as both a provider of technical solutions and a responsive, inclusive process that connects structural drivers of encroachment with farmer decision-making. Extension services have the potential to drive positive behavioural change by promoting sustainable rangeland management practices. These goals can be achieved by educating farmers, fostering participatory decision-making, and supporting community-led initiatives. Furthermore, the conceptual framework highlights the importance of integrating indigenous knowledge systems with scientific extension methods to improve relevance and adoption rates. As such, agricultural extension is depicted not only as a provider of technical solutions but also as a dynamic, responsive, and inclusive process that connects the structural factors of bush encroachment with the adoption of sustainable land practices by communal livestock farmers. Enhancing this connection can facilitate the implementation of extension strategies that promote the enduring sustainability of communal grazing areas in the Mopani District and comparable rangeland environments across sub-Saharan Africa.

Study aims and objectives

This study aims to promote sustainable management frameworks and agricultural practices by revitalising degraded rangelands and improving the living conditions of vulnerable communities through agricultural extension strategies. The findings are expected to shed light on the effectiveness of current agricultural extension services and identify potential areas for improvement in combating bush encroachment. The study's objective is to identify feasible agricultural extension approaches to eradicate bush encroachment on communal land. The study is guided by the research question constructed as: Which workable agricultural extension approaches can assist livestock farmers in eradicating bush encroachment under communal land.

Study Methodology

Study Area

Mopani District lies in the north-eastern part of Limpopo Province of South Africa (Figure 2)**.** It comprises five (05) municipalities, namely Greater Letaba, Greater Tzaneen, Greater Giyani, Maruleng, and Ba-Phalaborwa, under which agricultural extension is administered. It is known for its non-commercial communal land system and its susceptibility to natural disasters, including bush encroachment, storms, lightning, floods, and fires. It is bordered by the Vhembe district to the north, Kruger National Park to the east, Ehlanzeni district of Mpumalanga province to the south, and Greater Sekhukhune district to the west. According to Figure 3**,** the area has recorded a maximum of 47.9 °C and a minimum of 3.5 °C between the years 2010 and 2024. The maximum daily precipitation recorded was 142.7 mm on the 20th of January 2013, and about 85% of its rainfall occurs in the summer. The area's extensive communal lands are managed through traditional farming practices by individual households and/or community groups. The selection of this district was based on the area's distinctive economic, ecological, and social context, which has influenced the local responses to bush encroachment.

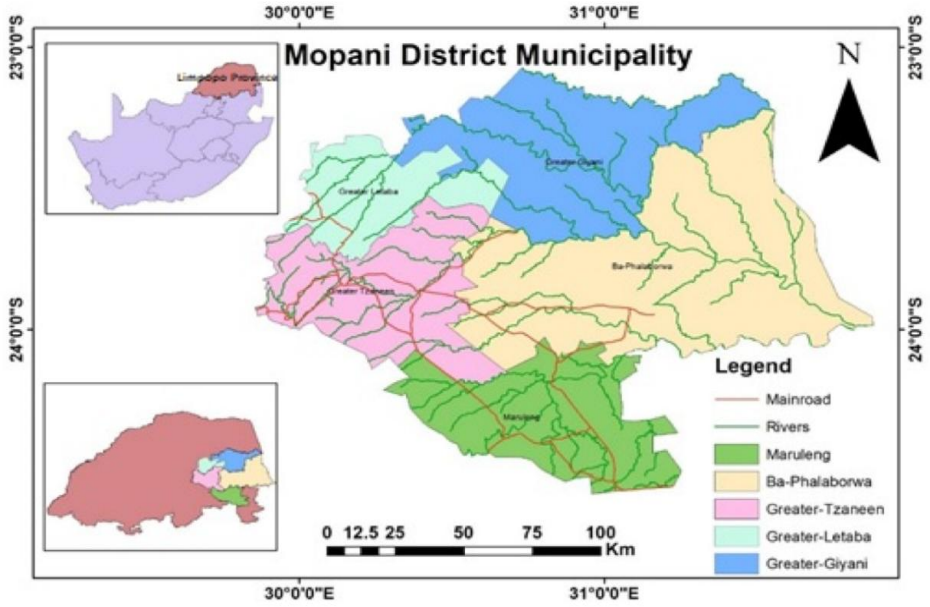

Figure 2. Mopani District Map. Source: Nembilwi *et al*., 2021

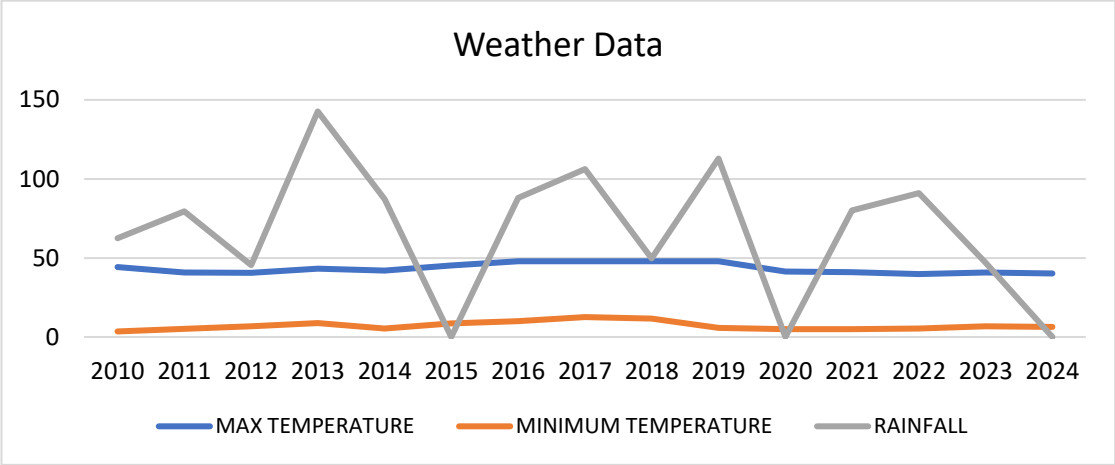

Figure 3. Yearly recorded maximum and minimum temperatures, and daily rainfall at Sekgosese service center weather station, Mopani District. Source: Limpopo Department of Agriculture and Rural Development.

Research design and Sampling

This study used a descriptive cross-sectional research design to collect both qualitative and quantitative data from communal livestock farmers at a specific time to better understand their experiences. Purposive sampling was used to select smallholder livestock farmers with the most relevant experience and knowledge regarding bush encroachment. The sample was stratified across various geographic zones within Mopani District to ensure that both socio-economic and ecological variations are captured in bush encroachment severity and management approaches.

Data collection

Data were collected from farmers associated with 33 dipping tanks across Mopani District during livestock dipping activities, community meetings, farmers' days, and commodity study groups. The interview guides were organized around essential themes identified in the literature on rangeland degradation, livelihood vulnerability, and agricultural extension, while also allowing for probing and follow-up questions. During the interview, questions were translated from English into local languages (Pedi, Venda, and Xitsonga). Fifteen livestock farmers participated in pre-testing the questionnaires before the final data collection to ensure their validity and reliability. Data were collected from 300 smallholder livestock farmers across the following district municipalities: Greater Letaba (60), Greater Tzaneen (55), Greater Giyani (70), Maruleng (50), and Ba-Phalaborwa (65).

Data Analysis

Quantitative data were analysed using Statistical Package for the Social Sciences (SPSS) software version 27. In contrast, the questions not amenable to SPSS analysis were analyzed using the thematic analysis framework. The analysis followed the six-phase framework by Braun and Clarke (2006), consisting of

familiarisation with data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and then report production. An inductive coding approach was used to let themes emerge naturally from the data, free from predefined theoretical influences. This was done to ensure the analysis was grounded in participants' real-life experiences and the context of the Mopani District. Thematic saturation was achieved when the data revealed a wide range of interconnected themes, signifying a comprehensive exploration of the research topic. This indicates that the collected data were sufficiently extensive in scope and depth to support a strong, reliable interpretation.

Results

Socio-economic demographic characteristics

The results from Table 1 depicts descriptive information regarding the main attributes of the population in the study area. The age distribution of the respondents revealed a predominance of older farmers, particularly those above 60 years old (51,67%), 51–60 years (20.33%), 36-50 years (14%), and the 21-35 age group was equally represented at 14% each. The age difference was statistically significant (P<0.001). The results suggest that the respondents were generally experienced in farming, with the majority reporting either 6-10 years of experience (30.67%) or 20 years and above (30.33%), while fewer participants had 1-5 years (16.7%), 11-15 years (13.67%), and 16-20 years (8.67%) of farming experience. The difference in farming experience was statistically significant (P<0.001*).*

Table 1. Socio-Economic and Demographic Profile of the Respondents

Characteristics	**Response**	**x^2**	**p-Value**
Age	**(Frequency and Percentage)**		< 0.001
>20	0(0)		
21-35	42(14.00)		
36-50	42(14.00)	116,98	
51-60	61(20.33)		
60>	155(51.67)		
Farming experience			<0.001
1-5	50(16.67)		
6-10	92(30.67)		
11-15	41(13.67)	60,05	
16-20	26(8.67)		
20>	91(30.32)		

Perception of Bush encroachment

The result in Figure 4 shows information on primary drivers (CBE) of bush encroachment within the communal livestock system. The results show that climate change (44%), human settlement (31%), overgrazing (10%), don't know (9%), and veld fires (6%) are the key drivers within the communal livestock system. Furthermore, the factors involved in the spread of bush encroachment (RSBE) are multifaceted, as shown in Figure 5. The respondents identified cattle droppings (71%), overstocking (15%), and 'do not know' (14%) as critical elements in the spread of bush encroachment. In addition, respondents perceived numerous stakeholders in managing bush encroachment (RCBE), as highlighted in Figure 1.6: the government (50%), the government and farmers (30%), and farmers acting independently (20%), respectively.

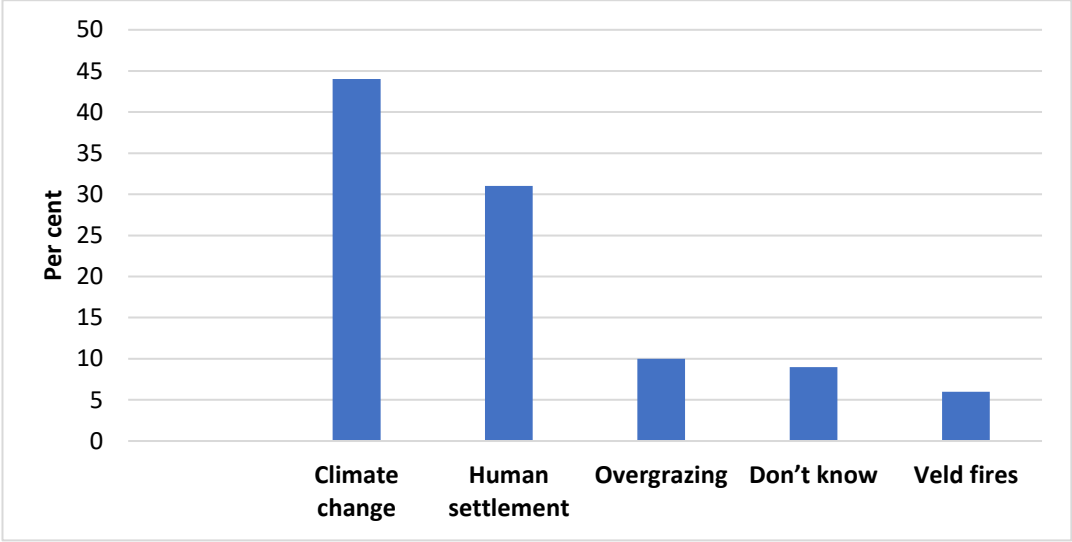

Figure 4. Key drivers of bush encroachment (CBE)

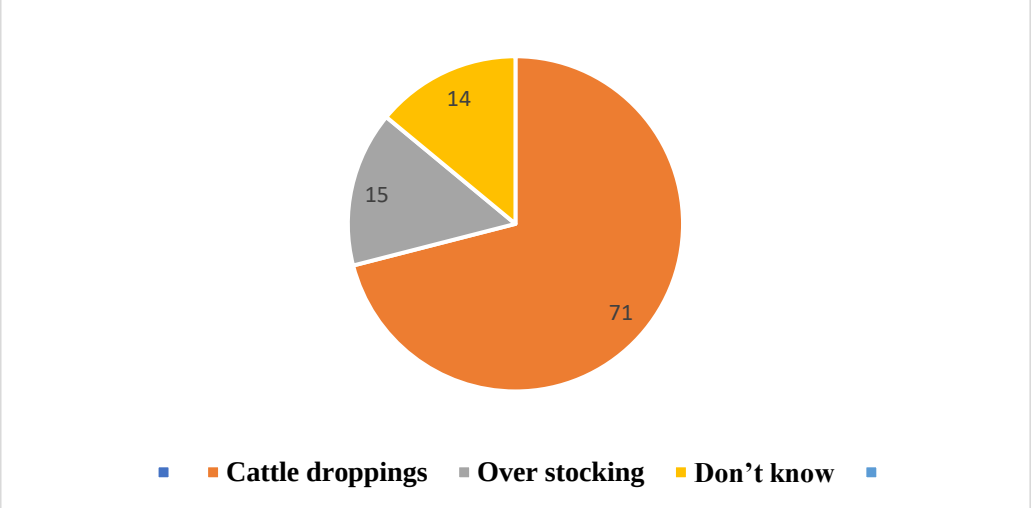

Figure 5. Responsible for the spreading of bush encroachment (RSBE)

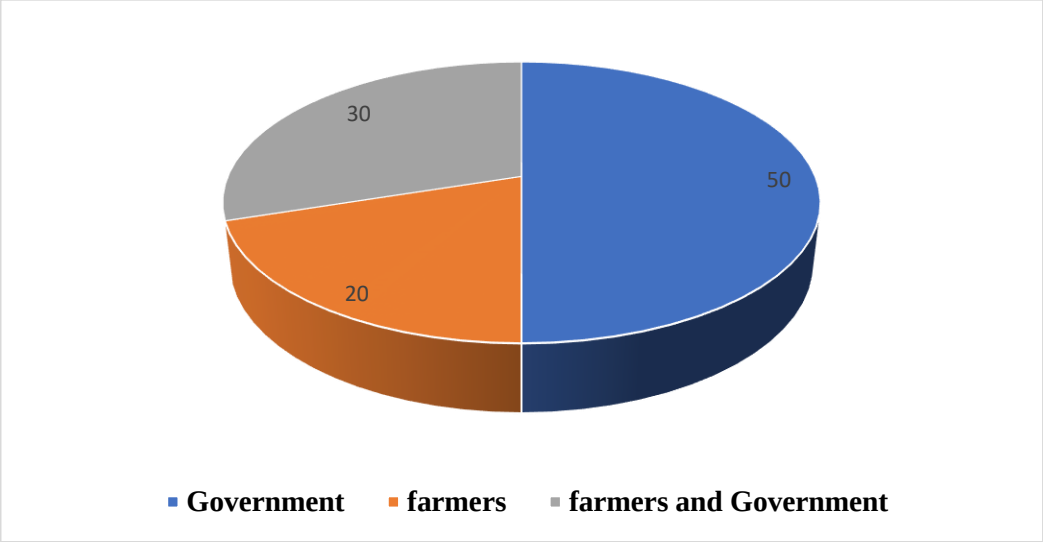

Figure 6. Responsible for control of bush encroachment (RCBE)

Responsibility and awareness towards bush encroachment

The findings from Figure 7 show a substantial gap in extension service support for controlling bush encroachment within the communal system. The results show that 90% of farmers reported receiving no assistance, while only 10% admitted to receiving support from agricultural extension services. Additionally, Figure 8 shows that around 60% of livestock farmers in the communal system favor mechanical cutting for managing bush encroachment, while 40% prefer fire management.

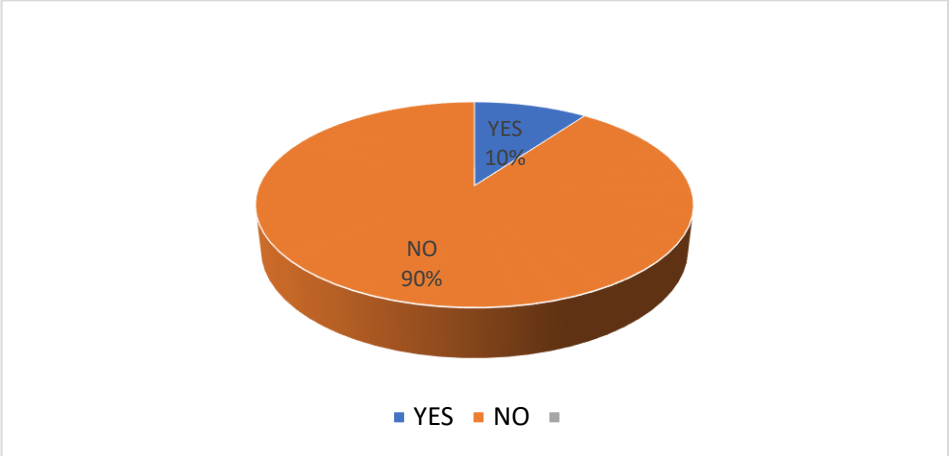

Figure 7. Agricultural support for managing bush encroachment

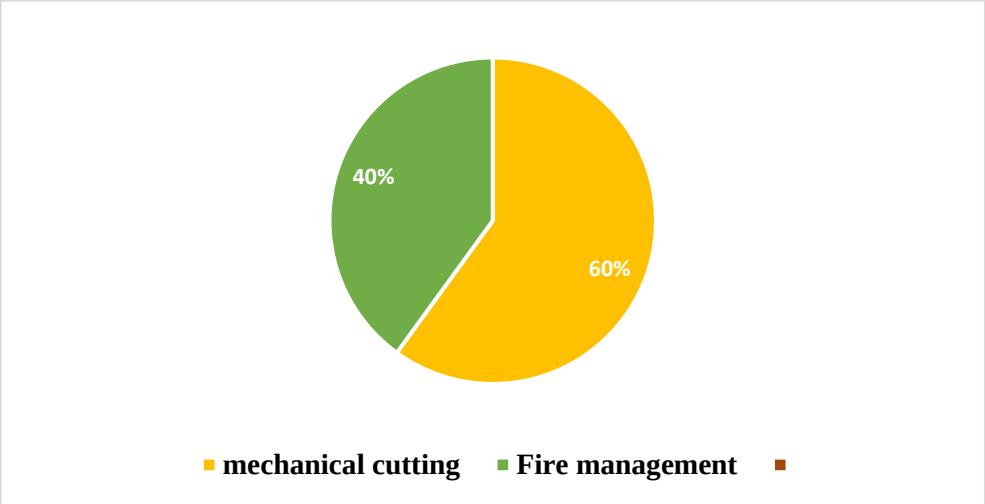

Figure 8. Control of bush encroachment (CLBE)

Discussions

Socio-Economic and Demographic profile of the respondents

The results shown in Table 1 reveal a strong link between age, farming experience, and the distribution of livestock farmers in the study area ($P < 0.001$). This suggests that age and farming experience significantly affect how farmers perceive and respond to agricultural extension efforts to control bush encroachment. The prevalence of older farmers in the sample could significantly influence technology adoption, as this demographic may be reluctant to adopt bush control methods that require mechanization, financial investment, or organized collective action. The smaller proportion of younger farmers may indicate a more receptive demographic for innovation-driven extension methods, especially those focused on technology transfer, participatory learning, and demonstration plots. Differences in farming experience underscore substantial variations in farmers' adaptive capacity and their interpretation of the environment. Experienced farmers may possess valuable indigenous and practical knowledge of rangeland dynamics; however, their familiarity with bush encroachment may lead them to accept it as a natural part of the landscape, reducing the perceived urgency of control measures. On the other hand, less-experienced farmers may lack extensive environmental knowledge but are more willing to accept science-based extension guidance and sustainable land management practices. The results indicate that extension interventions should not adopt a uniform approach; instead, they should employ differentiated strategies that acknowledge the needs, strengths, and constraints of various farmer groups. According to Gaur *et al*. (2024), extension programs should incorporate the expertise and local ecological knowledge of older farmers to enhance projects and, at the same time, promote opportunities tailored for youth, such as fodder production, charcoal businesses, and ecological restoration efforts. An individualized strategy is anticipated to boost farmer engagement, enhance the significance of extension communications, and improve the long-term effectiveness of rangeland restoration projects in Mopani District.

Key drivers of bush encroachment within the communal land system

In evaluating agricultural extension strategies to manage and eradicate bush encroachment in Mopani District, farmers expressed diverse perceptions. Most farmers reported noticeable changes in their land use due to the proliferation of encroached bush, which they link to a decline in agricultural productivity. Farmers expressed concern about the decline in grazing land because of bush encroachment, stating:

"Bush encroachment is caused by climate variability, which weakens the palatable grasses and promotes plant species that can easily survive under such climatic conditions".

These reveal that bush encroachment is a complex ecological occurrence influenced by various factors, and Farmers linked the proliferation of woody vegetation to the interplay of climate variability, settlement expansion, and alterations in land-use practices. Thus, highlighting bush encroachment as a multifaceted socio-ecological issue within communal livestock systems. Farmers who recognise climate change as a factor show increased awareness, leading them to take proactive measures to adapt to environmental changes affecting their livelihoods. This hypothesis is supported by evidence indicating that changes in rainfall and temperature patterns encourage the expansion of woody plants in savanna ecosystems (O'Connor *et al*., 2014). Farmers associated settlement expansion with reduced grazing land and restricted livestock to smaller areas, potentially increasing ecological stress and hastening bush encroachment. Farmers expressed concern about the decline in grazing land because of bush encroachment, stating:

"Bush encroachment is caused by climate variability, which weakens the palatable grasses and promotes plant species that can easily survive under such climatic conditions".

The lack of acknowledgment regarding overgrazing and veld fires as contributing factors indicates significant knowledge deficiencies that may impede the implementation of effective management strategies. The high frequency of "don't know" responses underscores respondents' limited understanding of ecological concepts. This lack of awareness may impede the implementation of effective management strategies and interventions among various stakeholders. Alternatively, the misuse of fire, such as frequent burning during autumn, promotes out-of-season growth, slowing grass development and giving woody plant species a competitive edge over grass. This is supported by the study of Pausas and Lamont (2022), which found that a single fire event can enhance tree density and stimulate tree seedling germination by scarifying the seeds. The results emphasize the need for extension interventions to improve ecological literacy, increase farmers' awareness of factors driving bush encroachment, and establish collaborative, adaptive strategies with various stakeholders. This method is essential for improving the resilience and sustainability of communal livestock systems amidst changing environmental conditions, particularly by enhancing the understanding of fire management practices and their role in maintaining ecological balance.

Farmers' Knowledge of Key Contributors to Bush Encroachment Proliferation Under Communal Land

The findings highlight the significance of local farmers' knowledge in comprehending bush encroachment and influencing behavioral responses to management interventions. Farmers have observed a connection between livestock droppings and the proliferation of woody species, demonstrating their understanding of how seeds spread in nature. This notion is supported by scientific research showing that livestock dung can help seeds sprout and support the growth of woody plants in areas with low fire occurrence (Tjelele *et al*., 2015 & Vukeya, 2022). Farmers' observations reflect a valid ecological process, underscoring the value of integrating local knowledge into rangeland research and management strategies, as demonstrated by previous successful initiatives. One farmer quoted that:

"Livestock that are not enclosed at night roam and sleep everywhere, and as they disperse dung, they also spread the seeds of invasive plant species. The government, with the assistance of the local chief, should identify the owners of and impose fines or penalties on them".

The lack of recognition of overstocking as a contributor to bush encroachment reveals a notable misunderstanding, despite strong evidence that excessive animal numbers reduce plant cover and promote woody plant growth (Bond & Parr, 2010). This lack of understanding may stem from the cultural and economic significance associated with owning livestock in communal systems. In these systems, herd size is intricately linked to wealth, identity, and livelihood security, which may explain the reluctance to acknowledge overstocking and its impact on bush encroachment. The widespread uncertainty among farmers suggests limited access to ecological information, which may impede informed decision-making and undermine the effectiveness of control measures (Kebede *et al*., 2020). The findings demonstrate the importance of extension strategies that integrate not only farmer perceptions but also indigenous knowledge with ecological science. This integration can lead to context-specific, participatory, and sustainable rangeland management practices, thereby improving the overall effectiveness of management strategies. Working together to share knowledge among farmers, extension workers, and researchers is crucial for improving teamwork and tackling bush encroachment in Mopani District and similar shared grazing areas.

Stakeholders' Roles in Controlling Bush Encroachment

Sustainable rangeland management for addressing bush encroachment requires ongoing monitoring, coordinated governance, sufficient resources, and active stakeholder participation. Farmers often see the government as primarily responsible for mobilising resources, enforcing policies, and carrying out large-scale interventions to tackle bush encroachment. This illustrates the historical political economy of communal land management in South Africa, showing how state support has significantly influenced rangeland governance. Relying too much on government assistance could weaken local stewardship unless balanced with approaches that promote farmer ownership and engagement. Agricultural extension plays a crucial role as an

intermediary, translating policy into actionable practices that empower communities to actively participate rather than passively benefit. In a co-management approach, both the government and the farmers share responsibility, with the government providing technical and financial assistance and the farmers contributing local knowledge, labour, and monitoring. This aligns with participatory extension models that focus on identifying problems together, making decisions collectively, and implementing collaboratively (Prajapati *et al*., 2025). Extension officers play a crucial role by establishing trust, nurturing relationships between farmers and government bodies, and aligning management approaches with ecological and socio-cultural settings. Farmer-led initiatives lacking institutional support frequently face significant challenges, including labor shortages, inadequate organization, and limited technical capacity. In communal grazing systems, the focus on maximizing production sometimes ignores environmental issues, leading to overgrazing that worsens bush encroachment.

These results underscore the critical need for policies that empower farmers with the knowledge and tools to manage land effectively. Bush encroachment management is characterized by a collaborative approach that requires vertical support from the state and horizontal collaboration among communities. Agricultural extension acts as the middleman, improving ecological effectiveness and increasing social acceptance of this governance model for bush encroachment management.

Perception of livestock farmers towards agriculture support in combating bush encroachment

Communal rangelands face challenges such as limited access, insufficient resources, and high farmer-to-agent ratios. These challenges impede the effective provision of technical support for controlling bush encroachment. While South Africa's extension policies officially endorse participatory, farmer-centered approaches, the services are often supply-driven and fail to effectively address local needs. Farmers expressed dissatisfaction due to limited availability, lack of adaptability, and poor relevance of current support systems. These shortcomings have fuelled the continuous spread of bush encroachment and, in some cases, led to reliance on unsustainable management methods, which further degrade the land and reduce agricultural productivity. Moreover, the absence of awareness campaigns, skills development initiatives, and ecological education worsens the problem, particularly affecting farmers with limited resources and no access to private advisory assistance. The failure of extension services widens social disparities, exacerbates environmental degradation, and weakens farmers' resilience. Support often focuses on quick chemical or mechanical actions, overlooking the essential ecological and management factors that contribute to encroachment. The findings reveal both quantitative and qualitative shortcomings in the current extension provision. Improving extension services through specialized training, community involvement, and incorporation of local knowledge is essential to enhancing the effectiveness, acceptability, and sustainability of interventions to control bush encroachment.

Practice used by livestock farmers in controlling Bush encroachment under the Communal System

Immediate livelihood pressures and broader ecological factors influence livestock farmers' preferences for bush encroachment management. Mechanical cutting was preferred for its ability to deliver visible, rapid results, especially in situations where a lack of grazing land poses a direct threat to household livelihoods. Mechanical cutting corresponds with traditional indigenous methods of bush removal, using axes or hand tools, thereby demonstrating continuity with established land-clearing practices (Umeghalu *et al*., 2022).

"We cut the encroached trees, especially the sickle bush; we make firewood, and this wood also helps in erecting our livestock kraals."

While mechanical control is effective in the short term, it tends to be labor- and cost-intensive, especially in large communal rangelands with extensive encroachment. Without follow-up actions such as controlled grazing or integration with fire patterns, areas cleared by mechanical means can quickly be invaded again as woody plants regrow from root suckers. The appeal of mechanical cutting, demonstrating continuity with indigenous land-clearing practices, is limited without supplementary measures such as controlled grazing, reseeding, or selective herbicide application.

Fire management is linked to traditional ecological knowledge and is acknowledged for its ability to restore the balance between grass and woody vegetation in extensive communal rangelands while requiring less labor. Nonetheless, its diminished preference appears to be constrained by regulatory constraints, perceived risks, and inadequate labor and organizational capacity for safe, controlled burning. Farmers may be hesitant to use fire due to concerns about penalties or insufficient confidence in their ability to safely execute prescribed burns. Additionally, an aging farming population, as indicated in Table 1.1, may be deficient in the labor and organizational capacity necessary to establish firebreaks, organize community fire teams, and effectively manage controlled burns.

"*We have been using fire for years to clear encroached bushes, and the grazing area has improved significantly*".

The different choices indicate that farmers' decisions are shaped by ecological suitability, socio-economic conditions, institutional constraints, and perceived feasibility. The results highlight the importance of agricultural support services expanding beyond recommending a single method and advocating for combined bush management strategies that incorporate farmer knowledge, ecological science, and participatory learning, thereby promoting sustainable rangeland restoration. Integrating farmer preferences into a holistic ecological and institutional framework allows agricultural extension to transform the current fragmented, method-focused approach into a unified, flexible strategy for restoring rangelands.

Recommendations

The study recommends that the approach to managing bush encroachment be informed by the Sustainable Communal Management Framework (SCMF), which identifies agricultural extension as the primary coordinating mechanism for integrating ecological restoration, livelihood support, and institutional collaboration. According to Figure 9, extension services must be transformed to adopt participatory, demand-driven, and climate-smart approaches that address the socio-ecological realities of farmers, rather than depending on top-down delivery methods. The framework supports integrated management strategies that incorporate mechanical clearing, prescribed burning, rotational grazing, reseeding, and soil conservation, facilitated by demonstration plots, farmer field schools, and technical training.

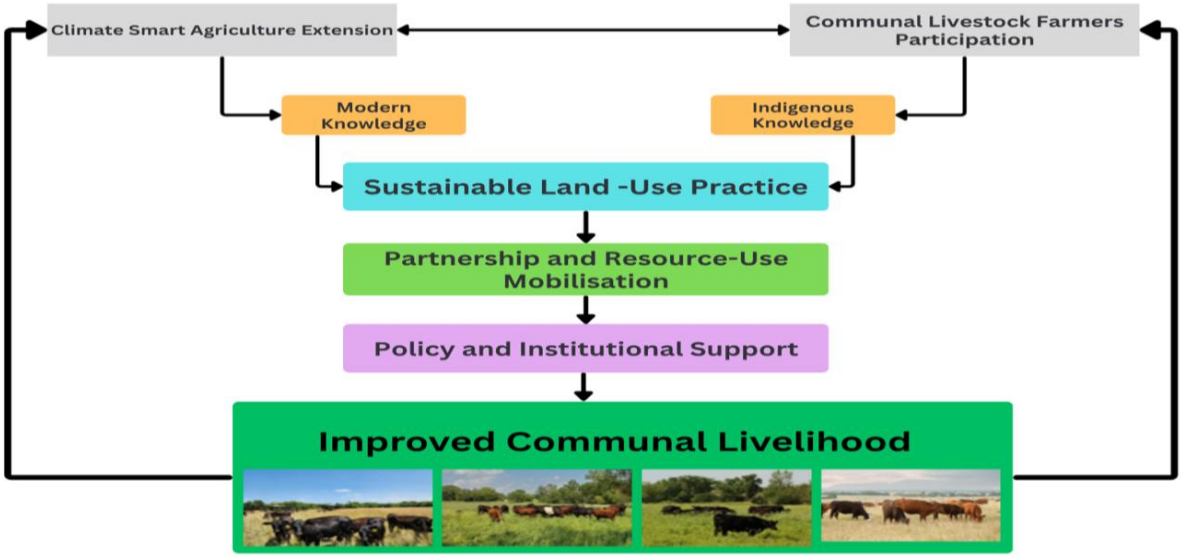

Figure 9. Sustainable communal management framework. Source: Author's own work

This approach highlights the importance of blending indigenous ecological knowledge with scientific evidence to preserve local ecological memory and enhance stewardship. Effective implementation requires polycentric governance, in which government agencies, traditional authorities, NGOs, private sector actors, and farmer organizations collaborate through formalized co-management arrangements and enhanced community-based rangeland committees. Enhancing local response capacity requires that extension services tackle socio-economic barriers by promoting youth employment in bush clearing, implementing labor-for-input initiatives, and facilitating livelihood diversification to alleviate pressure on communal grazing systems. The framework highlights the importance of monitoring, evaluation, and learning systems, such as farmer-based rangeland monitoring, to enhance accountability, adaptive management, and policy feedback. Hence, Figure 1.9 displays a policy framework that combines controlling bush encroachment with a comprehensive approach to sustainably managing land, restoring the environment, and strengthening community livelihoods.

Conclusion

This study concludes that bush encroachment in communal rangelands is a complex issue influenced by environmental changes, economic pressures, institutional shortcomings, and a lack of agricultural support. Despite knowing about the negative effects of too many woody plants on grazing, income, and food security, communal livestock farmers in Mopani District struggle to react due to a lack of training, financial resources, and coordination. The preference for cutting and controlled burning underscores the urgent need to tackle bush encroachment with affordable methods that suit communal livestock farming, underscoring the importance of holistic, eco-friendly management. The results show that for real improvement, it's important to create teamwork among farmers that allows them to make decisions together, along with strong support from institutions, even though the government has been Agricultural extension needs to evolve from basic advice provision to a broad-reaching institution blending local and scientific knowledge, encouraging involvement, building local skills, and supporting adaptable governance. Managing bush encroachment in Mopani District effectively depends on how well extension systems can combine restoring the environment with supporting people's livelihoods, involving the community in decision-making, and making lasting changes to institutions. Future research should focus on longitudinal monitoring frameworks and the economic viability of strategies for managing bush encroachment in communal livestock systems.

Competing interest

The authors affirm that there are no conflicts of interest that could reasonably be interpreted as compromising the objectivity or impartiality of this research.

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