



Review

A Review of Community-Based Strategies for Addressing Bush Encroachment in the Semi-Arid Savannah Rangelands of Southern Africa

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Abstract: There are distinct management approaches for communal properties and commercial agricultural properties concerning bush encroachment. The utilisation of community-based knowledge possesses the capacity to enhance our comprehension of localised circumstances and provide valuable experience in endeavours targeted at supporting local communities. The perception of bush encroachment control as a sustained endeavour rather than a singular occurrence is of utmost importance. This may include considering other solutions that may not always be the most convenient or cost-effective. The objective of this study was to evaluate the predominant methods employed by rural communities in semi-arid savannah rangelands in Southern Africa to manage bush encroachment. Using the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines, a literature search was conducted in the field of communal strategies of bush encroachment management. The findings of this study indicate that the predominant and commonly utilised management strategy for mitigating bush encroachment includes the extraction of plants for medicinal applications, followed by firewood extraction. Indigenous and traditional knowledge systems have played a pivotal role in communal bush encroachment management. It is recommended that communal approaches to bush encroachment management in Southern Africa's semi-arid savannah rangelands harness the power of indigenous knowledge while benefiting from modern scientific insights, ultimately leading to more effective and sustainable management practices. This can be accomplished by fostering community involvement and active participation, facilitating the exchange of knowledge, enhancing skills and expertise, preserving and safeguarding indigenous wisdom through documentation, and harmoniously blending traditional and scientific methodologies.

Keywords: *Dichrostachys cinerea*; rural communities; indigenous knowledge; contemporary control; management practice



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1. Introduction

Semi-arid savannah rangelands refer to regions that possess a natural or indigenous presence of grasses, grass-like vegetation, or forbs, which are subject to grazing or browsing

activities [1–3]. It is important to note that semi-arid savannah rangelands also play a significant role in supporting the livelihoods of rural communities, as they provide a wide range of ecosystem services that are derived from these areas [4,5]. Stevens et al. [6] reported that savannah rangelands play a significant role in sustaining approximately 50 percent of the worldwide livestock population while also serving as a crucial source of livelihood for over 250 million households worldwide. Historically, semi-arid African rangelands have suffered from deterioration due to the expansion of bushes, which are desired replacements for perennial grasses [5,7,8]. When rangelands degrade, many ecosystem services are lost, including the production of grass and livestock biomass, the replenishment of groundwater, the storage of carbon, and the prevention of soil erosion [7]. The degradation of semi-arid savannah rangelands is primarily associated with inadequate or nonexistent grazing management strategies, the extraction of vegetation for fuelwood, and often the absence of well-defined ownership rights over rangeland areas, particularly in rural communities throughout Africa [8,9]. According to Czeglédi and Radácsi [10], when the animal population surpasses the land's carrying capacity, it leads to the over-utilisation of grasses, resulting in a lack of regeneration for a significant portion of these grasses.

Consequently, the palatable grasses are gradually replaced by a range of woody species. The encroachment of rangelands directly affects a substantial population of over 250 million people, spread across more than 100 countries, as highlighted by Adger and Vincent [11]. This is because rangelands primarily serve as a crucial source of livestock feed, as emphasised by Kellner et al. [12]. Bush encroachment is a widely studied phenomenon in the field of ecology and land management [13]. It is a term used to describe progressive expansion (though not only limited to expansion) and also the encroachment, in areas that were never encroached on before, of woody vegetation, typically shrubs and small trees, into grasslands and savannas [14–16]. This phenomenon is characterised by an increase in the density, cover, and height of woody plants within these ecosystems. The encroachment of woody vegetation can have significant ecological, economic, and social implications [16,17]. Encroachment of woody species is a complex process influenced by various factors, including climate change, land use practices, fire suppression, and changes in grazing patterns in the semi-arid rangelands [12,18]. While some level of woody plant expansion is a natural process in certain ecosystems, human activities have accelerated and intensified this encroachment in many regions [19–21].

Several studies have investigated the causes and consequences of bush encroachment in different parts of the world, including Africa, Australia, and the United States [11,22–25]. Various methods have been used to monitor and assess the causes and impact of bush encroachment, such as remote sensing and spatial information, climate and weather analysis, fire analysis, hydrological changes, human or communal activities, long-term ecological research, and modelling approaches [18,26,27]. However, few studies are available on how communities manage bush encroachment at a grassroots level. This paper seeks to assess the prevalent methods employed by rural communities in the Southern African semi-arid savannah rangelands to address the issue of bush encroachment. This will pave the way for other researchers to investigate those methods further, looking at their effectiveness and efficiency. Furthermore, the findings of this study might help the government to invest more in those approaches used by local communities.

Due to the scarcity of scholarly resources on the topic of a communal-based approach to bush encroachment, this research study aimed to highlight the dearth of research on the community management of bush encroachment in communal semi-arid rangeland.

2. Literature Search Methodology

2.1. Search Strategy

To accomplish the aim, this study conducted a search on the Web of Science database using the keywords “communal-based approach” and “bush encroachment” as indicated in previous studies [28,29]. The search revealed that the notion of a communal-based approach to addressing bush encroachment is not adequately understood or represented. Specifically, a comprehensive literature search yielded almost 16,000 papers related to “bush encroachment management”, but just 30 articles were found on the topic of communal-based approaches to bush encroachment. It is important to note that, within the Web of Sciences database, the 30 publications were the maximum number of articles associated therewith. This situation is worrisome, particularly in Sub-Saharan Africa, where the expansion of bushes is a significant difficulty, especially in rural areas. However, the methods employed by rural populations to address this issue have not been well recorded or accounted for. Therefore, this research intends to emphasise and bring attention to this existing deficiency. The investigation of bush encroachment management was conducted using the specialised programme VOSViewer. Afterwards, a graphic overlay depicting the research efforts related to managing bush encroachment was created, as seen in Figure 1.

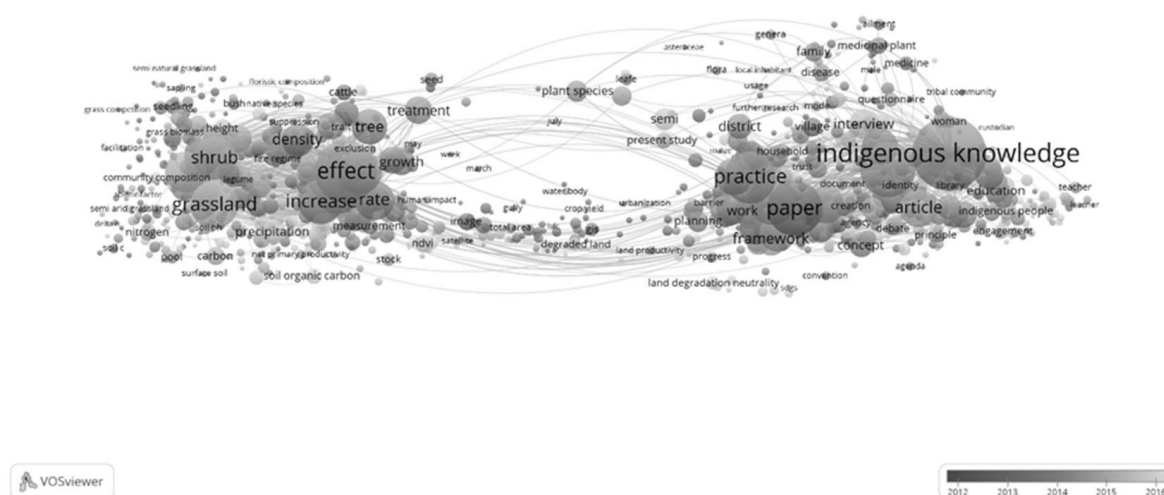


Figure 1. Structure of research in Web of Science using specialised VOSviewer tool software (1.6.20).

The literature search included English peer-reviewed articles and relevant technical reports. All information used in the evaluation and review was collected from extensive project reports and published papers. Numerous scientific databases were used to identify all the relevant articles and reports (Figure 2). However, the literature search focused on shrubs (woody plants), tree and bush encroachment, and communal-based approaches in unprotected areas, i.e., communal areas only. PRISMA facilitated the identification of the pertinent literature and documentation for this comprehensive review. A comprehensive review was conducted using PRISMA to thoroughly examine communal bush encroachment management approaches, encompassing all significant aspects and details, leaving no key point unexamined. This detailed analysis aimed to provide a comprehensive overview of the topic, analogous to a meticulous examination to ensure all factors were considered. The data were stratified and examined using the reference management programme EndNote 21 throughout data processing. EndNote 21 facilitated the elimination of duplicate papers, as well as the categorisation and organisation of the papers based on their respective subgroups, following Grangxabe et al.'s [30] approach. During the duplication procedure, thirty-six records were excluded before screening, and one duplicate was manually eliminated from the five.

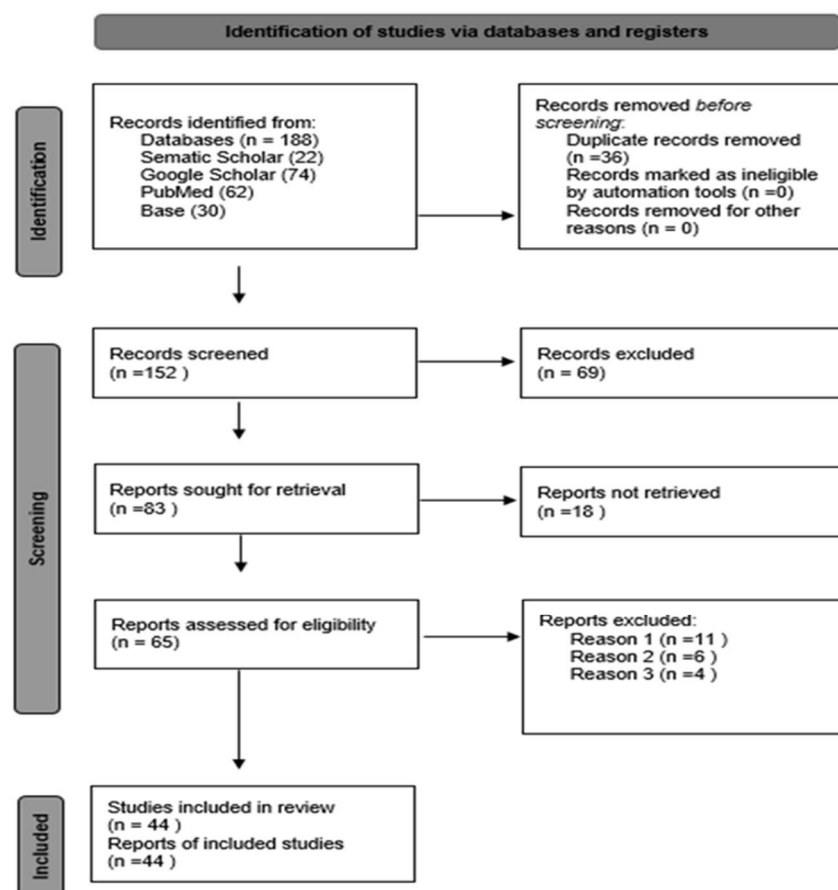


Figure 2. This paper elucidates the methodology employed in the process of selecting studies from the four most prominent databases. The approach described in this study follows the principles set out by the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA).

2.2. Data Extraction and Selection of Studies

The authors chose to employ four separate databases, namely Semantic Scholar (22), Google Scholar (74), PubMed (62), and Base (30). The criteria for selection included the following: (1) the assessment of bush encroachment in rangelands (savannah); (2) methods for the monitoring and assessment of bush encroachment; (3) communal-based approaches to bush encroachment management in savannah areas; (4) the impact of bush encroachment on communal savannah rangelands; (5) common strategies and techniques that have been employed to manage bush encroachment; and (6) the relevance of bush encroachment in South Africa, Ethiopia, Namibia, and the Kingdom of Swaziland. Despite containing the keywords in their titles and/or abstracts, all studies focusing on bush encroachment in protected areas were excluded during the screening process because they were irrelevant to the study and lacked relevant data. The relevance verification in this review was carried out by three writers who reviewed the titles and abstracts. Two authors of this review performed relevance checking, which consisted of reading the titles and abstracts; disagreements were resolved by consulting the third author for accuracy checking. After removing studies that were not relevant, two reviewers collected data from the studies that met the inclusion criteria. By utilising the worldwide databases, the writers successfully identified possibly relevant entries. As shown in Figure 2, a dataset was identified, and the database search resulted in 188 items. As a consequence, 21 reviews were excluded from the analysis due to their failure to fulfil the predetermined eligibility criteria (shown in Figure 2). A total of eleven (11) records were excluded from the analysis due to their antiquated nature and insufficient coverage of savannah rangeland, which predominantly

consists of grassland. Another justification for excluding an additional six articles was their exclusive focus on GIS, remote sensing, and modelling, without any consideration of community engagement. Furthermore, four papers were excluded due to their emphasis on wildlife management and national parks, which fell beyond the purview of the current study. However, 18 studies were excluded because the full papers could not be obtained given that they were not open access and the authors of those papers were not responding to emails; moreover, the papers were not available on ResearchGate. The authors obtained and evaluated the complete reports of publications that were considered eligible for inclusion by the authors. A total of 83 studies were found and evaluated for eligibility. In the present study, a total of 65 publications were selected for inclusion in the analysis. Subsequently, the whole texts of the remaining 65 reviews were meticulously scrutinised.

3. Impact and Significance of Shared Rangelands on Communal Savannahs

The African communal rangelands are characterised by conflicts pertaining to land use [25,31]. The negative impacts on the sustainability of communal savannah rangeland resources (forage, medicinal plants, and fruits) are believed to be associated with both centralised and local control over these resources [32]. Hardin [33] argues that the degradation of common properties is an inevitable outcome unless measures are taken to convert the property into private or public ownership with limited access rights. According to Schafer and Bell [32], the delegation of resource control to communities is posited to offer substantial motivation for the sustainable management of said resources. In a significant number of common property resources, clan leaders have been bestowed with the privilege of land ownership, which is subsequently upheld by community elders [31]. The poor organisation of institutions responsible for managing communal rangelands, coupled with changes in land tenure policies, is considered to be the primary cause of the gradual degradation of these rangelands [32]. In essence, degrading land can be attributed to the weakening local communal land management system, particularly the weakening of tribal councils [34].

Bush encroachment in Sub-Saharan Africa remains highly relevant due to its wide-ranging impact on the environment, economy, and society [5,18,23,24,35,36]. Some of the key reasons for its continued relevance include, but are not limited to, biodiversity conservation, ecosystem services, land degradation, water resources, livestock farming, fire risk, climate change, invasive species, conservation management, and, ultimately, economic impact [37–39]. In a study conducted by Jeltsch et al. [40], bush encroachment has been shown to reduce the carrying capacity of arid grasslands in southern Africa for cattle, and this is known to occur as a result of the selective overgrazing of grasses by cattle. As a result of bush encroachment, land degradation can negatively impact ecosystem services, which can lead to socio-economic difficulties, including a loss of income and insufficient income for the maintenance of livestock. It is envisaged that improved livestock productivity will have a positive effect on ecosystem services and, by inference, on the well-being of the surrounding communities.

Another study by Angassa [41] showed the ecological impact of bush encroachment on the yield of grasses in rangeland ecosystems. Non-encroached communal grazing areas had relatively increased yields that varied from 106% to 150% in comparison with bush-encroached areas that had lower yields. This was also evident in a study by Gobelle and Gure [42], which depicted the effects of bush encroachment on plant species composition, diversity, and its contribution to carbon stocks. Bush encroachment ultimately led to a reduction in rangeland productivity in the Borana rangelands of southern Ethiopia. The influence of ecosystems on human culture is substantial, with changes in ecosystems potentially exerting a profound effect on cultural identity and societal stability. Many

indigenous communities have cultural and traditional connections to the savannah landscapes, and bush encroachment can alter these landscapes, affecting local cultural practices and spiritual and religious beliefs [43]. Indigenous communities often rely on savannah rangeland landscapes for various traditional activities such as hunting, gathering, and agriculture. Indigenous cultures often have rituals, ceremonies, and cultural practices that are closely tied to the natural environment, including savannah landscapes. Changes in the landscape due to bush encroachment can impact these cultural practices and beliefs, as they are intimately connected to specific features of the landscape.

4. Historical Communal-Based Bush Encroachment Management

Historically, it has been observed that the growth of bushes was more rapid on small portions of property with moderate commercial ownership, whereas it was slower on territory with communal ownership [22]. Most southern African communities have a history of segregating black and white populations along semi-arid rangelands, resulting in black groups being restricted to smaller grazing areas. In the 1970s, South Africa was included in the erstwhile homelands, which were segregated physically inside the country. These territories covered 13% of the country's territory and had the highest population and animal density. It may be necessary to take into account historical environmental changes when evaluating communal sites under community systems. Many communities have developed communal approaches to address this issue of bush encroachment, drawing on their traditional knowledge and local resources [33,39]. These approaches often involved a combination of cultural practices, land management strategies, and community cooperation [5,33]. In the savannah rangelands of southern Africa, woody plants have played a crucial role in various aspects of local communities' lives. There is also evidence that this species was harvested for medicinal purposes and used by communal communities for fever reduction, antimicrobial properties, anti-inflammatory effects, gastrointestinal relief, respiratory issues, wound healing, and antioxidant properties, to name a few [44,45]. Spiky branches obtained from woody plants such as *Acacia tortilis* and *Acacia erubescens* serve as essential materials for building enclosures known as kraals [46]. These kraals are designed to safeguard livestock from potential threats, as documented in Smit [14].

In the past, local livestock farmers in many southern African countries heavily depended on two primary traditional rangeland management strategies, which are burning and mobility [6,41,47]. Other recognised rangeland management strategies include(d) the harvesting of parts of the plant for firewood or animal feed (Table 1). However, to fully understand their rangelands impacts and diverse traits, it is imperative that one understands their differentiation. Various bush encroachment management systems were assessed in the study in order to assess their effectiveness in restoring invaded habitats in rangelands. To control invasions of rangelands, various strategies and tactics are combined to develop a comprehensive rangeland management strategy. Communal livestock farmers employed burning as a means of controlling the proliferation of bushes and preserving the dominance of grass. Presently, these farmers have shifted away from using any form of control methods, as burning, once a prevalent method for bush control, has largely ceased to be a practised technique [48]. During dry seasons, livestock farmers would collect leaves and pods from woody plants to use as livestock feed [49]. Manual and mechanical methods, such as pulling, cutting, and causing physical harm to plants, are employed to manage certain invasive plant species, especially when the population is relatively limited in size. These procedures can be quite precise, therefore reducing harm to desired plants. Nevertheless, manual approaches often require a significant amount of effort and time. These strategies are efficacious when the treatments are provided repeatedly to hinder the weed from re-establishing [49]. This practice serves multiple purposes, including alleviating the

pressure on fodder production, supporting sustainable land management, and acting as a means to prevent the potential invasion of woody plant encroachment [50,51]. Table 1 shows an overview of the most popular or mostly used community-based approaches to manage the phenomenon of bush encroachment.

Table 1. Activities aimed mainly at controlling bush encroachment in communal areas.

Communal-Based Approach	Region	Author
Traditional Livestock Mobility	This method involves herd mobility, which has traditionally been used to respond to socio-ecological problems such as bush encroachment in the Leliefontein pastoral area, which is about 192,000 ha in size and straddles the Kamiesberg mountain range in the Namaqualand, South Africa.	Samuels et al. [52].
Harvesting and/or collection for firewood	In the Venda region of South Africa's Limpopo province, various components of the <i>Dichrostachys cinerea</i> plant, particularly its bark and roots, were harvested for their medicinal properties. In D'Nyala Nature Reserve and Shongoane Village, Lephalale, South Africa, <i>Dichrostachys cinerea</i> plant is mainly used as firewood for cooking and heating.	Tshisikhawe [53]. Chauke et al. [54].
Burning	It was common for livestock farmers to burn rangeland to maintain grass dominance in Botswana until burning was banned in 1980.	Reed et al. [55].
Animal feed	Livestock farmers in Namibia collected <i>Dichrostachys cinerea</i> leaves and pods to feed their animals, particularly goats, during the dry period.	Marius et al. [50].

5. The Contemporary Control of Bush Encroachment Through Community

There are several strategies for controlling bush encroachment, including mechanical, biological, chemical, or integrated methodologies [55,56]. However, in order to successfully execute these strategies, it is crucial to improve public awareness and employ a collaborative approach to the control of invasive woody species in areas where they pose a threat to the sustainability of rangeland management. A comprehensive study has been carried out across several regions in Africa to evaluate the influence of community management on encroachment in communal rangelands. The management of woody encroachment on community property (communalised arid rangeland) is distinct from that on land used for commercial agriculture, with a greater emphasis on restoring commercial farms. Modern technology specifically built for cutting and shaping dense vegetation is highly beneficial since the resulting chopped wood can be evenly spread throughout the soil as organic material [16,53]. This amendment improves the soil's composition and stimulates the sprouting of grass seedlings [27,46,57]. Although it may incur expenses, this technique efficiently and immediately addresses the problem, obviating the need to remove the perished plants [34,58]. The management of invasive plants is guided by the core concepts of maintaining recovered ecosystems, intervening early, and implementing successive control operations [13,27,59]. First and foremost, it is necessary to eradicate unwanted vegetation. Managing plants immediately upon emergence is a more straightforward and economical approach compared to eliminating thick colonies of invasive shrubs. The invasion of woody vegetation is a substantial problem that impacts rural areas. The control and eradication options involve the utilisation of grazing, fire, or a mix of both methods [60,61].

These research efforts help in developing evidence-based management strategies. Ongoing research and monitoring are crucial for understanding the dynamics of bush

encroachment and evaluating the effectiveness of management interventions [41,56,62]. Communities in South Africa are engaged in various initiatives to address bush encroachment and its impacts on their environment and livelihoods. These community-driven efforts play a crucial role in complementing government and conservation organisation actions. Some of the activities and approaches that communities are undertaking to combat bush encroachment include participatory land management; community-based conservation projects funded by the government that include collaborative partnerships, livestock management, awareness and education, and sustainable utilisation.

6. Discussion

The use of community knowledge as a foundation for understanding how changes in land use have historically impacted semi-arid rangelands provides an important methodological approach for analysing communities' responses to encroachment [39,44]. The underlying premise of the current review was that conventional practices of bush encroachment would have an impact on rangeland dynamics. There are three basic methodological guidelines: traditional mobility, burning, and harvesting, and each is influenced by a variety of economic and environmental factors (shown in Table 1). As a result, invasion control measures must account for this diversity in order to ensure treatment effectiveness. Thus, there are places and invasion scenarios in which a single strategy can be used; however, a combination of several strategies may be used concurrently, alternatively, or sequentially [31]. Manual clearing may be unsuitable for some protected areas or private rangelands [54]. Regardless of whether active clearance is attempted or an alternative approach is chosen, government interventions to improve rangeland management practices must be implemented consistently as the highest priority measure. Consequently, the program effectively addresses a multitude of fundamental issues, including land degradation, poverty, skills enhancement, and, eventually, the attainment of food security. However, it is crucial to involve communities not only in environmental awareness and education but also in the development of communal approaches to managing and controlling bush encroachment [63]. This holistic approach would be more effective in tackling the problem and ensuring the sustainability of the efforts made to combat bush encroachment. Regrettably, some of the least developed African governments, such as Tanzania, are falling short in providing even basic training and skills development related to bush encroachment [31]. While some developing nations, like South Africa, have made efforts by providing resources such as community-based funding, training, awareness campaigns, and ongoing research on bush encroachment, these initiatives have not yielded the desired results due to insufficient community engagement.

Several studies have been conducted that argue that local communities have a crucial role to play in managing bush encroachment, as they have traditional knowledge and practices that can be used to control the spread of woody vegetation [6,41,47]. The participatory approach, with the local community involved in decision-making and the implementation of management strategies, was successful in reducing bush encroachment and improving rangeland productivity. Socio-economic benefits for the local communities highlighted in this study range from the creation of employment opportunities to the promotion of community involvement and ownership and the strengthening of social networks. The failures of such approaches have been highlighted. Such failures and potential challenges include the lack of inclusivity and under-representation of certain social groups (gender, social hierarchies, or power dynamics). Participatory processes can also be influenced by power imbalances among different stakeholders. Certain individuals or groups within the community may have more influence or decision-making power, leading to their preferences dominating the process.

Research on indigenous environmental knowledge and monitoring is scarce in industrialised countries, despite its potential significance in the management of natural resources. Although local people worldwide have extensive knowledge about monitoring and managing savanna rangelands, there is a dearth of documentation or assessment about its implementation, utilisation, and advantages. The combination of indigenous knowledge and formal monitoring can enhance natural resource management, resulting in reciprocal benefits [55]. Ecologists worldwide have conducted comprehensive investigations to comprehend the causes and consequences of bush encroachment. However, previous research has mostly overlooked the indigenous community-based tactics and the perspectives of communal farmers when it comes to managing bush encroachment [7,55]. To successfully combine indigenous knowledge with formal techniques, it is crucial to provide a precise description of indigenous knowledge approaches and evaluate their legitimacy and compatibility with formal methods. The reliability of traditional environmental knowledge is occasionally associated with its degree of adherence to formal science.

Indigenous or communal-based approaches to bush encroachment management receive less research attention primarily because of constrained research funding, which is frequently allocated based on the priorities set by governments, non-profit organisations, and academic institutions [57]. Moreover, a lack of awareness among researchers and policymakers regarding the efficacy of indigenous management practices for addressing bush encroachment further contributes to this neglect [64]. When these traditional practices are not adequately documented or acknowledged on a broader scale, they tend to receive less research focus. Additionally, modern techniques for managing bush encroachment, such as mechanical clearing and the use of chemical applications, are often preferred. In numerous regions, Indigenous communities hold deep-rooted traditional knowledge and practices that have been transmitted across generations [65]. The incorporation of this traditional ecological wisdom into the management of bush encroachment offers invaluable insights and novel approaches. This integration approach acknowledges the significance of local wisdom and advocates for culturally relevant strategies in addressing the issue of encroaching vegetation [47]. The communal-based bush encroachment management practices indicated in Table 1 above are noted to be less sustainable currently due to the reason that they are not practised collectively [55]. Different regions have adopted and prefer different management practices. These methods mentioned can work effectively and efficiently when combined and used as a single way of managing bush encroachment because the use of one method can fail to control encroachment, whilst another method can have detrimental effects on the soil and other important species [66].

Effectively managing bush encroachment necessitates a sustained commitment of time and effort, rather than a singular endeavour. This may require the utilisation of procedures that are not necessarily the most expedient or cost-effective. The method of shrub (bush encroachers) removal that incurs the lowest cost is typically not the most economically efficient approach. The removal of mature shrubs within an ecosystem can lead to a notable increase in instability, hence requiring landowners to consistently and purposefully combat a rapid resurgence of vegetation, often consisting of new and potentially more hazardous woody species [41,67]. The current phenomenon of partially privatising community rangelands through the introduction of alternative land uses, such as semi-private and communal range fencing and crop cultivation, has resulted in the fragmentation of grazing lands and significant disruptions to traditional grazing systems [31]. Shikangalah and Mapani [68] posit that community-based knowledge exhibits more adaptability and relevance in the context of ecological impact assessments and other environmental concerns when compared to a majority of alternative sources of information. To mitigate environmental degradation,

the integration of community-based knowledge into scientific research and land use policy has the potential to enhance the understanding of local circumstances [65,69]

The primary and widely employed management approach for addressing bush encroachment involves the harvesting of the plant for medicinal purposes. This method has gained popularity due to the extensive knowledge transfer within communities, with traditional healers and village elders acquiring information about the uses of medicinal plants from their peers and previous generations through oral tradition [54]. In this context, the utilisation of the plant extends beyond the mere extraction of specific components like leaves and bark; often, the entire tree is uprooted [70,71]. This comprehensive approach is considered effective in preventing the regrowth of the plant, making it a preferred management technique [71].

7. Conclusions

Communal approaches to bush encroachment management in southern Africa's semi-arid savannah rangelands have proven to be promising and effective in addressing this significant ecological challenge. Indigenous and traditional knowledge systems have played a pivotal role in communal bush encroachment management. Local communities possess a wealth of knowledge about their ecosystems, which, when integrated with modern scientific approaches, can result in more effective and sustainable management practices. The assessment of community reactions to alterations in land utilisation was greatly enhanced by employing a methodological framework that relied on the utilisation of indigenous knowledge pertaining to the long-term impacts of land use change on grazing pastures. The current study posited that traditional land use techniques exert an influence on the overall dynamics of rangelands. It is recommended that communal approaches to bush encroachment management in Southern Africa's semi-arid savannah rangelands harness the power of indigenous knowledge while benefiting from modern scientific insights, ultimately leading to more effective and sustainable management practices. This can be accomplished by fostering community involvement and active participation, facilitating the exchange of knowledge, enhancing skills and expertise, preserving and safeguarding indigenous wisdom through documentation, and harmoniously blending traditional and scientific methodologies.

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