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LAND MANAGEMENT IN THE CONTEXT OF BUSH ENCROACHMENT

Progress Kashandula, Daniel Shagama, Jackson Hamutenya, Epafras Andreas

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AUTHORS:

Progress Kashandula, Daniel Shagama, Jackson Hamutenya, Epafras Andreas

ACKNOWLEDGEMENTS:

Dr Detlef Virchow (reviewer)

CONTACT INFORMATION

Namibia Biomass Industry Group (N-BiG)
5 von Braun Street
Southern Industrial Area
Windhoek
Namibia
Tell: +264 61 242 949
Email: info@n-big.org

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EXCUTIVE SUMMARY

Bush encroachment is a significant environmental challenge that affects ecosystems worldwide, particularly in savanna and arid regions. This issue is characterised by the progressive invasion of woody vegetation at high densities. Namibia, Botswana and South Africa have experienced similar consequences, including reduced rangeland carrying capacity, lowered groundwater levels, biodiversity loss and diminished ecosystem services. The primary causes are climate change, land use practices and shifts in ecological factors, leading to ecological, economic, and social repercussions.

Bush encroachment remains one of the major obstacles to sustainable land management. Addressing this issue requires a combination of ecological knowledge, practical solutions, and community engagement. By implementing integrated management techniques, it is possible to reduce the impacts of bush encroachment and promote the sustainable use of land resources.

Current control methods of bush encroachment include mechanical and chemical interventions, fire management and integrated land management strategies. Despite these efforts, bush encroachment persists. Addressing this issue requires ongoing research into the ecological, socio-economic issues, and climatic factors that contribute to bush encroachment. Collaborative efforts with local communities and across neighbouring countries are essential, promoting shared solutions and sustainable land management at the grassroots level, which is likely to ensure long-term success. Considering that bush encroachment negatively affects a large number of landowners across the three countries. Bush control efforts in form of labour-based or mechanical bush thinning are cost intensive. The development of value chains and the marketing of biomass products by dedicated businesses are ways of recovering these costs for owners. Various policies and regulations across the region are put in place to ensure sustainable bush control and biomass utilization with the greater aim to support land restoration and sustainable land use at local, national and regional levels. This report was produced as part of the EU Horizon 2020 SteamBioAfrica project, *https://www.steambioafrica.com/*.

1. INTRODUCTION

1.1. DEFINITION OF BUSH ENCROACHMENT

Bush encroachment is defined as the invasion and/ or the thickening of indigenous woody vegetation resulting in an imbalance of the grass to bush ratio, a decrease in biodiversity, and a decrease in carrying capacity, causing severe economic losses in both the commercial (freehold) and communal (non-freehold) farming areas (De Klerk, 2004; De-bushing Advisory Service, 2015; Namibia Nature Foundation, 2016). The phenomenon is commonly observed in many southern Africa countries, including Namibia, Botswana, and South Africa.

Evidence suggests that the problem of bush encroachment has been around for over a century, but increasing exponentially, so that most encroachment has only happened over 25 years ago. Over a century ago, there has been a directional shift toward increased abundance of woody vegetation worldwide. However, this shift is not unidirectional, many (potentially) greening ecosystems also suffer from both deforestation and tree dieback (De Klerk, 2004 & Smit, 2005). While trees proliferate in humid regions, unpalatable shrubs replace grasses in more arid regions. Encroachment is not a steady process but one that happens occasionally or sporadically. It sometimes starts in specific, small patches which expand gradually over several decades. Often, the process occurs quietly and virtually unnoticeably so that land users don't realise what is going on until the whole landscape is covered in bush. Various species are listed as part of the bush encroachment problem in southern Africa, and new species are being added. And as such, bush encroachment may not necessarily cause by particular species, but is rather a change in balance of the types of plants occurring in ecosystems.

1.2. MAJOR ENCROACHER PLANT SPECIES

Most bush encroacher species belong to the genus *Acacia*. The genus *Acacia* was reclassified into *Senegalia* and *Vachellia* for the African line, but the term *Acacia* is still widely used. The genus includes more than 900 species worldwide and is the second largest genus. Across the region, in areas with poor soil, the nitrogen fixing abilities of Acacias can increase soil fertility, which allows them to gain a competitive advantage over other species (Lesoli et al., 2013). The main bush-thickening species are outlined below. These species are indigenous and considered important parts of their respective ecosystems so that when being controlled, they should therefore never be eradicated, but merely thinned to a more natural (acceptable) density for a sustainable land management. Some are protected but are encroaching in certain areas.

Table 1: Major bush thickening species in Namibia, Botswana and South Africa

Scientific Name	Common Name	Photographs
Senegalia mellifera	Black Thorn	

Scientific Name	Common Name	Photographs
Vachellia reficiens	Red Umbrella Thorn	  
Terminalia sericea	Silver cluster leaf	  
Rhigozum trichotomum	Three-thorn	  
Colophospermum mopane	Mopane	  

Scientific Name	Common Name	Photographs
Combretum apiculatum	Red bush willow	
Dichrostachys cinerea	Sickle Bush	
Terminalia prunioides	Purple-pod Terminalia	
Vachellia luederitzii	Kalahari Acacia/False Umbrella Thorn	

Scientific Name	Common Name	Photographs
Vachellia nilotica	Scented-pod Acacia	
Eucalyptus spp.	Gum	
Prosopis spp.	Mesquite	

1.3. GENERAL CAUSES OF BUSH ENCROACHMENT

The causes of bush encroachment are complex but are directly related to the way that dynamic savanna ecosystems operate. In the natural savanna systems, the ratio between grasslands and thickets in constantly changing and is mainly affected by rainfall, soils, and nutrients, grazing, past livestock pandemics (e.g. rinderpest), decline of large browser and fire, shifting human settlements as well as land tenure and land-use patterns also influence the proliferation of bush in the region. The soil to moisture balance has an overwhelming effect on vegetation structure, composition and productivity thus playing a major role in determining whether or not grasses will dominate.

The reason that bush encroachment has become uncontrolled is mainly due to the decreased in soil quality caused by droughts and grazing, followed by the above-average rainfall years with frequent rainfall events, which favour mass tree recruitments.

Furthermore, various other factors such as nitrogen deposition, atmospheric CO_2 levels and climate interact to either constrain or promote the growth of thickening species. A change in just one of these factors might not be sufficient to trigger bush encroachment

(Brown & Archer, 1998). Some of these key drivers of bush encroachment are detailed below.

1.3.1. GRAZERS AND BROWSERS

Overgrazing by livestock suppress the dominance of grass species and favour the growth and multiplication of woody species because they then have increased access to available soil moisture. Grazing also indirectly contribute towards bush encroachment through dispersal of encroacher plant's seeds. The restrictions caused by fences can limit both wildlife and livestock movement, increasing grazing pressure in specific areas (Smit, 2005). Livestock can also displace browsers and seed predators impairing natural controls (Brown & Archer, 1998). Large browsers such as elephants, giraffes and rhinos can transform landscapes and considerably suppress woody thickening, but their populations have declined all over southern Africa (O'Connor et al., 2014).

1.3.2. CLIMATE

Savanna ecosystems are generally water limited and subsequently bush encroachment is associated with inter-annual rainfall variability. In arid and semi-arid environments, the woody cover and density tend to increase with increasing mean annual precipitation (Moleele et al., 2002). At the local scale, unusually high annual rainfall in multi-years promote an increase in woody vegetation cover and encroacher plants like *Senegalia mellifera* require at least 3 years of successive good rainfall to recruit successfully (de Klerk, 2004). Increased soil moisture availability, particularly when there is limited competition from grass, allows woody plant seedlings to survive and grow into bush thickets. Furthermore, variability in rainfall influences plant growth, recruitment and mortality. As a results high variability in semi-arid zones can support the enhancement of woody plants (Lesoli et al., 2013).

1.3.3. SUPPRESION OF FIRE

Regular burning with High-intensity fires, so called "hot" fires suppresses shrubs and woody seedlings preventing their development into mature woody plants resistant to fire and out of reach for browsers (Shikangalah & Mapani, 2020).

However, certain policymakers and farmers often overlook the significance of fire in savanna ecosystems, leading to the proliferation of woody vegetation. Overgrazing and limited fuel load necessitate the integration of fire into management strategies. Thus, establishing sustainable burning intervals and institutions for savanna ecosystems is crucial to minimize uncontrolled burning, drought impacts, and carbon release, while also understanding future climate conditions and minimizing negative impacts.

1.3.4. INAPPROPRIATE LAND-USE PRACTICES

Unsuitable land-use practices, such as improper land management, inadequate agricultural practices, and improper fencing, can contribute to bush encroachment. Improper land use may cause the degradation of grasslands, leaving room for woody species to expand.

1.3.5. TOPOGRAPHY AND SOILS

As a rule of thumb, grasses and woody plants utilize different soil resources, with grasses having fibrous roots in the upper soil layers and woody plants having deep-reaching roots. Fine-textured, shallow soils favor grasses, while deep, coarse soils with rapid water infiltration and nutrient leaching favour woody plants. In fertile areas, woody plant establishment may be limited by competitive

grasses and herbivores. However, slopes can cause the accumulation of water and nutrients downslope, promoting higher densities of woody plants (Nesongano, 2018).

1.3.6. ATMOSPHERIC CO2

The change in the world's climate is a global driver of bush encroachment that operates in the background and is easily overridden by local drivers of bush encroachment. Global warming is caused by rising atmospheric concentration of CO_2, which in turn "fertilises" woody plants (C_3 plants) and allows encroacher bush to grow faster than grasses (C_4 plants). However, it takes a series of above-average rainfall seasons to initiate bush encroachment from seed. The emerging bush seedling soon sinks a long taproot that accesses deeper soil moisture than relatively shallow-rooted grasses and gives it an adaptive advantage over grasses during dry spells.

Warmer temperatures caused by climate change – and the resulting absence of severe frost – can also encourage the proliferation of bush (Brown & Archer, 1998).

1.4. GENERAL IMPACTS OF BUSH ENCROACHMENT

The most concerning about bush encroachment is the decline in grazing capacity, loss of species diversity, alteration of hydrological regime (De-bushing Advisory Service, 2015) and increase in soil erosion as woody cover increases. The decline in forage production together with restricted animal access to available forage in bush-encroached rangelands are the major drivers of decline in grazing capacity. Loss of species diversity emanates from extinction of ecologically significant species as herbaceous species, mostly C_4 grasses are displaced by woody plants. Grasslands formerly known as being species-rich have undergone massive extinction of species due largely to competition for light, soil moisture and nutrients by woody plants (de Klerk, 2004). Bush encroachment does not reduce only the aboveground richness and abundance but also seed production thereby reducing seed contribution to the soil seed bank.

However, if the small cohort of seeds produced by vegetation and those dispersed by floods and wind form persistent seed bank, they facilitate regeneration following bush clearing. On the other hand, the water loss through evapotranspiration (ET) as woody cover increases is increasingly recognised as another key indicator of deterioration of the ecosystem services (Schick & Ibisch, 2021). Water is essential for ecosystem functioning including maintenance of eco-physiological functions of plants and provision of forage for livestock. In semi-arid rangelands, ET returns 90% of precipitation to the atmosphere, with transpiration from woody plants accounting for at least 60% of ET (de Klerk, 2004). Thus, increase in woody cover and densities beyond optimal threshold signals the ecosystem relapse. Hence, in southern African countries, especially Namibia, Botswana and South Africa mechanical clearing of woody plants is conducted by the national programmes to reclaim water recharge, species diversity and grazing capacity amongst others.

1.5. THE GLOBAL PERSPECTIVE

Savannas are a significant biome within the tropical and subtropical regions of Africa, Australia, North America, South America, and Southeast Asia. On a global scale, savannas encompass a rainfall regime from 300 to 2000 mm/per annum, although the majority of area considered savanna is on the drier end of this spectrum (O'Connor et al., 2014). They are typically defined as an admixture of a near-continuous grass layer and a discontinuous tree layer. Grasses, mostly perennial possess a C_4 photosynthetic pathway. Savanna vegetation is used mostly for support of livestock production but also underpins much of the protected area network of Africa and Asia that supports iconic large mammal wildlife consisting of grazers, browsers, and mixed feeders. The "balance" or coexistence between trees and grasses is a pivotal concept for understanding and use of savanna. Interest in the relation between these two components was founded in early observation that livestock production declined when woody plants increased at the expense of grasses. Since then, bush encroachment has been a colloquial term used to describe this process in Africa that elsewhere may be described as woody thickening, woody encroachment, brush encroachment, or an increase in woody cover (O'Connor et al., 2014). The term also now encompasses invasion of open tropical or subtropical C_4 true grassland by indigenous woody species. Similar invasion of vegetation such as tundra by woody species, as well as an increase of alien (exotic) woody plants in savanna or grassland. Bush encroachment is a vegetation dynamic of global importance that may result in a biome change with ramifications for the organization, functioning, and use of affected ecosystems.

Bush encroachment is the most common widespread form of land degradation affecting the southern African region. The bush encroachment phenomenon extends to countries such as South Africa, Botswana, Uganda, Zimbabwe, Ethiopia and Namibia (David et al., 2020). It affects each area differently – humid regions are dominated by trees, while arid areas are dominated by unpalatable shrubs (Brown & Archer, 1998).

To assess bush encroachment at a global scale, remote-sensing approaches emerged as a classic technology to assess the extent, rate, and pattern of change over a large spatial scale. Three approaches have thus far included lateral photographs, aerial photographs, and satellite imagery. Lateral photographs provide a record of landscape-level change since the 1870s, while aerial photography has been used since the 1930s to describe the extent of change. Satellite imagery offers analysis of a vast spatial scale at a high frequency, but has limited length of record. Meta-analysis at regional and cross-continental levels broadens the perspective of purported drivers of encroachment, but remote-sensing studies present a global perspective for tropical drylands. Venter et al., (2018) used high-resolution satellite imagery to assess the drivers and the extent of woody vegetation cover in sub-Saharan Africa. Their findings showed a 0.27 % $year^{-1}$ increase of woody vegetation cover confirming global greening trends and challenging the widely held theories about declining terrestrial carbon balances and desertification. Over the past three decades, 75 million ha (55%) of non-forest biomes in sub-Saharan Africa underwent significant net gains in woody plant cover (Fig. 1), while only 22 million ha (16%) experienced significant decrease in woody plant cover. The author alluded indicated that the "*woody cover loss was prevalent in parts of the Sahel, East Africa and much of Madagascar, but woody plant proliferation dominated the central-*

interior of Africa. Countries exhibiting a mean fractional increase >30% were Cameroon, Central African Republic, South Sudan, and Uganda. Almost all other counties experienced net greening, with only Congo, Kenya, Madagascar, Niger and Somalia undergoing a net decline in woody cover…. Areas with more than 75% initial cover experienced highest rates of loss, probably due to human-induced clearing. There was little difference between woody *plant proliferation inside (13.9%) and outside of (12.5%) protected areas. Proliferation trends were lowest in shrublands (3.5 ± 0.4% increase) and highest in Caesalpinioid savannahs (20 ± 0.4% increase), but were pronounced across all vegetation types, indicating that the drivers of this change are globally available, but act regionally allowing woody plant proliferation in some areas and deforestation in others."*

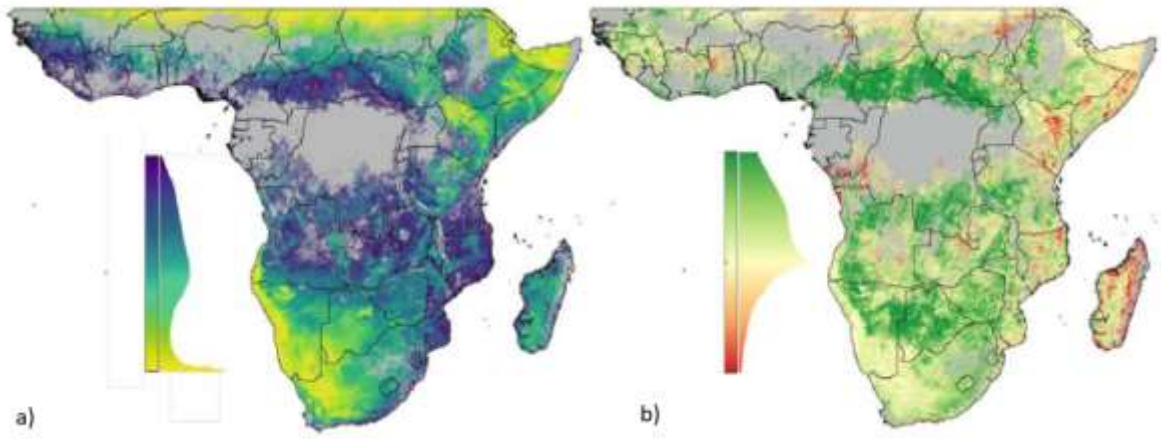

Figure 1:"Woody plant cover dynamics over sub-Saharan Africa. Satellite observations of 30 years of fractional woody plant cover (a) reveal a dominant increasing trend (derived from the slope of the linear trend line between 1986 and 2016) (b). Histograms alongside colour scales indicate data distributions. Grey areas were masked from the analysis and represent urban surfaces, wetland, cropland, and forest (areas >40% cover by trees >5 m). Maps were constructed in Google Earth Engine." Adopted from (Schick & Ibisch, 2021).

Given an alarming increase in human population, increase in bush cover may continue impacting negatively on people's livelihoods and global economy, particularly food security as the increase in woody cover forces reduction in stocking rates of grazers, deterioration of the ecosystem services and functioning as a result of bush encroachment (Schick & Ibisch, 2021).

2. THE EXTEND OF BUSH ENCROACHMENT IN NAMIBIA, BOTSWANA AND SOUTH AFRICA

2.1. NAMIBIA

Bush encroachment, a problem in Namibian rangelands, has been a long-standing issue with asymmetrical increases in woody biomass and depletion of herbaceous plant cover. By 1990, a total land surface area close to 15 million ha in the country was estimated to be heavily encroached by woody plant species. Re-evaluation in 2002 put the estimated affected land area at almost double at 27 million ha in total of which 16 million ha of encroached rangelands were in freehold

farming areas and 11 million ha was in communal farming lands (Zimmermann & Joubert, 2002). The table below shows the density of bush encroachment per region.

Table 2: Density of encroaching tree species in different regions of Namibia and total land area affected in communal and freehold farming areas (Adapted from Zimmermann & Joubert, 2002).

Affected Regions	**Encroacher woody species**	**Average Tree Density (No./ha)**	**Affected Total Hectares**	
			Freehold Land	**Communal Land**
Kunene/Omusati	*Colophospermum mopane*	2500	1 451 000	2 986 000
Erongo/Kunene	*Vachellia reficiens*	3000	1 676 000	691 000
Khomas/Omaheke	*Senegalia mellifera detinens*	2000	3 360 000	195 000
Oshana/Oshikoto	*Colophospermum mopane*	4000	482 000	1 090 000
Otjozondjupa	*Senegalia mellifera detinens*	8000	2 067 000	13 000
Otjozondjupa/Khomas	*Senegalia mellifera detinens*	4000	2 692 000	210 000
Otjozondjupa/Oshikoto	*Dichrostachys cinera*	10 000	2 513 000	1 220 000
Otjozondjupa/Omaheke	*Senegelia mellifera detinens*	5000	2 692 000	1 220 000
Omaheke	*Terminalia sericea*	8000	950 000	2 453 000
Hardap/Karas	*Rhigozum trichotomum*	2000	586 000	1 624 000
TOTAL			**15 777 000**	**10 482 000**

Latest studies show that bush encroachment affects nearly 45 million hectares of land in Namibia, affecting commercial and communal land (SAIEA, 2016) Fig. 2. With these encroached areas, Namibia has a supply of approximately 450 million tonnes of encroacher bush available for sustainable harvesting and utilisation. From an agricultural perspective, the encroached land has led to a significant loss in agricultural land productivity and a decline in carrying capacity from 1 LSU/ha (Livestock Unit per hectare) to 1 LSU per 20-30 hectares, negatively impacting farmers' socio-economic welfare (de Klerk, 2004).

The severity of the problem and economic repercussions of bush encroachment warrants urgent national intervention by the government. This intervention is based on the realization that bush encroachment has social, economic, and environmental ramifications beyond farm boundaries. Incentives for bush control include job creation, supporting rural and urban development, climate change mitigation, biological diversity restoration, energy generation, and water supply enhancement.

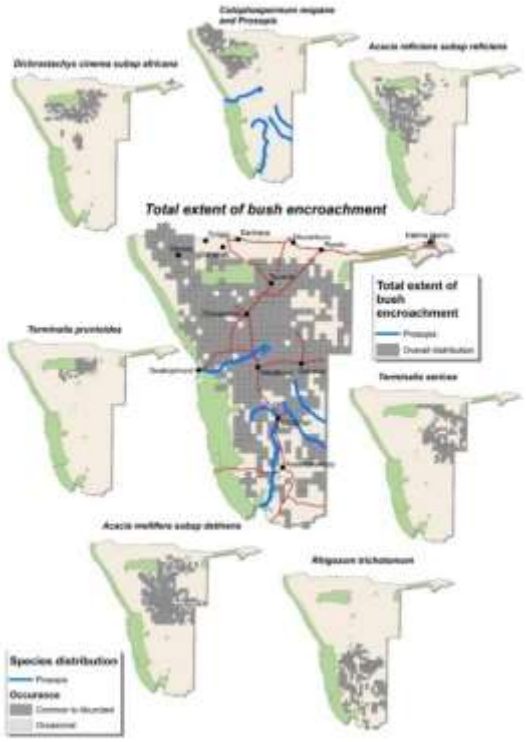

Figure 2: Bush Encroachment in Namibia and Main Encroacher bush extent: (SAIEA, 2016)

2.2. BOTSWANA

Bush encroachment in Botswana is a widespread issue, affecting about 37 million ha and 6.8% of the country's area by 1995 (Moleele et al., 2002). Though Bush encroachment in Botswana is widespread across the country, it is more pervasive in the southeast, scattered in the Kalahari and the Makgadikgadi pans (Moleele et al., 2002).

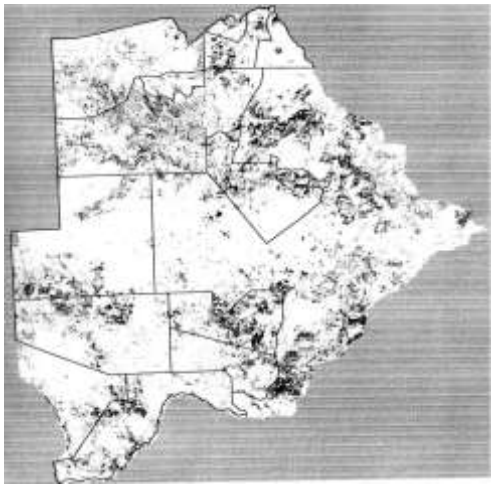

Figure 3: A map showing the extent of bush encroached areas in Botswana. Dark black represents the heavily affected areas; white represents those areas that have not yet experienced bush encroachment: (Moleele et al., 2002).

In 1975, Botswana's government introduced the Tribal Grazing Land Policy (TGLP) to address the degradation of communal grazing areas partly caused by bush encroachment. The policy aimed to control grazing pressure and ensure sustainable use of rangelands by allocating designated areas to individuals or groups responsible for their upkeep. This approach reduced overgrazing and promoted better land management practices, enhancing rangeland productivity. The policy also aimed to address socio-economic issues within rural communities by providing secure land tenure, empowering local farmers, and encouraging efficient agricultural practices. This marked a significant shift in Botswana's approach to managing rangelands, focusing on sustainability, productivity, and socio-economic benefits for its rural population (Botswana Government, 1975).

Overall, bush encroachment and its effect in Botswana is evident however there are no developed bush control and biomass utilisation initiatives in place, therefore the SteamBioAfrica project (later discussed in this paper) is one of its kind to open up such an endeavour.

Moleele et al., (2002) recommends that management should emphasize that unnecessary shifting of foci points (boreholes, wells, kraals etc) within grazing rangelands is detrimental to livestock grazers, as it subsequently leads to the entire pastures being dominated by bush encroachers, as is now the case. Furthermore, more research is needed in specific areas to pinpoint causes and responses to the bush encroachment problem in the country.

2.3. SOUTH AFRICA

Bush encroachment in South Africa is a major issue due to natural and human-induced factors. According to the latest estimate, about 7.3 million ha, or 6% of South Africa's land area, has been affected by bush encroachment (Warren et al., 2018). This is mostly in areas with more than 500 mm of rainfall per year.

Results from earlier studies were used to determine the average change in woody cover over the monitoring period for affected areas in each of the bioregional zones, and the total extent of bush encroachment in each zone was estimated from recent mapping of bush encroachment (Fig. 4).

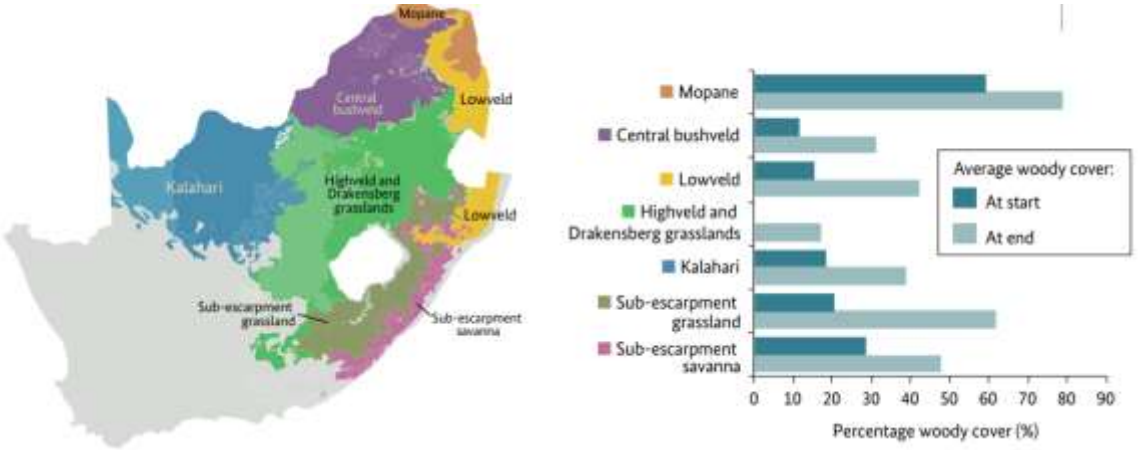

Figure 4: Bush encroachment zones in relation to biome and bioregion boundaries and the average percentage woody cover. Adapted from: (Turpie et al., 2019)

Apart from bush encroachment by native species, invasive alien plants of a wide variety of tree species which were introduced over the past few centuries to address timber shortages has also become a problem. The first plantations were in the Western Cape, but soon extended to areas of the Eastern Cape, KwaZulu-Natal, Mpumalanga and Limpopo. Land owners downstream of the plantations on both state and private land soon began raising concerns about the drying-up of streams and rivers downstream of the planted areas. Many of these tree species began to invade the adjacent natural vegetation, a tendency which was initially praised, but later led to concern about their potential impacts on river flows as well as biodiversity.

These invasive alien plants decrease water runoff, groundwater recharge, destruct habitats, contributes to flooding and wildfire risk. They use more water than native plants, causing 1.44 billion m^3 of water loss annually (David et al., 2020). To address the impacts of bush densification, South Africa has implemented various strategies, including legislation, monitoring programs, and control measures. These efforts aim to prevent the introduction of new invasive species, detect and respond to new incursions, and manage established invasive species to minimise their ecological and economic impacts.

3. IMPACTS OF BUSH ENCROACHMENT IN NAMIBIA, BOTSWANA AND SOUTH AFRICA

The overarching impacts of bush encroachment across southern Africa, especially Namibia, Botswana and South Africa are cross cutting. Bush can have positive effects on an ecosystem and support important ecological processes. However, the extreme thickening of bush is often associated with considerable negative impacts.

3.1. POSITIVE IMPACTS

Habitats: Bush habitats offer diverse wildlife and livestock browse, while open savanna landscapes with dense thickets may have the highest overall biodiversity (Smit, 2005).

Soil Fertility: Trees enrich soil through organic matter decomposition, while Fabaceae plants fix nitrogen, making encroached landscapes richer. Bushes, with deep roots, recycle nutrients from deeper levels.

Soil Hydraulic Properties: Rainwater infiltration is highest near woody plant canopies due to litter beneath the canopy and extensive root distribution, resulting in macropores that positively affect infiltration.

Economic Opportunities: Bush encroachment can encourage commercial use of woody biomass, diversifying the economy and generating income for both communal and commercial lands.

3.2. NEGATIVE IMPACTS

Hydrogeology: Some encroacher species have an extensive root system with a length of over 30m deep and have an impact on the groundwater. Thus, bush encroachment can reduce groundwater recharge and underground water levels due to increased air turbulence, lower albedo, and increased canopy interception of rain.

Biodiversity: Bush encroachment alters landscapes from grassland to shrub or tree savannas, leading to ecosystem and species loss in various regions worldwide. Bush

encroached areas often support lower plant species, mammals and reptiles than pristine savannas (Moleele et al., 2002).

Soils: Bush encroachment and the resulting increase in biomass can alter soil microbial communities, slows decomposition, and affects soil fertility. It also leads to soil erosion in bare areas between bushes.

Carbon sequestration: Carbon Sequestration: There is considerable scientific debate about carbon stored in bush encroached land and savanna ecosystems. Bush encroachment redistributes carbon among key terrestrial pools with arid areas likely becoming net sources of carbon, and areas with higher rainfall likely becoming net sinks. There is evidence that savanna ecosystems store more carbon due to higher soil organic carbon and that these can offset the emissions from removing the biomass.

Economic and Social: The decline in grazing capacity in Southern African countries makes livestock production economically unviable. Bush encroachment fragments landscapes, reducing carrying capacity, leading to food insecurities, poverty, and reduced aesthetic value for tourism. This degradation affects wetter and arid environments.

4. LAND MANAGEMENT AND BUSH ENCROACHMENT

4.1. LAND TENURE SYSTEMS/TYPES OF LAND USE

Land tenure systems are legal frameworks governing land ownership, use, and transfer within a jurisdiction, influenced by historical, cultural, economic, and political factors across different countries and regions. Land tenure systems play a crucial role in governing how resources are managed, including bush control and biomass utilization. These systems determine who has the right to use the land, how long they can use it, and under what conditions. Consequently, they significantly influence the effectiveness and sustainability of land management. Here are some common land tenure systems in Namibia, Botswana and South Africa.

Table 3: Land tenure system in the context of bush encroachment

Types of land Tenure/Land use	Description	Occurrence in country
Communal and/or Tribal Land Tenure:	Designated as communal areas, where traditional communities manage it for subsistence farming, livestock grazing, and cultural purposes. Traditional Authorities are local governance structures responsible for managing communal land and resolving land-related disputes within their jurisdictions.	Namibia, Botswana, South Africa
Commercial Land/Freehold Tenure:	Commercial/freehold farms are privately owned agricultural enterprises that engage in commercial crop farming, livestock production, or a combination of both,	Namibia, Botswana, South Africa

Types of land Tenure/Land use	Description	Occurrence in country
	operating under leasehold or freehold tenure systems and often using modern farming techniques. These lands can be bought, sold, or leased, typically owned by individuals, families, or corporations.	
Conservation and Wildlife Management:	These are national parks, game and nature reserves, and conservancies managed by the government focusing on biodiversity, wildlife, and ecotourism, while conservancies are community-based initiatives empowering local communities through wildlife-related tourism and sustainable hunting.	Namibia, Botswana, South Africa
Urban Land Tenure/ Urban and Industrial Land Use:	Urban land tenure consists of freehold and leasehold land as well as informal settlements which are spontaneously developed areas with limited tenure and basic services. Furthermore, Botswana's urban areas, which include residential, commercial, and industrial activities, serve as hubs for commerce, services, and manufacturing, promoting economic growth and urban development.	Namibia, Botswana, South Africa
Forest and Rangeland Management:	Forest Reserves protect and conserve forests, while Rangelands manage vast grazing land for livestock production, involving rotational grazing, fire management, and water provision for ecosystem health.	Namibia, Botswana South Africa
Mining and Extractive Industries:	Mining concessions grant areas for mineral exploration and extraction, subject to licensing and regulatory requirements, while mineral and gemstone claims grant individual or corporate rights to explore and exploit specific deposits.	Namibia, Botswana, South Africa
State/Public Tenure:	State land, owned and managed by the government, includes land allocated for public purposes like infrastructure, conservation areas, national parks, and government institutions.	Namibia, Botswana, South Africa

Types of land Tenure/Land use	Description	Occurrence in country
Agricultural Land Use:	Land used for crop cultivation, livestock farming, and other agricultural activities for food production and livelihoods in rural areas.	Namibia, Botswana, South Africa
Tourism and Hospitality	The land is utilised for lodges, campsites, safari operations, and other tourism-related activities.	Namibia, Botswana, South Africa
Grazing and Pastoral Land Use:	Extensive rangelands for livestock grazing to support pastoralism and livestock production.	Namibia, Botswana, South Africa

Land tenure systems profoundly affect how resources like land, vegetation, and biomass are managed. They shape the incentives and constraints faced by land users, thereby influencing the adoption of sustainable practices for bush control and biomass utilization. Knowledge on these systems is essential for designing policies and interventions that promote effective and sustainable land management.

5. OVERVIEW OF THE BUSH CONTROL METHODS IN NAMIBIA, BOTSWANA AND SOUTH AFRICA

5.1. REDUCING BUSH DENSITIES

Although bush encroachment is mostly associated with the negative impacts it has on farmers, some economic benefits emanate from its use. Shikangalah and Mapani (2020), highlighted that bush encroachment responsible for the degradation of land across southern Africa is a potential biomass resource. Harvesting and processing of this resource can reduce its negative socio-ecosystem impacts and provide much-needed sustainable energy sources. Thus, implementing effective land management practices can help mitigate these issues and potentially reverse the adverse impacts of bush encroachment.

Various methods for bush control are practiced in Namibia, Botswana and South Africa. Such methods include large-scale mechanical control, heavily mechanised control, manual and semi-mechanised control and chemical control. Other preventative measures to avoid encroachment in savanna are also used and include burning or controlled fire, biological control and manual control. The effectiveness of various bush control methods varies and can be difficult to trace due to a lack of controlled, closely monitored and scientific studies (SAIEA, 2016). Farmer's decisions on bush control methods normally depend on their preferences and/ or affordability. An overview of bush control methods are presented below.

Table 4: Methods of bush control

Methods of bush control	Description	Countries	Pictures
Manual	Hand tools such as axes, handsaws, and pangas are used. It is a selective method and minimises damage for desirable plants. It has few environmental impacts but can be slow and costly. Labourers need proper training to follow forestry regulations and health and safety guidelines. To reduce re-growth, stumps should be chemically treated or felled below the soil.	Namibia, Botswana and South Africa	
Semi-mechanised	Semi-mechanised bush control uses hand-held or pushed power tools to fell bush. This method can be used to produce animal feed, charcoal, and other products, as it is selective and more efficient than manual bush control. It's selective and efficient, requiring trained teams for access. Locally produced horizontal and vertical trolley saw cutters are commonly used in Namibia. Semi-mechanised methods for bush control require highly trained operators for safety and non-target removal. This method, known as stumping, involves manual felling of trees' biomass using handsaws, trolley saw cutters, and mattocks. It is expensive and should be combined with additional value addition of harvested wood. However, trees can also be cut below ground.	Namibia, Botswana and South Africa	 

Methods of bush control	Description	Countries	Pictures
Fully-mechanised	Mechanised bush clearing methods are the second most common approach to controlling encroaching woody species, but their long-term efficacy is uncertain. These methods use machinery like bulldozers, bush harvesting machines, tractor-mounted-saws, and modified rollers. They aim to harvest or thin the bush on larger scales and require skilled operators and supervisors. The effectiveness of these methods depends on factors like area, costs, throughput, market distance, and environmental compliance. If not properly implemented fully mechanised bush control is at risk of non-selective felling, soil disturbance, accidental fires, hydrocarbon spillage, and safety concerns.		 
Biological	Biological methods use natural factors like fungi and browser to control bush. It involves browsing animals like game species, goats, and sheep to suppress the growth of bushes. Fungi and microorganisms can be used to accelerate decomposition of biomass, stumps, and root systems.	Namibia, Botswana and South Africa	
Chemical	Chemical bush control methods involve the use of arboricides, which kill woody plants by inhibiting photosynthetic. In Namibia, aerial broadcasting of arboricides has been banned by the Forest Regulations of 2015, allowing only selective application. Chemical treatments can be applied in soil, foliar, and cutting stems and stumps. The most common chemical	Namibia, Botswana and South Africa	

Methods of bush control	Description	Countries	Pictures
	is Tebuthiuron and Bromacil, which target absorption by encroaching tree species via root uptake. These are freely available for use by farmers in Namibia. Manual application of arboricides is the cheapest bush treatment method in Namibia, costing between N$175/ha and N$262.50/ha compared to aerial spraying and manual cutting. However, selective targeting is less effective due to uncertainty over the wide lateral extent of target species and benevolent trees.		
Veld fire	Fire management practices in Namibia, Botswana, and South Africa vary based on their unique environmental contexts and cultural perspectives. Namibia uses controlled burning for land management, Botswana uses prescribed burning and suppression strategies, and South Africa's government's Working Group on Fire Program focuses on fire prevention, early detection, and suppression. These practices aim to balance ecological benefits with human life and infrastructure protection. Namibia's fire management strategy also focuses on preventing and controlling wildfires and promoting ecological resilience. The country unique ecosystems, including savannas, grasslands, and dry forests, are highly susceptible to fires due to their arid climate and flammable vegetation. The Ministry of Environment across the region plays a crucial role in developing policies and guidelines for fire management.	Namibia, Botswana and South Africa	

It is widely recognized that correct, sound management practices are prerequisites for rangeland reclamation. In view of this, initially bush control cannot be seen as a one-off practice and, therefore, aftercare treatment (mechanical, biological or chemical) is indispensable for long-term success. The rate of reinfestation will have a profound influence on the economic viability of bush control programmes.

In this respect, the influence of any bush eradication programme is of short duration and that its success would, therefore, be dependent on the kind of aftercare programme.

6. AFTERCARE PRACTICES FOLLOWING INITIAL BUSH CONTROL

Different aftercare methods are suggested and a detailed overview of the different aftercare options in the 3 southern African countries is given. This is mainly the chemical (selectively applied arboricides), the mechanical (stump removal) or the biological (browsing, controlled fire) aftercare.

Many of the affected landowners respond to the phenomenon of bush encroachment by harvesting the bush by either complete removal of the bush for crop production or by thinning the encroacher bush (Smit, 2005). This however does not guarantee the desired rangeland since many of the encroacher bushes do not die after their canopies and stems have been removed, they simply resprout from cut stumps or roots (Strohbach, 1998). According to Brown and Archer (1998), the positive impacts of bush control only last for 5 – 7 years because most bush control measures are only effective at killing the top part of the plant, leaving the roots and seeds alive.

This allows saplings to regenerate from roots and stumps and seedling growth from the seeds (Brown & Archer, 1998). Bush control methods attempt to shift the rangeland vegetation from being dominated by woody vegetation to herbaceous vegetation for livestock sustenance. Flexible and adaptive rangeland management practices are essential to ensure that bush encroachment does not result in irreversible degradation. To restore the degraded land, aftercare is recommended after harvesting. Aftercare ensures that (1) the rangeland is kept in a productive grassy state and (2) prevents re-encroachment which is nature's response to radical bush control (De-bushing Advisory Service, 2015). This is however dependent on the land-use objectives. Aftercare mechanisms are intended to target unwanted plants and create a competitive environment for the desired plant species (Namibia Nature Foundation, 2016).

Whatever the method may be, aftercare treatment should continue indefinitely. Various after care methods are described below:

Table 5: Aftercare practices after bush thinning

Methods of aftercare		Description
Chemical aftercare		Arboricides containing active ingredient are chemicals used for aftercare, suppressing unwanted bush growth. The active ingredient is the chemical that kills the plants while the additive ingredient keeps the chemical mix

Methods of aftercare		Description
		stable preventing it from deteriorating in hot conditions. They are most effective after mechanical harvesting or fire. Arboricides used includes Tebuthiurone, Bromacil, Picloram, and Triclopyr, which disrupt photosynthesis in plant leaves, leading to leaf drop and regrowth cycles. Foliar-applied arboricides, like Picloram and Triclopyr, are absorbed by plants, causing death. Arboricides are available either in liquid, pellet, or powder form. They can be applied manually, mechanically, or aerially, with selective and non-selective groups used in rangelands to reduce invasive species' competitive ability.
Biological aftercare		Biological control measures use living organisms to reduce woody plant growth and reproductive capacity and effects of woody plant. The he loss of mega-herbivores can partly be compensated by farming with goats, sheep, and wildlife. Biological control can also involve the introduction of invertebrates or diseases. The main goal is to ensure woody species reproduce and grow without aggressive colonization, making it a sustainable mechanism. Fire-controlled burning of rangeland is also a natural and biological method to kill immature, small woody plants and soft-coated seeds. It requires less dry herbaceous matter per hectare and is more difficult to achieve than goat browsing. It impedes woody re-growth, reducing pressure on land managers.
Manual aftercare		Small bush and saplings are removed by chopping them off about 10 cm below ground level, thus killing the whole plant. This aftercare method is quick and easy even on hard ground because the targeted woody plants are small. However, it is very difficult to control coppicing cut stems in this manner so that the method is less appropriate for situations were woody re-growth is caused by coppicing stems. One worker alone can apply manual aftercare to a large area (several hectares) each day, depending of course on the density of emerging woody plants. The biggest drawback of manual control is that some saplings may be overlooked.

7. WHAT COMES AFTER BUSH CONTROL?

The treated landscape might not appear homogenous. In some landscapes, after bush control, there should be thicker patches of bush (mostly on more fertile soil, near seasonally-wet depressions, south-facing hill slopes, etc.) and thinner patches (on infertile soils and in exposed, hot, windy locations such as plains and north-facing hill slopes). A mosaic of landscapes favours higher biodiversity that is more resilient to negative environmental impacts like climate change. There should be a mix of tree and bush species and an adequate number of large trees that suppress woody saplings by competitive suppression.

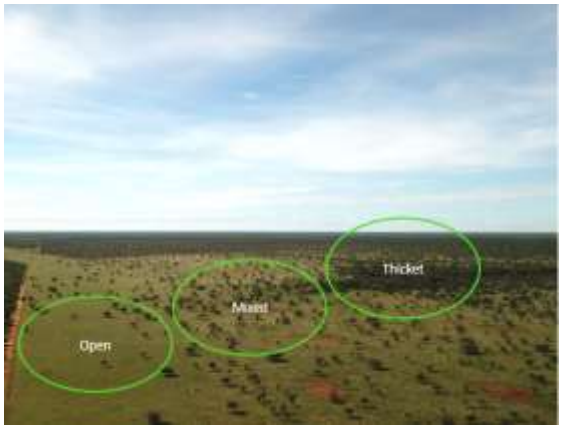

Figure 5: Savannah Mosaic System

Where grass growth was stunted by dense bush, a "grass explosion" often occurs after bush control. Such an explosion tapers off after about 7 years because the grasses have depleted the residual soil fertility left when encroacher bushes were removed. The level at which grass production stabilises depends on the number of bushes left intact, as woody plants improve soil fertility. It also depends on the abundance and vigour of perennial grasses in the post-bush grass sward: the more perennial grasses managed to establish in bush-controlled veld, the more stable its long-term grass yield and nutritive value.

Bush thinning alone does not alter the botanical composition of the grass sward. Too often, only those ephemeral, opportunistic grass and weed species that managed to survive bush encroachment are the only herbaceous species left. They flourish but form an unstable layer with too few nutrients to maintain grazing animals throughout the year. Long-lost perennial grass species often have to be re-introduced artificially to improve the grass sward permanently. Only then will the post-bush grass yield stabilise at a relatively high level, offer more acceptable nutrition to grazing animals (i.e. reduce the need for nutrient-dense licks) and contribute to a better spatial distribution of grazing animals.

7.1. EFFECTS OF BUSH CONTROL ON CARBON STOCKS, WATER BALANCE, AND EROSION, CLIMATE IMPACT MITIGATION POTENTIAL.

Research on bush control in Namibia, Botswana, and South Africa shows it can positively impact carbon stocks, water balance, erosion, and climate mitigation potential, despite negative impacts of bush encroachment. Bush control can enhance carbon sequestration in vegetation and soils, reducing greenhouse gas emissions and contributing to climate change mitigation efforts. It can also improve water balance by reducing competition between vegetation and grasses, enhancing groundwater recharge, improving streamflow, and increasing water infiltration rates. Bush control practices also play a significant role in erosion control, as dense bush can exacerbate soil erosion by increasing surface runoff and reducing vegetation cover, altering soil nutrient status, and causing flooding and sediment loads in

aquatic ecosystems. By reducing vegetation density and improving ground cover, bush control measures can promote soil conservation.

8. BUSH UTILIZATION AS ECONOMIC POTENTIAL

Bush encroachment negatively affects a large number of landowners across the three countries. Bush control efforts in form of labour-based or mechanical bush thinning are cost intensive. The development of value chains and the marketing of biomass products by dedicated businesses are ways of recovering these costs for owners.

The current economic utilisation of encroacher bush in southern Africa focuses mainly on firewood for local communities, charcoal for exports, and small production of compressed firewood. However, numerous end-use opportunities can be identified. Some require large quantities of resources, others much smaller quantities but may still lead to considerable value addition as well as to the creation of small and medium enterprises (SMEs) and employment.

There is extensive, diverse demand for biomass on both domestic and international markets, with interest shown by, among others: **the energy sector**, whose especially large demand is sufficient to trigger large-scale bush clearance projects. Bush material can be used to substitute firewood in private households and fossil fuels such as coal or oil in industrial boilers and power plants; **the agricultural sector**, which can use biomass as feed for cattle or wild animals, or as fertiliser for crop production; and **the construction industry**, where biomass can be used to produce building materials, such as chipboards or wood panels. Different value chains that could be driven from encroacher bush are presented below.

Table 6: Value development from encroacher bush

Value chain development		Description
Biomass burners/ boilers -woodchips		Wood chips are produced in the bush. Mobile chippers convert the biomass into a medium-sized solid material. The large demand for biofuel in industrialised countries can often not be satisfied due to limited resources. Both pellets and chips can be used for heat and power generation. Pellets are not yet produced in Namibia. Biofuels could be used to reduce the region's energy dependency on fossil fuel imports.

Value chain development		Description
Charcoal		Charcoal is produced from solid wood of different dimensions, preferably 10 to 20 cm in diameter. In principle, all wood species are suitable for charcoal production. Heavy hardwoods result in the best charcoal for barbequing. The wood is mainly harvested manually in communal areas and on commercial farms and is heated resulting in partial combustion. In Namibia, nearly all commercial producers use simple drum kilns made from steel sheets. The charcoal is packed on the spot into 50kg bags. Some larger trading companies do retail packaging for direct exports to overseas markets. In Namibia, 50 per cent of the charcoal is exported in 50kg bags to South Africa.
Bush feed		Considering the current controversial stage of knowledge, the production of bush feed can either be based on young parts of the bush only (twigs and leaves) or on whole encroacher species, in both cases provided they are edible and not harmful for the livestock. The raw material must be chipped as fine as possible and should finally be mixed with different additives. Pelleting might further improve the suitability as commercial product. Due to the numerous options of the production process, it is difficult to estimate the required investment for a commercial production plant.
Compressed wood briquettes		Compressed firewood is mainly used for heating; industrial uses might be possible in the nearer future. Despite different production technologies, all products are made by fine grinding of wood chips and subsequent compacting of the dry untreated biomass. The aim of compressing is a higher bulk and energy density compared to biomass chips, so that transport costs can be reduced and the combustion behaviour can be improved.
Fence poles		Poles for the construction of traditional houses and fencing are one of the main biomass products from bush species. They are predominantly used by communal and commercial farmers and sold informally. Formal sales are very limited. In the global formal trade the market requires standardised straight length and diameter, and poles are thus mainly from man-made forests

Value chain development		Description
Firewood		Firewood is often used for cooking and heating, mainly from dead and dry wood, for own consumption and sale in informal markets. Firewood is sold by numerous informal producers in communal areas and by some commercial farmers. It is collected manually and cut into desired lengths. Only a small portion of the firewood is from encroacher bush, mainly as by-product of bush thinning on commercial farms
Wood Plastic Composites (WPC)		The use of wood and plastic is relatively new even in industrialised countries. The composites are made from a mixture of saw dust and polypropylene or polyethylene. Market products contain at least 30% plastics. In Namibia, WPCs might be an interesting value chain to manufacture products for indoor construction, furniture production and agriculture. Mixed species were suitable as input material in Namibian trials. The entire bush can be used, including leaves.
Biochar		Biochar has the potential to become an important product for agricultural use for commercialisation. It can be used for soil enhancement as it increases the soil's water and nutrient holding capacity and also as an additive for livestock nutrition in order to improve the animal's health.
Wood-Cement (bonded bricks or boards)		Wood particles can be used as an organic aggregate in the concrete mixture. The cement acts as wood particle binder. This mixture is suitable to produce solid or hollow bricks, panels and prefabricated walls for outdoor construction material, partitioning, ceilings, acoustics applications, wall cladding, roofing, shuttering and more. The products are commonly accepted by local and international markets due to their excellent properties including insulating capability and non-combustibility. They are hardly known in Namibia but are used in other countries.
Parquet		This type of flooring is popular in European and North American countries, but also with higher income groups in Namibia, Botswana and South Africa. For parquet, wood of high density is required, a condition that is fulfilled by encroacher bush species. The single elements are relatively small and if larger elements are required, strips could be glued together. Insofar encroacher species could be considered for a production.

Value chain development		Description
Shingles		Shingles are a traditional roofing material in particular in southern Germany, Austria and Switzerland. They also enjoy increasing demand. They are, even in these countries with very high labour costs, mainly produced manually. There are no specific machines available. “Split Shingles” are more natural as they are split by an axe along the natural fibre. “Saw Shingles” are cut without considering the natural fibre directions. This could partially be done with a customised, partly mechanised “log splitter”. Important requirements, such as the natural durability, should be fulfilled by some encroacher species.
Smoking/Aromatic Material		Woody aromatic material has a small but increasing local (in particular private) market. It is used to aromatise meat or fish and is currently often imported and marketed at high prices. It could be considered as by product (residue) of wood chipping, sawing or production of sticks and handles. Production of smoking material can only be a very small business, but the effort and investment are minimal. A local entrepreneur has only to test which types of saw dust or chips are suitable and demanded depending on the timber species. Thereafter, only investments in packaging and marketing are required.
Carving		Carving is a traditional activity in several parts of southern Africa and beyond, nowadays focusing mainly on the tourism market. Suitable species are available. Due to the widespread local experience and the assistance a lot of carvers received in the past as well as the knowledge about suitable timber species amongst carvers, so no special actions are required.

8.1. A POTENTIAL VALUE CHAIN: ACHIEVEMENT THROUGH STEAMBIOAFRICA PROJECT

SteamBioAfrica is a collaboration between Africa and Europe aiming to provide long-term sustainable benefits in southern Africa (Namibia, Botswana and South Africa) by addressing two major challenges:

- The need for clean, secure, and reliable energy

- The need to address the challenge of encroacher bush and other invasive woody biomass species.

Figure 6: Torrified woodchips produced from SteamBioAfrica project

At the time of writing this publication the project was actively engaged in sales trials for produced torrefied woodchips. Torrefied woodchips went through a torrefaction process wherein the raw biomass is subjected to a temperature range of 200–300 C with the medium being limited oxygen or inert such as nitrogen and results in solid biofuels with upgraded physicochemical properties such as higher energy density, lower moisture, higher calorific value, hydrophobic nature, and better grindability. This clean-burning, solid biofuel aims to replace charcoal and wood for cooking and heating purposes, as well as coal in power generation. This environmentally friendly fuel will emit less smoke and pose fewer health risks, offering a healthier and more sustainable energy solution for households and industries alike. Additionally, it is expected to be economically competitive.

Whether for bush control or biomass utilization, there are policy frameworks in place that govern these processes to ensure sustainability and mitigate negative environmental impacts. These frameworks provide guidelines and regulations that aim to balance ecological health, economic viability, and social well-being. Most of them have been outlined below.

9. LEGAL AND REGULATORY FRAMEWORK FOR BUSH CONTROL AND SUSTAINABLE UTILIZATION IN NAMIBIA, BOTSWANA AND SOUTH AFRICA

The management of bush control, biomass utilisation and bush value chain development is mentioned in various policies and regulations spanning from forestry to energy and industrial development. The economic opportunities of using woody biomass for different value chains can lead to overutilization. This necessitates clear guidelines on responsible thinning/bush control and on creating a balance between rehabilitating and maintaining savanna ecosystems. The current governance frameworks provide a solid base for environmental safeguards. If done correctly, the sustainable removal and use of excess bush biomass can have positive impacts on the environment and economy and does not contribute to further degradation. However, currently key actors of the sector face challenge and barriers that limit their capacity to undertake sustainable bush management. Guidance is required to support the sector in taking a sustainable path. The ministry responsible for environment and forestry under their mandate as the regulator of natural resource use, promoting sustainable utilisation and maintaining ecosystems and biodiversity, provides clarity and guidelines on the sustainable use of bush resources. Sustainable bush control can contribute to SDG13 (Climate action) and SDG15 (Life on earth) ensuring the conservation, restoration, and sustainable use of terrestrial ecosystems

(15.1), combatting desertification, and restoring degraded land and soil (15.3), reducing the degradation of natural habitats to halt the loss of biodiversity (15.5) and reducing the impact of invasive species by eradicating priority species (15.8). Here are some of the key references per country:

9.1. NAMIBIA

- **Environmental Management Act (2007)**: The Environmental Management Act in Namibia provides the legal foundation for environmental protection, sustainable development, and the management of natural resources.
- **National Development Plans**: Namibia has developed several national development plans that guide the country's socio-economic development, environmental sustainability, and natural resource management. Notable plans include the Fifth National Development Plan (NDP5).
- **Environmental Impact Assessment (EIA) Regulations (2012)**: Namibia's EIA regulations outline the process of conducting environmental impact assessments for development projects including bush control and utilization, ensuring potential environmental and social impacts are assessed, mitigated, and monitored.
- **Forest Act (2001)**: The Forest Act in Namibia promotes sustainable management, conservation, and utilization of forest resources, outlining guidelines for practices, permits, and sustainable harvesting of timber and non-timber forest products.
- **Voluntary Certification Schemes**: Namibia has implemented voluntary certification schemes, such as the Forest Stewardship Council (FSC), to promote sustainable practices in specific sectors, such as responsible forestry and resource management.
- **The Environmental Assessment Policy for Sustainable Development and Environmental Protection (1995) for the protection of natural resources:** Defines activities that require an Environmental Clearance Certificate, which includes bush-based harvesting activities. Synergies with the enforcement of these legislations are key to ensuring a sustainable biomass sector.
- **National Agricultural Policy (1995):** This policy links agricultural sector to national development objectives such as high and sustained economic growth, employment creation, increased income equality and industrial development. This policy establishes “mechanisms to support farmers in combating bush encroachment effectively in both the short and long term”. This includes making bush thinning technologies and inputs available at the lowest possible prices; conducting research and offering advisory services to farmers on issues relating to bush control and use; and promoting private-sector and labour-intensive use of bush-based products.

9.2. BOTSWANA

- **National Conservation Strategy for Botswana (2003)**: The document outlines a comprehensive strategy for conserving and utilizing Botswana's natural resources, emphasizing biodiversity conservation, community involvement, and integrated land-use planning.
- **Wildlife Conservation and National Parks Act (1992):** The act is the primary legislation for Botswana's wildlife conservation and management, establishing regulations for wildlife

habitats, national parks, and game reserves.

- **Environmental Impact Assessment (EIA) Regulations (2005)**: The regulations outline the process for conducting environmental impact assessments for proposed Botswana development projects, ensuring sustainable development and consideration of potential environmental and community impacts.
- **Botswana Bureau of Standards (BOBS)**: BOBS is responsible for creating and enforcing standards and certifications across sectors like environmental management, agriculture, and product quality, ensuring compliance with international best practices.
- **Botswana Unified Revenue Service (BURS):** BURS is Botswana's tax and customs administration authority, enforcing taxation regulations, including import and export regulations, which can affect trade and international standards adherence.
- **Voluntary Certification Schemes:** There are various voluntary certification schemes adopted in Botswana, such as eco-labelling programs for tourism accommodations or sustainable agricultural practices. Examples include the Green Key certification for eco-friendly accommodations and Fairtrade certification for promoting fair trade and sustainability in agriculture.

9.3. SOUTH AFRICA

- **National Environmental Management Amendment Acts (NEMA), 2004**: The goal is to regulate or prohibit activities that could harm the environment and address related issues.
- **National Environmental Management Act (NEMA):** The National Environmental Management Act of 1998 in South Africa aims to promote cooperative environmental governance by establishing principles for decision-making, establishing institutions for co-ordination, and addressing related matters, thereby ensuring the protection of the environment. NEMAs align with various policies and frameworks, including:
- **National Environmental Management Principles (Government Notice No. 1077 of 2016):** This document outlines the principles guiding environmental management in South Africa, including sustainable development, public participation, and the precautionary approach.
- **Environmental Impact Assessment (EIA) Regulations, 2006:** EIA regulations assess and mitigate environmental impacts of proposed developments, aligning with international standards set by IAIA and UNEP.
- **Forest Stewardship Council (FSC) Certification:** South Africa has implemented voluntary certification schemes, such as the Forest Stewardship Council (FSC), to promote sustainable practices in specific sectors, such as responsible forestry and resource management.
- **Sustainable Agriculture Initiative (SAI) Platform**: The SAI Platform, a global organization, promotes sustainable agricultural practices, and in South Africa, agricultural regulations and policies align with its principles and guidelines.
- **Occupational Health and Safety Act:** The Occupational Health and Safety Act ensures workplace health, safety, and welfare, promoting compliance with

international standards like ILO conventions and guidelines.

- Other regulations and listings made for the realisation of the Acts with regards to the consideration and management of bush encroachment in South African landscapes include **The Regulations on the National Forests Act (NFAREG), 2009 and NEMA Listing Notice 1, 2 & 3 of 2010**.
- **National Environmental Management: Biodiversity Act (NEMBA), 2004:** The Act aims to manage and conserve biological diversity within the Republic, focusing on species and ecosystems, regardless of protected areas. Biodiversity encompasses variability among living organisms from terrestrial, marine, and aquatic ecosystems, including species, species,and ecosystems.
- **National Forests Act (NFA), 1998**: The policy promotes sustainable forest management, restructures state forests, protects specific trees, promotes environmental, economic, educational, recreational, cultural, health, and spiritual uses, promotes community forestry, and encourages participation by disadvantaged individuals.

- **National Water Act (NWA) of 1998:** 'ensures that the nation and water resources are protected, used, developed, conserved and controlled protecting aquatic and associated ecosystems and their biological diversity, reducing and preventing pollution and degradation of water resources...'.
- **Conservation of Agricultural Resources Act (CARA), 1983:** The Republic's conservation efforts include maintaining land production, preventing erosion, preserving water sources, and protecting vegetation from weeds and invader plants

10. INCLUSION OF GROUPS AT RISK OF BEING MARGINALISED AND USER ASPECTS OF RURAL ACTORS IN POTENTIAL HARVESTABLE AREAS.

Ensuring the inclusion of marginalized groups and addressing the needs of rural actors in potential harvestable areas is critical for sustainable and equitable resource management. This approach promotes social justice and enhances the effectiveness and acceptance of bush control and biomass utilization projects. Here are key considerations and strategies in each country:

10.1. NAMIBIA

The Forest Act of 2001 emphasizes the importance of involving marginalized groups and considering user aspects in sustainable resource management and equitable development in Namibia. The regulations outline guidelines for community-based resource management and include marginalized groups in decision-making processes. This is key to ensure all social groups are involved in sustainable bush control and biomass utilisation.

10.2. BOTSWANA

Botswana's community-based natural resource management (CBNRM) initiatives prioritize the inclusion of marginalized groups and rural actors in decision-making processes. This approach aims to promote equitable and sustainable resource use while safeguarding local communities' interests. The CBNRM program addresses the challenges and opportunities associated with natural resource management, highlighting the importance of

community participation and customary rights recognition.

10.3. SOUTH AFRICA

South Africa's policy and legal frameworks are crucial for promoting social equity and sustainable development in potentially harvestable areas. These include involving marginalized groups, such as rural communities, indigenous peoples, women, youth, and people with disabilities, in decision-making processes. Land reform and tenure security are also essential, ensuring secure land tenure for marginalized groups. Participatory approaches, such as community consultations and collaborative planning, are essential for involving rural actors in decision-making. Capacity building initiatives focus on enhancing knowledge, skills, and access to resources for marginalized groups. Access to markets and financing is crucial for marginalized groups, and sustainable land management practices and equitable sharing of benefits are essential. South Africa's comprehensive policies and legal frameworks, such as the National Forest Act of 1998, provide clear guidelines and mechanisms for participation, equitable resource allocation, and conflict resolution.

11. CONCLUSION AND RECOMMENDATIONS

Bush encroachment is a global problem and often refers in literature to a process of environmental degradation. In Africa pastoralists are directly affected by the invasion of woody vegetation and the simultaneous suppression of grasses due to the increasing of unpalatable species for their livestock.

Based on available evidence bush encroachment could have significant negative impacts on the overall supply and value of ecosystem services, biodiversity and livelihoods.

We recommend that that to effectively control bush encroachment and promote sustainable land management, it is essential to strengthen extension services and institutions dedicated to rangeland management. This approach should be universally applied, regardless of the specific strategies or regions involved. Key practices include maintaining sustainable stocking rates and implementing rotational grazing practices that allow grazing areas to recover adequately.

Furthermore, to manage bush encroachment optimally at national to local levels, it is essential to identify thresholds of potential concern and develop rigorous monitoring systems based on the latest scientific evidence. These thresholds and systems should be tailored to the specific biodiversity and ecosystem services of different regions.

Legal Reforms and Development of Norms and Standards for Managing Bush Encroachment:

This is key to effectively manage bush encroachment by removing legal barriers, clarify the legal framework, and develop a set of norms and standards that streamline the process of clearing and thinning encroached areas. Addressing potential conflicts between statutory bodies and reducing bureaucratic delays are critical steps in this process.

Establishing government-funded manual clearing programs in selected communal areas

To effectively address bush encroachment in communal rangelands, it is crucial to establish government-funded manual clearing programs in affected areas. These programs should focus on the grassland ecoregions and other localised problem areas where bush encroachment has significantly impacted land productivity and ecosystem health.

Establishing and decentralise bush encroachment information and advisory service

To effectively manage bush encroachment across different regions and land use types, it is essential to set up a dedicated bush encroachment information and advisory service. This unit would develop comprehensive guidelines, offer decision-support systems, and provide tools to land managers for effective bush encroachment management. Namibia is one of the good examples to have set up an Advisory Service, however, it needs decentralisation.

Conducting further research on bush encroachment

Further research is essential in several key areas. This research will provide a deeper understanding of the biodiversity impacts, the effects of woody biomass removal on soil fertility, the role of woody cover in restoring degraded soils, and the barriers preventing active clearing by landowners.

Development of value chains

Prioritizing research for cost-effective bush control

Given that bush control is a costly endeavor, it is crucial to prioritize research aimed at developing additional value chains. These value chains can help offset the expenses associated with bush control, making the process more economically viable and sustainable

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