HARVESTING AND PROCESSING NAMIBIAN ENCROACHER BUSH

Beyond Bush

Compendium of Harvesting and Processing Technologies for Encroacher Bush in Namibia • *Second Edition*

N-BiG
Namibia Biomass Industry Group

MINISTRY OF ENVIRONMENT, FORESTRY AND TOURISM

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Supported by
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

ABOUT N-BiG

The Namibia Biomass Industry Group (N-BiG) is a not-for-profit industry association with the mission of shaping the future of bioenergy and bio-based products in Namibia by driving innovation and technology development and providing technical expertise on biomass value chains. N-BiG has a diverse membership that includes private, public, and academic actors involved in the Namibian bush-biomass sector and beyond. Through its advisory service, N-BiG strengthens the capacity of its members, small and medium enterprises (SMEs) and farming communities, to manage and utilise biomass in a sustainable manner.

N-BiG was established under Section 21 in 2015 with the support of the Bush Control and Biomass Utilisation (BCBU) Project (2014-2024), implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

HARVESTING AND PROCESSING NAMIBIAN ENCROACHER BUSH

Compendium of Harvesting and Processing Technologies for Encroacher Bush in Namibia

WHAT IS THIS BROCHURE ABOUT?

This brochure presents and compares different methods for harvesting, processing and transporting bush biomass, as well as best practices in sustainable harvesting and aftercare. It is based on the study "Compendium of harvesting technologies for encroacher bush in Namibia" (2015) by M.J. de Wet. The publication covers the recent developments and new information on harvesting and processing Namibian bush biomass.

CONTENTS

BIOMASS: A RESOURCE FOR LAND RESTORATION

Bush encroachment is estimated to affect 45 million hectares of land in Namibia. At least 50 per cent of the land area is covered by thick bush with densities of up to 6,000 bushes per hectare. Bush encroachment has become a key indicator for land degradation, with adverse impacts on biodiversity, soils, livelihoods and, critical for an arid country, water availability.

At the same time, encroacher bush is a huge source of biomass, estimated at an average of 36 tonnes per hectare - which equates to 1.5 billion tonnes on the 45 million hectares that are affected. Of this, 30 per cent can be harvested sustainably, i.e. around 450 million tonnes. This is the standing bush biomass only, not considering annual expansion and regrowth. These are approximations based on available research. It is essential that site-specific resource quantification confirm the actual harvestable biomass for harvesting and investment decisions.

EXTRACTION

30 – 33% of the resource is recommended for extraction.
Currently, approximately 2 million tonnes are removed per year.

SPREAD

Bush encroachment has been spreading over time, with historic estimations suggesting an average rate of spread at approximately **3% per annum**.

REGROWTH

The resource regrows after harvesting. Regrowth depends on a variety of site-specific conditions, including the implementation of aftercare. Regrowth cycles can vary between 20 - 40 years, equivalent to an **increase of 2.5 - 4 mm in stem diameter per annum*.**

**Cunningham, P. & Detering, F. (2017). Determining age, growth rate and regrowth for a few tree species causing bush thickening in north-central Namibia. Namibian Journal of Environment 1 A: 72-76.*

Bush value chains such as charcoal, woodchips, bush-based animal fodder and biochar use the biomass to create positive opportunities for the Namibian economy. Biomass value chains increase agricultural productivity and enhance economic growth, employment and energy security, without competing with food production. The development of bush-based industries in Namibia is important to drive rehabilitation efforts and finance the restoration of bush encroached land. The market for biomass is expected to continue growing both domestically and internationally over the next decade, driven by increased demand for energy and products.

Restoring degraded, bush encroached land is a key priority in national policies such as the National Rangeland Management Policy and Strategy (NRMP&S) and in international frameworks such as the United Nations Convention on Biological Diversity (UNCBD), the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention to Combat Desertification (UNCCD) and Namibia's commitment to these frameworks. The sustainable use of resources is promoted by national development goals under the National Development Plan 5 and Harambee Prosperity Plan II, Vision 2030 and the National Forest Act. Promoting domestic value addition for local resources is closely aligned with the National Industrial Policy of 2012 and the Growth at Home Strategy.

The Namibia Biomass Industry Group (N-BiG) promotes the implementation of sustainable bush control and biomass utilisation as outlined in these national and international commitments and policies. N-BiG explores market opportunities for bush-based products, fosters the growth of supply and demand of the local and regional biomass industry and encourages industry diversification – to contribute to the sustainable use of biomass and the rehabilitation of bush encroached land in Namibia.

> Encroacher bush is a huge source of biomass, estimated at an average of 36 tonnes per hectare.

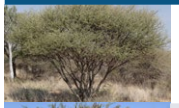
Comparison of landscape under bush control and heavily encroached landscape

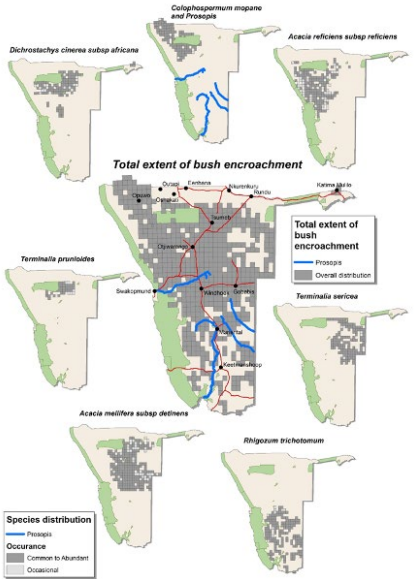
THE BUSH ENCROACHMENT CHALLENGE

Bush encroachment in Namibia is caused by indigenous bush species. These species can have positive effects on ecosystems and support important ecological processes. However, the extreme thickening of bush is often associated with considerable negative impacts on the productivity of land, biodiversity, water availability and livelihoods.

Pioneer species are hardy species which are the first to colonise barren environments or previously biodiverse steady-state ecosystems that have been disrupted by fire or clearing.

Encroacher Bush Species

	#	SCIENTIFIC NAME	POPULAR ENGLISH NAME	AFRIKAANS NAME
	1	*Senegalia mellifera*	Black Thorn	Swarthaak
	2	*Vachellia reficiens*	Red Umbrella Thorn	Rooihaak
	3	*Terminalia sericea*	Silver cluster-leaf	Geelhout
	4	*Rhigozum trichotomum*	Three-thorn	Driedoring
	5	*Colophospermum mopane*	Mopane	Mopani
	6	*Dichrostachys cinerea*	Sickle Bush	Sekelbos
	7	*Terminalia prunioides*	Purple-pod Terminalia	Deurmekaarbos
	8	*Vachellia luederitzii*	Kalahari Acacia / False Umbrella Thorn	Baster-haak-en-steek
	9	*Vachellia nilotica*	Scented-pod Acacia	Lekkerruikpeul



Bush encroached areas in Namibia according to SAEIA 2016

Bush encroachment is driven by poor rangeland management such as replacing indigenous animals, particularly browsers, with lesser adapted livestock at high stocking rates, changes in climate and increasing atmospheric CO_2 and changes in natural fire regimes.

Thinning bush encroached landscapes and restoring rangelands can have a positive impact on the resilience of communities and ecosystems to climate change, can improve land productivity and water availability and ensure food security.

Bush encroachment is a continuous process in savannas and cannot be controlled by a single bush control event. Integrated management of bush encroachment should involve various preventive and restorative measures and include interventions to avoid bush encroachment, interventions that reduce bush densities, as well as follow-up interventions that prevent or manage re-encroachment. This requires continuous planning and implementation.

Planned grazing restores rangelands

Bush control creates jobs in rural areas

Bush-based biomass is a valuable resource

ENVIRONMENTAL CONSIDERATIONS

Bush control, especially on a larger scale, can only be implemented successfully if the environmental impacts are fully understood and considered.

Selectivity

Unselective harvesting has considerable negative impacts on biodiversity. Selective harvesting is vital to:

- ensure desirable species are retained,
- maintain a heterogeneous landscape with favourable sub-habitats to enhance biodiversity,
- enhance natural control. Clearing of land is a shock to the ecosystem and can lead to aggressive regrowth, germination and seedling establishment. Larger bushes of various species suppress the growth of smaller bushes.

Harvesting should focus on the dominant encroacher species as well as the most dominant height strata. Harvesting should aim to leave a diversified height strata behind, including trees and shrubs of different sizes. Some encroacher species should also be left unharmed, as they are native to the ecosystem and provide important ecosystem functions (browse for game, nutrient cycling, micro-habitats etc.).

Large trees are protected

Conservation

Large and protected trees should not be targeted for bush harvesting. It is illegal to cut any tree with a trunk diameter larger than 18cm at the base or taller than 4m. Additionally, no harvesting should be conducted in or near sensitive areas such as river courses (not within 100 m), steep slopes (above 12 degrees) and micro habitats (termite mounds, dead trees, etc.).

Bush encroachment is caused by native species that fulfil important ecosystem functions and should remain part of the landscape. Thickets of bush should be maintained to create patch mosaics and a heterogeneous landscape. Any plants that are not considered problem species should be maintained to create sub-habitats for increased biodiversity.

> Bush control can only be implemented successfully if the environmental impacts are fully understood and considered.

Soil Health

Due to the extent of bush encroachment in Namibia, the focus should be on restoring savanna ecosystems. Large-scale clearing of bush can lead to soil disturbance and have a negative impact on soil nutrient cycling and thus reduce fertility. Heavily disturbed, exposed and eroded soils can lead to the breakdown of soil aggregates releasing soil organic carbon.

The focus should rather be on improving the soil by leaving some dead trees on the land as bush filters, for example. Together with minimising soil disturbance, enhancing the activity and diversity of soil fauna, reseeding and good grazing management, these practices can enhance soil organic carbon. Well managed grazing can also have positive effects on nutrient cycles, water holding capacity and biodiversity.

Soil disturbance should be avoided

Sustainability of the Value Chain

It is important to note that the following aspects contribute to long term sustainability:

- Good governance: The industry must be well managed and controlled.
- The environment should gain in the process, implying a best practice approach to restore grasslands, indigenous trees and natural biodiversity.
- The most appropriate and best practice technologies and methods should be followed with the least amount of soil disturbance, noise and emissions.
- The socio-economic wellbeing of the workers should be attended to by endeavouring to introduce permanent workflow, safe working conditions and skills development.
- The full value chain should be profitable and economical to commercial as well as SME operations.

Protective wear is crucial for safe working conditions

International environmental guidelines such as the FSC, ISO 14 000 and ISO 22 000 can contribute to the long-term sustainability of the sector by promoting responsible harvesting, harnessing of thermal energy, soil enhancement, reseeding / replanting and aftercare, as well as minimising visible emissions, toxic residues and disturbance of biodiversity.

Doing the above as a collective – as a unified biomass harvesting and savanna restoration industry – will give a good name and a sought-after 'brand' to Namibian biomass products. This would lead to continued exports, growth and subsequent prosperity for the participants.

> Well managed grazing has positive effects on nutrient cycles, water holding capacity and biodiversity.

BEFORE BUSH HARVESTING

Assess the Land

What are the causes of bush encroachment? 1

The site-specific causes of bush encroachment and barriers to the natural recovery of the land must be understood. Develop a clear picture of the future status of the land.

What are the characteristics of the ecosystem? 2

Suitable harvesting and aftercare methods depend on the natural vegetation and dominant species, amount of rainfall, soil types and structure - amongst other factors. Potential seed contaminated areas at risk of encroachment should also be considered and managed.

What is my plan? 3

This should include the preparation of the land before bush thinning (access, fire breaks or measures to control seeds), the thinning operations themselves and an aftercare treatment programme. The plan should include a rough calculation of required resources (time, equipment, costs) and a schedule according to seasonality. The plan should consider if the biomass will be used for value addition or if it will be left in-situ. The type of value chain chosen will influence the harvesting and aftercare methods.

When am I successful? 4

This builds on the clear picture of the future status of the land. Develop performance measures and monitor them over time to establish best practices and promote learning.

Choose Suitable Methods

Suitable harvesting and aftercare methods depend on the dominant species, soil structure and type, dominant land use, planned use of the biomass and affordability.

Take Steps for Authorisation

For every area (including those below 150 ha), a harvesting permit and potentially a transport and export permit are required. If bush control is conducted on more than 150 ha, an Environmental Clearance Certificate is required in addition to the harvesting permit. More information is available in the MEFT Forestry and Environmental Authorisations Process for Bush Harvesting Projects booklet (2023).

> Suitable harvesting and aftercare methods depend on the dominant species, soil structure and type, dominant land use, planned use of the biomass and affordability.

Resources

- The Forestry Act (2001) was under review at the time of publication. Above figures may therefore change. It is recommended that the Directorate of Forestry is consulted before any bush control activities are conducted.
- The Bush Control Manual (2017) provides detailed guidelines for calculating the bush density on your farm and various harvesting methods.
- The Forestry and Environmental Authorisations Process for Bush Harvesting Projects booklet (2023) prescribes bush densities that should remain after thinning.
  *This publication is under review.
- The Biomass Quantification Tool (2021) provides estimations on wood and bush feed biomass or can be used to conduct general surveys on plant densities.
- The National Strategy on the Sustainable Management of Bush Resources 2022-2027 provides guidelines on bush control and the development of bush value chains to ensure the resource is used sustainably.

IMPACT OF BUSH HARVESTING METHODS

Manual and Semi-Mechanised

Small scale labour intensive (manual) conventional biomass harvesting methods:

- Axe, panga, pruning and pruning shears, hand saws
- Push trolley with power driven circular saw or a multi-circular saw that is power take-off (PTO) driven (limited application)
- Chainsaws

ENVIRONMENTAL IMPACT  TO

KEY CONSIDERATIONS

- Manual methods can be very selective and minimise damage for desirable plants.
- Time and labour-intensive.
- The regrowth of cut stumps tends to be multi-stemmed which can exacerbate future problems.
- Due to the strong coppicing ability of most encroacher species, at least 90% will regrow if an area is completely cleared (100% for *Dichrostachys cinerea*). This can be reduced with selective harvesting and aftercare.
- If bushes are removed 10 cm below the soil surface, they often do not show any regrowth (exception: *Dichrostachys cinerea*).
- Workers should be sufficiently trained and monitored to ensure protected species and oversized specimens are not harvested and bushes / trees of various height strata remain on the land afterwards.

Fully Mechanised

Mechanised systems can be used to either control bush or for harvesting and productive use of the bush biomass:

- Excavator, skidsteer, or similar equipped with circular saw (more selective)
- Excavator, skidsteer, or similar equipped with hydraulic blade (more selective)
- Bush roller mounted on frontend loader (less selective)
- Mulchers or flails mounted to excavators, skidsteers, tractors, or similar (less selective)
- Bulldozer/grader/tractor with bucket (high risk of soil disturbance, but is often used due to availability and cost effectiveness) (less selective)
- Chain pulled between two tractors or dozers (less selective)

ENVIRONMENTAL IMPACT  TO

KEY CONSIDERATIONS

- Heavy machinery can create considerable soil disturbance and compaction. It is essential to reduce soil disturbance by moving equipment along designated access roads, avoiding equipment swivelling and/or excessive turning, avoiding harvesting in wet, muddy conditions and sensitive areas (rivers, pans, slopes, rocky outcrops, termite hills, etc.).
- Mechanised operations come with higher risks of over-harvesting. Excessive bush harvesting degrades land, with the risk of it worsening the original bush encroached state. Bare soils lead to soil erosion and loss of soil fertility with the risk of irreparable habitat destruction and desertification. Continuous oversight and management is therefore essential when using mechanised systems.
- Heavy machinery needs to be operated and maintained correctly to avoid oil and fuel spills in field. If spills do occur, they should be removed and treated accordingly.
- Heavy machinery is at high risk of causing accidental fires. Operators should always have firefighting equipment on hand.
- Operating heavy equipment is dangerous. Operators need to use suitable Personal Protective Equipment (PPE), have first aid kits readily available and need to be trained accordingly.
- If used incorrectly, heavy equipment can encourage areas to become re-encroached to even higher densities than before within 5 – 6 years due to invasion of pioneer species, increased seedling establishment and coppicing.
- At least 90% of the harvested stumps will regrow without follow up treatment. *Dichrostachys cinerea* often has a 100% regrowth. Aftercare is vital.
- Some of the harvested bush material should be left on the land to provide soil cover to allow grasses to recover (see Brush Packing below). This bush material will eventually break down, enhancing soil fertility. Re-seeding with grasses can be useful as a follow-up treatment.
- Harvesting must be selective, leaving bushes of different sizes and densities to create a diverse landscape. Harvesting mechanically can be done along contour strips, to ensure both operational efficiency and reduce risk of over harvesting.

> Harvesting must be selective, leaving bushes of different sizes and densities to create a diverse landscape.

ENVIRONMENTAL IMPACT KEY

AFTER BUSH HARVESTING

Thinning bush creates a vacuum, which leads to aggressive regrowth. This can be reduced through aftercare or post-harvest treatments, a competitive grass layer and a balance of bushes.

Controlled Fire

Fire plays an important role in savanna ecosystems and is largely responsible for maintaining a balance between grasses and woody species. A high intensity fire is required to control bush seedlings, coppice, or to maintain bush at the right height for browsers. The use of stem burning (a small, low intensity fire around the stems) can also be used to selectively kill bush.

ENVIRONMENTAL IMPACT

KEY CONSIDERATIONS

- Fire is better suited for areas with considerable rainfall and good soil moisture. A fire should only be used if there is enough residual soil moisture from the previous season.
- Must be followed with periodic follow-up burns.
- Different bush species have a different sensitivity to fire. Some may be more resistant to fire, regrow rapidly or germinate after fires.
- Burning too frequently can also have a negative impact on biodiversity, soils and basal cover.
- When used correctly, fire can kill most seedlings and saplings.
- Regulations and guidelines on the use of fire must be followed to avoid uncontrolled fires.
- Trampling with animals before a controlled burn can prevent the soil from capping during a fire and can reduce the fuel load underneath large shade trees minimising damage.
- Perennial grass seeds must have shed before burning.
- The land should be rested for at least a year to allow grasses to recover and accumulate fuel load for a follow-up fire to kill coppice and remaining seedlings.

Biological Control

The main aim of biocontrol is to ensure bush can reproduce and grow but does not aggressively thicken. Biological control methods include:

- Native browsers (Eland, Kudu, Giraffe, Black Rhino, Elephant, Steinbok, Dikdik, Hare, etc.)
- Domesticated browsers (Goats, Nguni cattle)
- Invertebrates (Insects and fungi)
- Parasitic plants

ENVIRONMENTAL IMPACT

KEY CONSIDERATIONS

- Biocontrol agents can survive in a treated area for a long time. They are mobile, actively look for new target plants, and can re-establish themselves.
- They can be a very inexpensive and environmentally sound measure if carefully screened.
- May cause damage to non-target species as well.
- The use of domesticated browsers can also contribute to higher meat production and income.
- Can be very effective – especially if combined with fire. In a Namibian trial, the combination of goats and fire reduced bush density by 60% within 40 years.

Mechanical Control

The use of machinery for aftercare purposes is rare but may either be used as a follow-up to chemical control (e.g. with soil applied chemicals) where the dead bushes often remain standing, or it can be used to harvest coppice after initial harvesting for further value addition, e.g. bush-based animal fodder.

ENVIRONMENTAL IMPACT

KEY CONSIDERATIONS

- Heavy machinery can create considerable soil disturbance and/or soil compaction. It is essential to reduce soil disturbance as far as possible. It is advisable to allow grasses enough time to completely re-establish themselves on the bare soil after initial control before using further heavy machinery follow ups.
- Heavy machinery for aftercare can have a high ecological risk and limited benefits.
- Mechanised aftercare is one of the most expensive options.

Chemical Control

Chemical control as a harvesting method does not support the use of the biomass and value chain development. Several types of arboricides are available, which differ in the way they are applied:

- *Soil Applied Arboricides* are applied to the soil and absorbed by the roots. They are applied as granules, liquid and/or a wettable powder.
- *Foliar Applied Arboricides* are sprayed onto the plant and absorbed by the foliage or stems. They are best applied selectively by hand, via a knapsack sprayer.
- *Cut Stump Application* normally takes place directly after mechanical control. The arboricide is manually painted or sprayed onto the freshly cut stump.

ENVIRONMENTAL IMPACT

Low for stem-applied arboricides, high for soil-applied arboricides

KEY CONSIDERATIONS

- Aerial arboricide application is highly unselective and is prohibited by law.
- The accumulation of arboricides can create unwanted ecosystem impacts.
- Incorrect use of arboricides can cause considerable collateral damage by run-off, leaching into groundwater and spray drift.
- Arboricides can be very effective when the correct application instructions are followed.
- Some soil applied arboricides have long residual effects in the soil which can help to supress seedling regeneration for up to 5 years but, equally, these same arboricides are the highest risk for causing collateral damage.
- Chemicals should be applied in a year with low seed production.
- Cut-stump application is very selective with little off-site effects. However, stems must be cut cleanly, cleaned of any residues or dust and treated within a short window after harvesting to achieve the best results.

Manual Control

Manual methods for aftercare involve the digging out of roots and manually removing coppice or saplings e.g. with an axe, mattock or Tree Popper.

ENVIRONMENTAL IMPACT 

KEY CONSIDERATIONS

- Very selective and minimal impact on desired plants.
- Job opportunities for unskilled labour.
- If the root is not removed, there will be regrowth. Digging out the roots effectively controls regrowth and coppicing.
- Very time consuming.

Reseeding

Effective bush control must include both top-down and bottom-up measures. Sowing perennial grasses can help accelerate the recovery of the grass layer, increasing competition for woody species. Seeds can be mixed with manure and/or biochar into seedcakes, seed bombs or blocks, or mixed directly into livestock feed for dispersal.

ENVIRONMENTAL IMPACT 

KEY CONSIDERATIONS

- Native species should be used to avoid potential changes to the ecosystem with unknown consequences.
- Seeds can be harvested on or around the treatment site.
- Seed bombs, cakes or blocks can protect the seeds from being carried away by insects or small mammals.
- Dispersal must be timed with the wet season for the best results.
- Especially suited for selectively controlled areas with trees that provide shade and nutrients.
- The establishment of the grass layer can take years. Other aftercare measures must be used to prevent re-thickening of woody species.

Soil Enhancement

The removal of biomass can have a negative impact on the soil, depending on the initial bush control method used. Soil enhancement can accelerate the restoration of soil fertility and includes:

- Use of Brush Packing or Bush Filters (see Decision Support System for *Acacia Mellifera* booklet (version 2, 2017))
- Application of Wood Ash
- Application of Biochar or Wood Acid

ENVIRONMENTAL IMPACT 

KEY CONSIDERATIONS

- Brush packing is a cost-effective measure requiring no additional inputs and can create a favourable micro-habitat for grasses to grow.
- Soil enhancement measures do not directly address the regrowth and coppicing ability of plants, but they address one of the key causes of bush encroachment: low soil fertility.

Grazing Management

After bush control, the area must rest to ensure the recovery of grasses. A sustainable grazing or veld management programme should be developed to control re-growth. Reviving Namibia's Livestock Industry - Regenerative Livestock Production gives an overview of of best practices for livestock management (2019).

ENVIRONMENTAL IMPACT 

KEY CONSIDERATIONS

- Responsible grazing management should be a key component in every bush thinning programme.
- Sustainable grazing management must limit overgrazing and land degradation.
- Responsible grazing management can lead to more stable production during droughts and greater cattle yield potential, contribute to soil fertility and limit conflict with wildlife.

> Native species should be used to avoid potential changes to the ecosystem with unknown consequences.

ENVIRONMENTAL IMPACT KEY

For more detailed information on positive and negative impacts on the environment, please refer to **Van der Waal, C. & Stoldt, M. (2020). Environmental Assessment of Post-Harvest Treatment Measures.** Commissioned by the MEFT / GIZ BMCC II Project.

MARKET OVERVIEW

The market for biomass is expected to continue growing both domestically and internationally over the next decade, driven by increased demand for energy and products.

Domestically, Namibia's demand for firewood will steadily increase as rural and informal electrification remains slow. Local demand for wood chips will remain constrained until local biomass energy power is established or pelleting projects are developed.

Internationally, demand for certified charcoal will drive continued growth within the charcoal industry. Additionally, climate change commitments will drive the demand for sustainable biomass energy markets for fossil fuel substitution, which may encourage new export markets for energy products to develop.

> The market for biomass is expected to continue growing both domestically and internationally over the next decade, driven by increased demand for energy and products.

Current and Projected Biomass Utilisation in Namibia (2018-2025)

	2018	2019	2020	2021	2022	2023	2024	2025
Charcoal*	810 000	900 000	1 000 000	1 100 000	1 210 000	1 333 000	1 464 000	1 610 000
Firewood	582 000	593 000	604 000	616 000	627 000	639 000	652 000	664 000
Poles	237 000	239 000	242 000	244 000	247 000	249 000	252 000	254 000
Wood chips								
Ohorongo	20 000	10 000	10 000	20 000	20 000	20 000	20 000	20 000
Namibia Breweries	9 000	9 000	9 000	9 000	9 000	9 000	9 000	9 000
NamPower	0	0	0	0	0	0	50 000	204 000
Total, tonnes of wood per annum	1 658 000	1 751 000	1 865 000	1 989 000	2 113 000	2 250 000	2 447 000	2 761 000

**Production is represented in wood equivalents, whereby a 20% carbonisation efficiency is assumed.*
***All figures are given in tonnes of dry matter.*

HARVESTING METHODS

Bush harvesting can be achieved at any scale, whether it is small scale manual harvesting, medium scale semi-mechanised harvesting or large-scale fully mechanised harvesting. There are a number of harvesting methods that have proven successful in Namibia and new methods are continuously being tested.

The following harvesting methods – divided by their degree of mechanisation – are currently being used for different value chains in Namibia:

All harvesting methods can cause negative impacts when used incorrectly. Training operators on how to use different harvesting and aftercare methods is vital to minimising environmental damage. N-BiG's Advisory Service provides training and information materials (www.n-big.org).

Well-trained harvesters know how to minimise environmental damage

Manual Harvesting

The most commonly used harvesting practice is manual harvesting using hand-held tools such as axes and pangas. It is commonly used in Namibia because barriers to entry are low, skills readily available and capital costs are small.

Manual harvesting is not very productive per unit, but it is easily scaled. However, as it grows in scale, management and administration become more intensive.

Environmental risks associated with manual harvesting include illegal harvesting, accidental fires and littering.

Notable factors:

- Provision of decent housing
- Provision of personal protective equipment
- Administrative requirements, including Social Security registration
- Provision of training, including environmental and health and safety
- Legal status of migrant workers

Challenges include:

- High turnover of employees
- Production incentives often cause undesirable outcomes (illegal harvesting, accidental fires, etc.)
- High administrative burden
- Seasonal availability of labour: Workers often return home during the wet season

Semi-Mechanised Harvesting

Semi-mechanised harvesting involves the use of hand-operated/drawn power tools, including chainsaws and trolley saws. It is relatively uncommon in Namibia due to the lack of skills available, higher upfront and operational costs and common mismanagement of such operations.

When employed correctly, semi-mechanised harvesting can be equally cost effective as manual harvesting but far more productive.

Environmental risks associated with semi-mechanised harvesting include over harvesting, illegal harvesting, accidental fires, littering, fuel and oil spills.

Notable factors:

- Provision of training, including environmental, health and safety, operational and maintenance
- Provision of decent housing
- Provision of personal protective equipment
- Availability of skills
- Higher capital requirements

Challenges include:

- Correctly operating and maintaining equipment
- Management of operators
- Production incentives often cause undesirable outcomes (illegal harvesting, accidental fires, etc.)
- Sourcing and stocking of spares and consumables

> When employed correctly, semi-mechanised harvesting can be equally cost effective as manual harvesting but far more productive.

Semi-Mechanised Harvesting

Fully mechanised harvesting is becoming more popular in Namibia

Fully Mechanised Harvesting

Fully mechanised harvesting encompasses the use of self-powered/driven equipment, including excavators, skid steers and bush rollers. Fully mechanised harvesting is growing in popularity in Namibia, partly due to the fact that service providers are readily available.

Fully mechanised harvesting is highly productive per unit and, as such, also tends to be more cost effective. However, this is not viable for small-to-medium applications (unless via a third-party service provider), as the capital and operational costs are high.

Environmental risks associated with fully mechanised harvesting are over harvesting, illegal harvesting, soil disturbance, accidental fires, fuel and oil spills.

Notable factors:

- High capital requirements
- Provision of training, including environmental, health and safety, operational and maintenance
- Provision of suitable management

Challenges include:

- Correctly operating and maintaining equipment.
- Mitigating environmental risks
- Equipment finance

> Fully mechanised harvesting is growing in popularity in Namibia, partly due to the fact that service providers are readily available.

COMPARISON OF HARVESTING METHODS

The table refers to the smallest operational units of various harvesting methods. Once the preferred method and scale is selected, the operational units can be multiplied based on the intended output.

The models assume that the achievable harvesting yield averages 10 tonnes per hectare, which is based on a conservative assumption supported by the Detailed Assessment of the Biomass Resource and Potential Yield in a Selected Bush Encroached Area of Namibia study (Smit et al, 2015).

ASSUMPTIONS		
Harvesting rate	10	tonnes/ha
Average bush weight	0,05	tonnes
Small bush weight (<2cm diameters)	0,02	tonnes
Working hours per day	10	hours/day
Working days per month	21	work days/ month
Fuel price	16	NAD/l

> Once the preferred method and scale are selected, the operational units can be multiplied based on the intended output.

													COSTS									
													CAPEX			OPEX, PER MONTH						
HARVESTING METHODS	INTENDED SCALE	BUSH PER DAY - MIN	BUSH PER DAY - MAX	MONTHLY PRODUCTION - MIN (TONNES/MONTH)	MONTHLY PRODUCTION - MAX (TONNES/MONTH)	RECOMMENDED METHODS		ADVANTAGES	DISADVANTAGES	EXAMPLES	SMALLEST OPERATIONAL UNIT	TOOLS/EQUIPMENT	PPE	OTHER	SALARY	DEPRECIATION	CONSUMABLES	FUEL	COST PER MONTH/UNIT	HARVESTING COST PER TONNE - MAX	HARVESTING COST PER TONNE - MIN	MARGIN OF SAFETY	AVERAGE COST PER TONNE, HARVESTED
MANUAL	Low	40	60	42	63	Axe		Scalable, operators readily available, selective	Management intensive, leaves jagged stumps, no soil disturbance	Agra (N$500)	1	N$650.00	N$500.00	N$2,000.00	N$3,600.00	N$550.00	N$130.00	N$-	N$4 280.00	N$101.90	N$67.94	15%	N$97.66
SEMI-MECHANISED	Medium	120	150	126	157,5	Chainsaw		Scalable, leaves cleanly cut stumps, selective	Skilled operators are scarce, maintenance intensive	Husqvarna H61 Chainsaw (N$7,631.30)	1	N$8,500.00	N$2,000.00	N$2,000.00	N$5,000.00	N$1,541.67	N$1,680.00	N$3,360.00	N$11,581.67	N$91.92	N$73.53	15%	N$95.14
	Medium	120	150	126	157,5	Trolley saw		Scalable, leaves cleanly cut stumps, selective	Not suitable in all terrains, high maintenance	Bosvreter 6.5 Hp petrol (N$ 16,362.00)	1	N$17,000.00	N$500.00	N$2,000.00	N$5,000.00	N$1,750.00	N$3,528.00	N$7,056.00	N$17,334.00	N$137.57	N$110.06	15%	N$142.39
MECHANISED	High	1200	1600	1260	1680	Mini excavator + cutting shear		Windrows bush, cleanly cut stumps at ground level, selective, available as service	Capital intensive, high maintenance, moderate soil disturbance	N-BiG Leasing Model	1	N$1,250,000.00	N$500.00	N$5,000.00	N$8,000.00	N$35,305.56	N$8,400.00	N$16,800.00	N$68,505.56	N$54.37	N$40.78	15%	N$54.71
	High	1400	1600	1470	1680	Skidsteer (Wheeled) + circular saw		Leaves cleanly cut stumps, selective	Capital intensive, high maintenance, heavy soil disturbance	Gehl	1	N$800,000.00	N$500.00	N$5,000.00	N$8,000.00	N$22,805.56	N$11,760.00	N$23,520.00	N$66,085.56	N$46.60	N$40.78	15%	N$50.24
	High	1600	4000	1680	4200	Bush roller - without raking		Most cost effective, fast, available as service	Very capital intensive, high maintenance, moderate soil disturbance	Ombengu bushroller	1	N$6,000,000.00	N$500.00	N$10,000.00	N$8,000.00	N$167,666.67	N$31,920.00	N$63,840.00	N$271,426.67	N$40.78	N$16.31	15%	N$32.83
	High	500	1250	525	1312,5	Bush roller - with raking		Available as service	Very capital intensive, high maintenance, heavy soil disturbance	Ombengu bushroller	1	N$6,000,000.00	N$500.00	N$10,000.00	N$8,000.00	N$167,666.67	N$31,920.00	N$63,840.00	N$271,426.67	N$130.49	N$52.19	15%	N$105.04

PROCESSING

Once harvested, the bush biomass is available for processing. The processing method and scale will depend on the desired product and intended market.

This booklet will focus on primary processing of bush biomass into basic products such as wood logs, wood chips and milled fibre, which can then respectively be further processed into final products such as charcoal, bush-based animal fodder, energy products.

Wood Logs

Logs are used to produce firewood, charcoal and/or biochar. Logs are cut into desired lengths, usually when the wood is still fresh. The logs are then typically left to dry before packaging or further processing. While shorter logs dry faster, a higher number of cuts is required.

The recommended processing methods differ depending on the intended scale of operation. Small-to-medium scale operations are better suited to manual and/or semi-mechanised processing methods, while large scale operations are better suited to fully mechanised methods.

Wood Chips

Wood chips are used as input for compressed wood logs or compost and they can be used as an energy feedstock. Wood chips are either processed from fresh wood, using sharp tools (e.g. woodchippers, using knives) or they are processed from dry wood, using dull tools (e.g. horizontal grinders, using hammers).

Small-scale operations are best suited using hand-fed woodchippers, whereas medium-to-large scale operations are better suited to using towed or self-propelled horizontal grinders.

Milled Fibre

Milled fibre refers to the milling of fine branches (< 2cm diameters) used as a component of bush-based animal fodder.

Small-scale operations are best suited to milling the branches with a small hammermill. Medium-to-large operations benefit from chipping the branches first and then milling them with a hammermill, either with separate equipment or specialised combined equipment. As the milled fibre should not be used without supplements, mixing is also required.

> Once harvested, the bush biomass is available for processing. The processing method and scale will depend on the desired product and intended market.

A chipper converting the bush biomass into solid material

COMPARISON OF PROCESSING METHODS

The table refers to the smallest operational units. Once the preferred product, method and scale are defined, the operational units can be multiplied based on the intended output.

PROCESSING METHODS	INTENDED SCALE	BUSH PER DAY - MIN	BUSH PER DAY - MAX	MONTHLY PRODUCTION - MIN (TONNES/MONTH)	MONTHLY PRODUCTION - MAX (TONNES/MONTH)	RECOMMENDED METHODS	ADVANTAGES		DISADVANTAGES	EXAMPLES	SMALLEST OPERATIONAL UNIT	COSTS										
												CAPEX			OPEX, PER MONTH							
												TOOLS/EQUIPMENT	PPE	OTHER	SALARY	DEPRECIATION	CONSUMABLES	FUEL	COST PER MONTH/ UNIT	PROCESSING COST PER TONNE - MAX	PROCESSING COST PER TONNE - MIN	MARGIN OF SAFETY	AVERAGE COST PER TONNE, PROCESSED
WOOD LOGS (FIREWOOD OR CHARCOAL)	Low	20	40	21	42	Axe	Scalable, low entry barriers, low maintenance		Management intensive	Agra (N$500)	1	N$650.00	N$500.00	N$2,000.00	N$3,600.00	N$550.00	N$130.00	N$-	N$4,280.00	N$203.81	N$101.90	15%	N$175.79
	Medium	50	80	53	84	Chainsaw	Scalable, equipment readily available,		Skilled operators are scarce, maintenance intensive	Husqvarna H61 Chainsaw (N$7,631.30)	1	N$8,500.00	N$2,000.00	N$2,000.00	N$5,000.00	N$1,541.67	N$1,680.00	N$3,360.00	N$11,581.67	N$220.60	N$137.88	15%	N$206.13
	Medium	50	80	53	84	Axes + Circular saw	Equipment readily available		More manually intensive, most expensive	Bosvreter (N$17,372.00)	3	N$19,300.00	N$1,500.00	N$6,000.00	N$10,800.00	N$2,608.33	N$3,528.00	N$7,056.00	N$23,992.33	N$457.00	N$285.62	15%	N$427.01
	High	400	600	420	630	Chainsaws + PTO branch logger + tractor	High throughput, cost effective		Capital intensive, higher maintenance	Remet CNC RP 200 (EUR 4,435.00), New Holland TT4.90 (N$450,000.00)	6	N$604,000.00	N$9,000.00	N$12,000.00	N$30,000.00	N$20,777.78	N$10,080.00	N$20,160.00	N$81,017.78	N$192.90	N$128.60	15%	N$184.86
WOOD CHIPS (ENERGY FEEDSTOCK)	Low	250	300	263	315	Tow-behind chipper (30-40 hp) + panga + manual feeding					4	N$300,000.00	N$2,000.00	N$8,000.00	N$18,800.00	N$13,833.33	N$6,720.00	N$6,720.0	N$46,073.33	N$175.52	N$146.26	15%	N$201.85
	Medium	1500	1800	1575	1890	Medium horizontal grinder (275-350 hp) + haulage & feeding excavator					3	N$6,000,000.00	N$1,500.00	N$6,000.00	N$36,000.00	N$112,111.11	N$50,400.00	N$50,400.00	N$248,911.11	N$158.04	N$131.70	15%	N$181.74
	High	2400	2800	2520	2940	Large horizontal grinder (600-800 hp) + feeding excavator					3	N$14,000,000.00	N$1,500.00	N$6,000.00	N$36,000.00	N$260,259.26	N$134,400.00	N$134,400.00	N$565,059.26	N$224.23	N$192.20	15%	N$257.86
MILLED FIBRE (BUSH BASED ANIMAL FODDER)	Low	50	60	21	25	Small motor-driven hammermill + panga + hand mixing	Equipment readily available				2	N$555,000.00	N$1,000.00	N$4,000.00	N$7,200.00	N$5,250.00	N$3,360.00	N$6,720.00	N$22,530.00	N$1,072.86	N$894.05	15%	N$1,233.79
	Medium	120	160	50	67	Tow-behind chipper (20-25 hp) + panga + medium hammermill + feed mixer					4	N$225,000.00	N$2,000.00	N$8,000.00	N$17,200.00	N$10,708.33	N$10,080.00	N$20,160.00	N$58,148.33	N$1,153.74	N$865.30	15%	N$1,326.80
	High	170	200	71	84	All-in-one Bush-to-feed system + chainsaw				Bosvreter Bos-tot-kos (N$598,575.00)	4	N$610,000.00	N$2,000.00	N$8,000.00	N$15,800.00	N$12,629.63	N$21,840.00	N$43,680.00	N$93,949.63	N$1,315.82	N$1,118.45	15%	N$1,513.19

TRANSPORT

Once processed, the biomass products need to be transported from the field to either a collection point or to the market.

In-Field Transport

In-field transport refers to the transport of products from the field to a central collection point (e.g. farm gate, access road, etc.). It typically requires the equipment to move off-road and along farm roads or fence lines for distances under 10-15 km. In-field transport methods are usually slow moving and therefore not suitable for longer distances.

For small scale operations, a utility vehicle with a trailer (e.g. bakkie) is best suited. Such vehicles are readily available and versatile, but their carrying capacities are low. For medium-to-large operations, tractors with trailers are best suited, as they are robust and have higher carrying capacities.

Long-Distance Transport

For transport of products over longer distances (e.g. to market), specialised road-going solutions are preferred. This typically entails travelling on gravel and/or tar roads for distances over 10-15 km.

For small scale operations, a utility vehicle with a trailer can serve a dual purpose. For medium-to-large operations, trucks of varying capacities are preferable. Long-distance transport can readily be outsourced via third-party service providers.

> For small scale operations, a utility vehicle with a trailer can serve a dual purpose. For medium-to-large operations, trucks of varying capacities are preferable.

Milled encroacher bush transported to storage

COMPARISON OF TRANSPORT METHODS

The table refers to the smallest operational units of various transport methods. Once the required scale is defined, the operational units can be multiplied based on the intended volumes.

Transport methods	Intended scale	Monthly production - min (tonnes/month)	Monthly production - max tonnes/month)	Recommended methods	Advantages	Disadvantages		Examples	Smallest operational unit	Costs: CAPEX			Costs: OPEX, per month				Cost per month/unit	Assumed distance travelled per month	Running cost per km - average	Running cost per tonne - kilometre (assuming empty backhaul)	Margin of safety	Average cost per tonne-kilometre	Example: transport cost per tonne for delivery 20 km away
										Tools/Equipment	PPE	Other	Salary	Depreciation	Consumables	Fuel							
In field (offroad, farm roads)	Low	120	180	Bakkie + 1.5 tonne trailer + manual loading	Equipment readily available, versatile	Inefficient, unless a used vehicle can be used		Ford Single Cab (N$333,700.00) + Trailer	1	N$370,000.00	N$500.00	N$2,000.00	N$5,000.00	N$7,185.19	N$1,680.00	N$3,360.00	N$17,225.19	2520	N$6.84	N$9.11	15%	N$10.48	N$209.62
	Medium	300	500	Small tractor (50-60 Hp) + 5 tonne tipper trailer + portable feeding conveyor	Cost effective	Becomes less effective over longer distances		New Holland TT3.50 (N$332,120.00) + Mad Farmer 5 tonne tipper (N$95,000.00), Flowscan Multipurpose conveyor (N$19,500.00)	1	N$480,000.00	N$500.00	N$2,000.00	N$5,000.00	N$13,666.67	N$2,520.00	N$5,040.00	N$26,226.67	1680	N$15.61	N$6.24	15%	N$7.18	N$143.62
	High	1000	1500	Medium tractor (90-100 Hp) with 10 tonne tipper trailer	Most cost effective	Capital intensive. Needs to be loaded via conveyor		New Holland TT4.90 (N$448,891.30) + VZS 10 tonne Tipwa Duo (N$210,000.00)	1	N$700,000.00	N$500.00	N$2,000.00	N$5,000.00	N$19,777.78	N$3,360.00	N$6,720.00	N$34,857.78	1680	N$20.75	N$4.15	15%	N$4.77	N$95.44
Long distance (tar & gravel roads)	Low	120	180	Bakkie with 1.5 tonne trailer	Equipment readily available, versatile	Inefficient, unless a 2nd hand vehicle can be used		Ford Single Cab (N$333,700.00) + Trailer	1	N$370,000.00	N$500.00	N$2,000.00	N$5,000.00	N$7,185.19	N$2,940.00	N$11,760.00	N$26,885.19	10500	N$2.56	N$3.41	15%	N$3.93	N$78.52
	Medium	300	360	Small truck (3 tonne capacity)	Available as service			FAW 6.130FL (N$270,000.00) + Loadbed (N$50,000.00)	1	N$330,000.00	N$500.00	N$2,000.00	N$8,000.00	N$6,444.44	N$4,200.00	N$16,800.00	N$35,444.44	8400	N$4.22	N$2.41	15%	N$2.77	N$55.46
	High	2500	3000	Large truck & trailer (90-110 m3)	Available as service			FAW J5N 33.420FT 6×4 (N$1,000,000.00) + Trailer (N$500,000.00)	1	N$1,500,000.00	N$500.00	N$2,000.00	N$8,000.00	N$28,111.11	N$14,280.00	N$57,120.00	N$107,511.11	8400	N$12.80	N$0.85	15%	N$0.98	N$19.63

EXAMPLE: SMALL-SCALE WOOD LOG PRODUCTION

The objective is to produce 150 tonnes of wood logs per month (equivalent to 30 tonnes of charcoal or biochar per month), delivered at the farm gate.

Using the data from the Harvesting, Processing, and Transport Cost Tables, the table below compares two production methods to achieve the same intended output, the first using a manual approach (axes) and the second using a semi-mechanised approach (chainsaws).

For the manual example, 3 harvesting units coupled with 5 processing units and 1 in-field transport unit are required.

For the semi-mechanised example, 1 harvesting unit coupled with 2 processing units and 1 in-field transport unit are required.

Considerations

- The manual example has marginally lower capital and operational costs.
- The manual approach requires more than twice the number of operators.
- The semi-mechanised example is marginally less cost effective per unit produced.
- Both examples assume the capital cost of a new utility vehicle for in-field transport, which is likely unnecessary at a small scale.

Conclusions

- The manual operation would be marginally more cost effective, but more management intensive.
- The semi-mechanised operation would be more productive per operator and hence less management intensive.
- As capital costs are similar for both approaches, the decision would be based on management capacity, availability of spares and personal preference.

> The semi-mechanised operation is more productive per operator and hence less management intensive.

Case Study 1 - Wood Logs

						COSTS											
						CAPEX				OPEX, PER MONTH							
150 TONNES OF WOOD LOGS PER MONTH, DELIVERED AT FARM GATE (5 KM AWAY)	REQUIRED PRODUCTION PER MONTH	HARVESTING UNITS REQUIRED	PROCESSING UNITS REQUIRED	TRANSPORT UNITS REQUIRED (IN FIELD ONLY)	CAPEX REQUIRED - HARVESTING	CAPEX REQUIRED - PROCESSING	CAPEX REQUIRED - TRANSPORT	CAPEX REQUIRED - TOTAL	OPEX PER MONTH - HARVESTING	OPEX PER MONTH - PROCESSING	OPEX PER MONTH - TRANSPORT (5 KM IN-FIELD TRANSPORT TO FARM GATE)	OPEX PER MONTH - TOTAL	COST PER TONNE - HARVESTING	COST PER TONNE - PROCESSING	COST PER TONNE - TRANSPORT	COST PER TONNE - TOTAL	ADVANTAGES	DISADVANTAGES
OPTION 1 - AXES	150	3	5	1	N$9,450.00	N$15,750.00	N$372,500.00	N$397,700.00	N$12,228.57	N$20,380.95	N$10,985.00	N$43,594.52	N$97.66	N$175.79	N$52.40	N$325.85	Cost effective	Managing intensive
OPTION 2 - CHAINSAWS	150	1	2	1	N$12,500.00	N$25,000.00	N$372,500.00	N$410,000.00	N$12,255.73	N$25,454.21	N$10,985.00	N$48,694.94	N$95.14	N$206.13	N$52.40	N$353.67	8% less cost effective	

EXAMPLE: MEDIUM-SCALE WOOD CHIP PRODUCTION

The objective is to produce 1,500 tonnes of wood chips per month, delivered to the off-taker within 100 km of the farm gate.

Using the data from the Harvesting, Processing, and Transport Cost Tables, the table below compares two production methods to achieve the same intended output, the first using a semi-mechanised approach (chainsaws and small chippers) and the second using a fully mechanised approach (excavator and medium sized chipper).

For the semi-mechanised example, 11 harvesting units, 5 processing units, 4 in-field transport and 1 long distance transport unit are required to produce 1,500 tonnes per month.

For the fully mechanised example, 1 harvesting unit, 1 processing unit, 1 in-field transport and 1 long distance transport unit are required to produce 1,500 tonnes per month.

Considerations

- The semi-mechanised approach has significantly lower up-front capital requirements. However, it has notably higher operational costs.
- The fully mechanised approach is almost 20% more cost effective per unit.
- The fully mechanised approach requires only 7 skilled operators while the semi-mechanised example requires 36 semi-skilled operators, making it more management intensive.
- The semi-mechanised approach requires multiple operational units and therefore has better operational redundancy.

Conclusions

- If capital is a major constraint, then the semi-mechanised approach remains viable, as it can be up-scaled easily over time.
- If capital is not a major constraint, then the fully mechanised approach will be more profitable and easier to manage.

Case Study 2 - Wood Chips

							COSTS														
							CAPEX					OPEX, PER MONTH									
1500 TONNES OF WOODCHIPS PER MONTH, DELIVERED TO OFF TAKER (50 KM AWAY)	REQUIRED PRODUCTION PER MONTH	HARVESTING UNITS REQUIRED	PROCESSING UNITS REQUIRED	TRANSPORT UNITS REQUIRED - IN FIELD		TRANSPORT UNITS REQUIRED - LONG DISTANCE	CAPEX REQUIRED - HARVESTING	CAPEX REQUIRED - PROCESSING	CAPEX REQUIRED - TRANSPORT - IN FIELD	CAPEX REQUIRED - TRANSPORT - LONG DISTANCE	CAPEX REQUIRED - TOTAL	OPEX PER MONTH - HARVESTING	OPEX PER MONTH - PROCESSING	OPEX PER MONTH - TRANSPORT (5 KM IN-FIELD TRANSPORT TO FARM GATE)	OPEX PER MONTH - TRANSPORT (50 KM ON TAR TO OFF-TAKER)	OPEX PER MONTH - TOTAL	COST PER TONNE - HARVESTING	COST PER TONNE - PROCESSING	COST PER TONNE - TRANSPORT	COST PER TONNE - TOTAL	TOTAL PERSONNEL REQUIRED	ADVANTAGES	DISADVANTAGES
OPTION 1 - SMALL CHIPPERS, CHAINSAWS, SMALL TRACTORS, LARGE TRUCK	1500	11	5	4		1	N$137,500.00	N$1,550,000.00	N$1,930,000.00	N$1,502,500.00	N$5,120,000.00	N$127,398.33	N$230,366.67	N$104,906.67	N$107,511.11	N$570,182.78	N$84.93	N$153.58	N$141.61	N$380.12	36	Operational redundancy, lower upfront investment required	Management intensive, inefficient
OPTION 2 - MEDIUM GRINDER, EXCAVATOR SHEAR, LARGE TRACTOR, LARGE TRUCK	1500	1	1	1		1	N$1,255,500.00	N$6,007,500.00	N$702,500.00	N$1,502,500.00	N$9,468,000.00	N$68,505.56	N$248,911.11	N$34,857.78	N$107,511.11	N$459,785.56	N$45.67	N$165.94	N$94.91	N$306.52	7	Cost effective, efficient	High upfront investment

AFTERCARE

Most encroaching species have a rapid regrowth rate. Post-harvest or aftercare measures are necessary to limit regrowth and support the development of the grass layer. The effectiveness of different aftercare measures highly depends on soil composition, rainfall patterns, species and the initial harvesting method.

Aftercare measures can be a costly investment with limited returns in the short term. However, in the long term, grass regrowth and increased carrying capacity as well as groundwater recharge will cover the investments. Aftercare measures currently used in Namibia are detailed in the table below.

The costs presented in this table were calculated based on self-reported financial data from commercial farmers. For manual and chemical applications, a cost per plant treated was calculated and the total costs per ha were estimated based on the number of treated plants. The frequency is applicable to most cases but was initially defined for 5,000 ha farms with an average annual rainfall of 500mm. The annual average cost over 10 years considers the number of repetitions needed over 10 years and the cost per ha of each of these repetitions, assuming slower regrowth after each repetition.

ENVIRONMENTAL IMPACT KEY

LOW MEDIUM HIGH

AFTERCARE PRACTICE	INITIAL DENSITY	EQUIPMENT NEEDED	STAFF NEEDED PER 100HA	FREQUENCY RECOMMENDED	AVERAGE COST P/HA FIRST INTERVENTION	AVERAGE COST P/HA OVER 10 YEARS	CONSIDERATIONS	ENVIRON-MENTAL RISKS
Manual and semi-mechanised	1000 TE/ha -500 trees per ha	Handsaws, pruning shear, protective clothing (N$300 per person), axe (N$500)	1 tree feller/farmworker (~N$3,000 per month for 4 months including transport, food and accommodation)	Every two years	N$39 per ha	N$13 per ha	Labour intensive and selective	
Controlled fire	1000 TE/ha	Fuel/fire setters	2-3 workers (~N$100 per day each for 2-5 days)	Every 3-5 years at the end of the dry season	N$5 per ha Incl. renting land for cattle: N$85 per ha	N$2 per ha Incl. renting land for cattle: N$34	Inexpensive with mixed effectiveness. Not advised for *D. Cinerea* (Sicklebush)	
Foliar chemical	1000 TE/ha - 500 trees per ha	Chemical input (ACCESS/BOWSER, Crop Oil = N$220 per L), container to mix chemicals (N$200 per container, protecting clothing and gear (N$300 per person)	1-2 workers (~N$75 per day per worker for 60 working days including transport, food and accommodation)	Every year for the first 3 years, then about once every 3 years	N$49 per ha	N$11 per ha	Labour intensive and selective	
Chemical on cut stump with foliar application follow ups	750 stumps to cover per ha	Chemical input (ACCESS/BOWSER, Crop Oil = N$220 per L), container to mix chemicals (N$200 per container), protecting clothing and gear (N$300 per person)	Cut stump application: 1-2 workers (~N$72 per day per worker for 60 working days including transport, food and accommodation for first intervention). Follow ups foliar: 1 worker for 20-30 working days	Cut stump application shortly after harvesting, then foliar application 2 years later and follow ups every 3 years.	N$73 per ha (cut stump application)	N$28 per ha	Observed effectiveness but costly first intervention.	
Soil chemical	1000 TE/ha - 500 trees per ha	Chemical input (BUNDU, Crop Oil = N$260 per L), container to mix chemicals (N$200 per container, protecting clothing and gear (N$300 per person), application tools (syringe, 5ltr empty plastic bottle N$250 each)	1 worker (~N$72 per day for 20-30 working days including transport, food and accommodation for first intervention)	Start 2-3 years after harvesting and follow up every 3 years.	N$35 per ha	N$5 per ha	Cost-effective, can affect other plants, risk to economic activity if groundwater is contaminated or traces of chemicals found in meat.	
Biological control (goats)	1000 TE/ha	Goats (N$700-900 per animal)	1 shepherd per 200 goats (N$1,200 per month)	Low intensity: 150 goats per 100 ha High intensity: 300 goats per 100 ha. A few months after harvesting.	Initial cost per ha (buying goats): N$1,150 per ha (low intensity)	Generates income from year 2 (selling and buying) benefits = N$155 per ha every year	Needs to be combined with other aftercare measures to contain regrowth in the long-term.	
Brush packing		N/A	5 workers could cover 5 ha in 40 working days (N$60 per day per worker)	Once right after harvesting	N$2,000 per ha covered	Only one intervention	Effective at promoting grass growth and better soils. Needs to be combined with reseeding and will cover only small areas. Resources already available.	
Reseeding		Seeds (*Cenchrus ciliaris*) 3-5kg per ha N$100/kg	1 worker could cover 125ha in 45 working days (N$60 per day per worker)	Shortly after harvesting – before rainy season	N$420 per ha covered	Only one intervention	Effective for grass regrowth and competition with bush. Seeds should be dispersed shortly after harvesting and close to rainy season.	

AFTERCARE COMPATIBILITY MATRIX

HARVESTING PRACTICE / AFTERCARE PRACTICE	MANUAL AND SEMI-MECHANISED	CONVENTIONAL MEDIUM TO LARGE-SCALE MECHANISED	HIGHLY MECHANISED	CHEMICAL CONTROL	BIOLOGICAL CONTROL	CONTROLLED FIRE
Controlled Fire	↑ Considerable coppicing after mechanical control is best controlled with fire and browsing. A 90% mortality of *Senegalia mellifera* was achieved with mechanical control and fire. ↓ Severe disturbance can distribute the seeds and prepare a seedbed. Some species may be encouraged to germinate (e.g. *Dichrostachys cinerea*) after fire. ➔ Complement with browsers.			↑ After chemical control, there is little biomass to support a fire.	↑ Biological control is the most effective if combined with fire. Fire reduces the canopy height for browsers, who control coppice. ↓ The uniform application of fire and grazing can decrease the spatial heterogeneity and thus species richness.	
Biological Control				↑ Chemicals can contain the infestation, while goats kill the coppice. ↓ Chemicals can be found in animal tissue – adhere to dosage and instructions.		
Manual / Mechanical Control	↑ Regrowth can be mechanically or manually removed and used for different value chains e.g. in bush feed. ↓ Physically removing larger coppiced plants is labour intensive. Many encroacher species must be removed to a depth of at least 20cm below ground. **The use of heavy machinery in post-harvest operations is not recommended due to the high soil disturbance and soil compaction expected.**			Mechanical control can be used after a chemical or mechanical thinning. **The use of heavy machinery in post-harvest operations is not recommended.**		
Chemical	↑ Stems are cut cleanly, which is ideal for stump applied chemicals minimising amount of chemical used with good results.	↓ Depending on the method used, selective treatment with chemicals may be difficult. Seeds are widely distributed.	↑ Stems are cut cleanly, which is ideal for stump applied chemicals minimising amount of chemical used with good results.			
Grazing Management	Continuous overgrazing contributes to bush encroachment. Grazing management impacts regrowth and recruitment of the bush, thus influencing the effectiveness of aftercare. Livestock can remove excess foliage to facilitate other post-harvest treatment measures.	↑ Trampling by livestock can break up hardened soil surfaces encouraging a better infiltration of rain and germination of seeds. ↓ Livestock are effective dispersers of seed and promote germination.		↓ Livestock should not graze in the treated areas to avoid contact with the arboricide. Adhere to product label or restrictions imposed by markets.	↓ Browsers may feed on grasses and palatable fodder bush before controlling encroacher bush. Avoid overgrazing.	↑ Synergies: Animals control the amount of grass creating natural fire breaks. Fuel should only accumulate in areas which are not liked by animals. Fire then improves grazing. ↑ Before fire, livestock should graze in the area to trample under large trees and shrubs to protect them. ↓ The area burnt must be left untouched and allowed to rest.
Reseeding	Effective control must include both top-down and bottom-up control to minimise unwanted regrowth. Reseeding can be used with all harvesting and bush control methods.					
Soil Enhancement	↑ The use of arboricides and heavy machinery for aftercare can limit the restoration of soil fertility. In addition, the harvesting of biomass removes nutrients from the land. To speed up the restoration of soil fertility, minerals removed through the harvesting of bush must be returned.				↑ Soils fertilised with manure are often more biologically active and fertile.	↑ Fire has a positive impact on nutrient cycling and soil fertility. ↓ Be careful of very hot or too frequent fires, which can have a negative impact on soils.

SPECIALISED EQUIPMENT REQUIREMENTS

The harsh Namibian conditions require special equipment and a close monitoring of its wear and tear.

Tyres

The high wear on tyres of in-field equipment should not be underestimated. Developing access roads is critical to ensure that frequently travelled routes are free of sharp stumps and rocks. For equipment that needs to travel off-road, there are a number of options:

- **Steel tracks:** Avoid tyres completely by using equipment on tracks. Tracks are robust and spread the weight of the equipment over a greater surface area, leading to less severe soil disturbance. The disadvantage of tracks is that they are slow moving.
- **Foamed tyres:** Foaming regular tyres with a specialised foam compound significantly extends the life span of tyres. Equipment can continue to operate with large punctures. Disadvantages of foam are the high upfront cost and the additional weight to the tyres.
- **Chained tyres:** Chaining regular tyres is another way to extend the life span of tyres, preventing most punctures without adding too much weight for driving at higher speeds. The disadvantage of chains is that they do not eliminate all risk of smaller punctures, and they should be used in conjunction with other puncture prevention products.
- **Solid tyres:** Solid rubber tyres are very robust and have a long life in-field. The disadvantage of solid wheels is that they are heavy and rigid, suited for slow speeds only.
- **Forestry tyres:** Specialised tyres for traditional forestry applications are higher ply tyres which are more resistant and allow for higher speeds. The disadvantage of forestry tyres is that they are more costly than regular tyres and still susceptible to punctures. They are also more difficult to repair.
- **Puncture prevention products:** There are a number of puncture prevention products in liquid, gel or slime forms that are applied to tyres to self-repair smaller punctures. The disadvantages are that these products are not able to repair or prevent larger punctures.

Abrasiveness

Namibian encroacher species are classified as hard woods with a bulk density of around 0.7 g/cm3. The bush typically also has a high mineral content within the wood and bark. These characteristics make the wood very abrasive and increase wear and tear of harvesting and processing equipment.

Some considerations include:

- Frequent sharpening and maintenance of fast-moving blades (chainsaws, circular saws, etc.).
- Use of hardened steel for cutting edges.
- Avoiding sand contamination as far as possible.

Dust

Dust combined with high ambient temperatures increases the risk of equipment overheating. Dust build-up on radiators - restricting airflow - and high ambient temperatures (>40 °C) can cause equipment to easily overheat, increasing fuel consumption and risk of failure. Failure can also lead to fires, which cause damage to the equipment, put operators at risk of injury and risk uncontrolled veld fires. Dust can also enter into fuel or oil tanks, blocking fuel filters and building up internally.

Operators need to be protected against dust. Dust masks and protective goggles should be worn by all operators at risk of continued dust exposure.

Some considerations include:

- Frequent cleaning of equipment. It is advisable to have an air compressor on site to clean radiators and other intake areas.
- Keeping spares on site (e.g. air filters, fuel filters, etc.).
- Having firefighting equipment in-field at all times.
- Training operators on routine maintenance and firefighting.
- Providing operators with suitable personal protective equipment.

> “The harsh Namibian conditions require special equipment and a close monitoring of its wear and tear.

RECOMMENDATIONS

The biomass market is expected to grow both domestically and internationally over the next decade. As a result, the demand for biomass harvesting will increase. This will provide considerable incentives to rehabilitate bush encroached and degraded landscapes in Namibia. To ensure that biomass harvesting is responsible and profitable, biomass producers should pay attention to the following recommendations:

Start with a bankable business plan. The business plan should consist of:

- A bush control plan considering the causes of bush encroachment, a clear vision for the landscape after bush harvesting, preparatory and aftercare measures, as well as potential follow-up harvesting.
- A detailed equipment selection plan, considering suitability for the local conditions and environmental impact. Key environmental considerations include the selectivity of the equipment and potential soil disturbance.
- A long-term biofuel off-take agreement from a reputable buyer/user. Ensure full understanding of the specifications, terms and conditions.
- A comprehensive breakeven analysis considering the harsh Namibian conditions, fuel consumption, wear on cutters and tyres as well as training.
- A guaranteed biomass supply base for the duration of the contract period.
- A full understanding of the value chain and its risks from start to end.
- Site inspections of harvesting sites and equipment suppliers to familiarise yourself with the industry and all the complexities of the supply chain.
- Consideration of outsourcing capital-intensive components (e.g. mechanised harvesting and long-distance transport).

Before starting bush harvesting it is also important to consider the following:

- Check the local technical back-up levels on spares, in-house knowledge and experience with special attention to the chipping / grinding operations.
- Do not underestimate the abrasiveness (mainly caused by imbedded silica) and difficulties of handling the Namibian bush as well as the high volumes of low bulk density chipped material.
- Compile a formal Request for Proposals including throughput figures, technical and back-up specifications, general and specific conditions of contract and invite a minimum of three suppliers per key harvesting component for tender.

> The biomass market is expected to grow both domestically and internationally over the next decade.

SERVICE PROVIDERS AND EQUIPMENT SUPPLIERS

Investing in one's own highly mechanised harvesting systems is not feasible for everyone, as it is extremely capital intensive and requires the owner to keep said equipment busy over a given payback period to justify such an investment.

From a land owner's or biomass processor's perspective, most would not be able to justify owning such highly mechanised equipment, as they would only require such equipment for limited periods of time or limited number of hectares. As such, renting such equipment would be much more favourable. Processors benefit from the speed and efficiency of highly mechanised systems, while not burdening themselves with the downsides, such as the high capital investment, maintenance and management of such operations.

The benefit to the service provider is that they can keep their equipment busy by serving a broader market, varying in project size or desired outcome, allowing these service providers sufficient return on investment.

Companies and organisations in Namibia have realised this gap within the market:

Namibia Biomass Industry Group lease their mini-excavator systems, including fuel and skilled operators, on an hourly rental basis, at specified rates per hour for bush harvesting and compiling the bush into windrows. The productivity ranges from 1.5 to 2 hectares per day for harvesting and windrowing.

For more information, visit www.n-big.org

Ombengu Energy lease their Bushroller systems, including fuel and skilled operators, at specified rates per hectare for either bush rolling or both bush rolling and raking the bush together into heaps. The productivity is 2 hectares per hour for bush rolling.

For more information, visit www.ombengu-bushroller.com

SERVICE PROVIDERS AND EQUIPMENT SUPPLIERS*

Harvesting

PRODUCT & SUPPLIER	PRICE
Bosvreter/Trolly saw 6.5 / 7HP / 9HP Piet Simpson Bosvreter Dwaalboom RSA Cell: +27 82 574 3792 piet@bosvreter.co.za www.bosvreter.co.za	*N$ 16 362 – 24 000*
Husqvarna T435 Chainsaw 14"3/8" H36 / Husqvarna 545FX brush cutter Turner Morris 4 Einstein Road, Southern Industrial, Windhoek Tel: +264 61 274 744 • +264 81 378 0352 www.turnermorris.co.za/products	*N$ 6541.54 - 9874.21*
Bush cutter 400MM blade 13Hp Turner Morris 4 Einstein Road, Southern Industrial, Windhoek Tel: +264 61 274 744 • +264 81 378 0352 www.turnermorris.co.za/products	*N$ 32 457.35*
STIHL Chainsaw Windhoek city centre/ Head office and Warehouse Tel: +264 61 295 7000 • +264 61 295 6000 info@cymot.com www.cymot.com	*N$ 7935*
Vertical bush cutter / Horizontal bush cutter Inventec Agricultural & Industrial Designs 16 West Street, Otjiwarongo, Namibia Tel: +264 67 307 489 • +264 81 124 1916 • +264 81 323 9560 info@inventecnam.com www.inventecnam.com	
Bush Roller Ombengu Energy Windhoek Cell: +264 81 148 5095 • +264 81 148 5141 stefan@ombengu.com • daniela@ombengo.com www.ombengu-bushroller.com	

**Prices must be verified with the respective service providers and equipment suppliers.*

PRODUCT & SUPPLIER	PRICE
Hydraulic Equipment Manufacturer & Suppliers, Bulldozing and Ground Clearing Pretorius Plant Hire Trust Etienne Rosseau Street Northern Industrial Area, Windhoek, Namibia Tel: +264 261 327 • 081 129 7060 nico@pretoriusplanthire.com Burger Equipment and Spares Okahandja Tel: +264 62 500 370 manager@burgersafrica.com www.burgersafrica.com	
8 Hydraulic tree felling shears and Clamping devices, Heavy duty hydraulic tree lifter WoodCo/Transworld Cargo Heiko Meyer Windhoek Tel: +264 81 200 0000 hrm@iway.na	
Turbo saw SB300 with hydraulic oil cooler FL&A Burger Equipment and Spares Otjiwarongo Tel: 264 67 307 478 manager.otji@burgersafrica.com www.burgersafrica.com	
Three-wheel loader Agra Hardware outlets Windhoek Tel: +264 61 290 9208 www.agra.com.na	
Woodline Trevi Benne felling tools. Hydraulic tree felling sheers **TreeCycle (Pty) LTD** Langebaan, Western Cape, South Africa Tel: +27 22 772 0307 • +27 82 338 8951 shaughn@treecycle.co.za www.treecycle.co.za	

Chipping

PRODUCT & SUPPLIER	PRICE
Mobile chipper Plaas Toerusting Namibia Suiderhof, Windhoek Cell: +264 81 220 5337 mariouweyer@gmail.com	*N$ 20 000*
Chipper on Trailer Plaas Toerusting Namibia Suiderhof Windhoek Cell: +264 81 220 5337 mariouweyer@gmail.com	*N$ 63 000*
M80 6.5HP Pro Wood Chipper Turner Morris 4 Einstein Road, Southern Industrial, Windhoek Tel: +264 61 274 744 • +264 81 378 0352 www.turnermorris.co.za/products	*N$ 22 545*
Grizely Chipper 13HP Turner Morris 4 Einstein Road, Southern Industrial, Windhoek Tel: +264 61274 744 • +264 81 378 0352 www.turnermorris.co.za/products	*N$ 52 000*
M100 15HP Pro Wood Chipper Turner Morris 4 Einstein Road, Southern Industrial, Windhoek Tel: +264 61 274 744 • +264 81 378 0352 www.turnermorris.co.za/products	*N$ 39 339.13*
Wood chipper Grizely 75 / 250 ABC Hansen Namibia 218 Propshaft Rd, Samcor Park, Pretoria, 0105, South Africa Tel: +27 12 803 0036 sales@abchansen.co.za www.acbhansen.co.za	*N$ 40 000 – 202 000*
Kalahari / Namib / Sahara Chippers Thor Industries Nickel street, Prosperita, Windhoek Cell: +264 81 311 8663	*N$ 36 000 / 80 000 / 110 000*

PRODUCT & SUPPLIER	PRICE
TOMCAT model 125 AFP Chippers 13, 20, 25-40, 60-80 HP **TOMCAT Model AFE 20, 35, 65** John Deere Agri Implements cc (T/A Hoffman's farm implements) PO BOX 60 Otjiwarongo	*N$ 180 000 – 432 000* *N$ 212 000 – 530 000*

Combined Chipper-Mills

PRODUCT & SUPPLIER	PRICE
Oubaas Bokos Mill **Klein Baas** The Farm Yard Trading cc 210 Rensburger Street, Lafrenz Ind., Windhoek Tel: +264 61 245 320 • thefarmyard@iway.na	*N$ 155 000* *N$ 138 000*
JF 2D Chipper Hammer Mill **JF 10D Chipper Hammer Mill** **JF 10D Chipper Hammer Mill** Hochland Tractors Pelican Street, Hochlandpark Windhoek Tel: +264 61 229 655 sales@hochlandtractors.com • www.hochlandtractors.com	*N$ 19 500* *N$ 49 500* *N$ 85 000*
Model 225 trailer mount double blade, 31 HP **Model 225 trailer mount double blade, 35 HP** **25 Double blade** Mfangano 9 6th street, Wynberg, 2090 Johannesberg, South Africa Tel: +27 086 199 9984 • Cell: +27 82 747 1920 sales@mfangano.co.za • www.mfangano.co.za	*N$ 130 909* *N$ 142 500* *N$ 70 875*
Hammermill Chipper Renov Namibia Auas Valley Windhoek Tel: +264 61 300 687 • +264 6125 5977 • renov@iway.na	*N$ 32 556*
225 Mk2 Gravity Chipper + Grinder **225 Hydraulic Feed Chipper + Grinder** **225 Mk2 Gravity Chipper + Grinder Trailer Mounted** **225 Hydraulic Chipper + Grinder** Ritlee Unit A07 Grander Place, Grander Road Spartan, Kempton Park Gauteng Tel: +27 114 523 434 • marc@ritlee.co.za • www.ritlee.co.za	*N$ 120 000* *N$ 280 000* *N$ 210 000* *N$ 420 000*

Hammer Mills

PRODUCT & SUPPLIER	PRICE
S-TRF 300GP Fodder Chrusher (hammermill 5Hp) **S-TRF 600GX Hammer mill 13Hp** **S-TRF 800GX Fodder Chrusher (hammermill) 13Hp** Turner Morris 4 Einstein Road, Southern Industrial, Windhoek Tel: +264 61 274 744 • +264 81 378 0352 www.turnermorris.co.za/products	*N$ 12 500* *N$ 24 782.61* *N$ 28 222.22*
Rumax BD90 PTO+A74:G79 Hammer Mill **BD32 Hammer Mill Diesel** **BD55C 7.5 KW Hammer Mill** **BD55 22KW Hammer Mill** **BD90 30KW Hammer Mill** **BD90 PTO Hammer Mill** BJP Supplies 1 Samuel Walter Street, Worcester 6850 Tel: +27 023 342 6070 • jaco@rumax.co.za • www.rumax.co.za	*N$ 18 000* *N$ 47 000* *N$ 47 000* *N$ 60 000* *N$ 81 000* *N$ 87 000*

Milling & Mixing

PRODUCT & SUPPLIER	PRICE
Bos tot Kos Piet Simpson Bosvreter Dwaalboom RSA Cell: +27 82 574 3792 • piet@bosvreter.co.za • www.bosvreter.co.za	*N$ 499 001*

Mixers

PRODUCT & SUPPLIER	PRICE
0.5T Consentrate mixer **1T Consentrate mixer** **2T Consentrate mixer** Turner Morris 4 Einstein Road, Southern Industrial, Windhoek Tel: +264 61 274 744 • +264 81 378 0352 www.turnermorris.co.za/products	*N$ 127 600* *N$ 149 350* *N$ 171 100*

Pelletisers

PRODUCT & SUPPLIER	PRICE
Pellet Mill 200 **Pellet Mill 280** ABC Hansen Namibia 216 Propshaft Rd, Samcor Park, Pretoria, 0105, South Africa Tel: +27 12 803 0036 sales@abchansen.co.za www.acbhansen.co.za	*N$ 35 000* *N$ 55 000*
Flat die pelletiser SKJ200 7.5Kw size 2-8mm (200-300 kg/h) **Flat die pelletiser SKJ200 11Kw size 2-8mm (300-500 kg/h)** Turner Morris 4 Einstein Road, Southern Industrial, Windhoek Tel: +264 61 274 744 • +264 81 378 0352 www.turnermorris.co.za/products	*N$ 56 669.32* *N$ 79 750*
Drostky T1 machine **Drostky S4 machine** **Drostky S8 machine** **Drostky M8 machine** **Drostky M16 machine** **Drostky M16 machine** Rumax BJP Supplies 1 Samuel Walter Street, Worcester 6850 Tel: +264 023 342 6070 jaco@rumax.co.za • www.rumax.co.za	*N$ 18 000* *N$ 30 000* *N$ 44 500* *N$ 60 300* *N$ 92 000* *N$ 80 000*
Pelleting Machine The Farm Yard Trading cc 210 Rensburger Street, Lafrenz Ind., Windhoek Tel: +264 61 245 320 • thefarmyard@iway.na	
Animal Feed pelletiser machine Agri con, Martiens de Jager P.O.Box 28212, Danhof 9310 South Africa Tel: +27 718 773 324 • martiens@agriconsra.com Agri feed systems P.O.Box 735, Cradock 5880, South Africa Tel: +27 82 652 4930 • info@agrifeedsystem.coza Jones Masjiene P.O.Box 352, Koster 0348, South Africa Tel: +27 82 971 6529 • design@jonesm.co.za	

Wood Slicing

PRODUCT & SUPPLIER	PRICE
Houtsaag/Stationary table saw Piet Simpson Bosvreter Dwaalboom RSA Cell: +27 82 574 3792 piet@bosvreter.co.za • www.bosvreter.co.za	*± N$ 20 000*
Wood saw / Dropper saw Inventec Agricultural &Industrial Designs 16 West Street Otjiwarongo Namibia Tel: +264 67 307 489 • +264 81 124 1916 • +264 81 323 9560 info@inventecnam.com • www.inventecnam.com	

Kilns / Retorts

PRODUCT & SUPPLIER	PRICE
Kilns Cowboys Trading and Rental Solutions 13 Hidipo Hamutenya, Swakopmund Tel: +264 64 418 150 info@cowboys.com.na • www.cowboys.com.na	*N$ 2000*
Retorts Ideal-X Klein Windhoek T: +264 61 242 086 • C:+264 81 149 1086 dagmar@ideal-x.com.na • www.ideal-x.com.na	
Charcoal Pots Inventec Agricultural &Industrial designs Johan Theron 16 West Street, Otjiwarongo, Namibia T: +264 67 307 489 info@inventecnam.com • www.inventecnam.com	
Briquette Press Flo-Scan Technologies cc 33 Main Street, Villiers, Free State, South Africa Tel: +27 79 912 2528 • +2758 821 0153 info@floscan.co.za • www.floscan.co.za	*N$ 135 000*

Industrial Wood Chips

PRODUCT & SUPPLIER	PRICE
TOMCAT Model 200 AFE 50Hp Chipper **TOMCAT Model 250 AFE 65Hp Chipper** **TOMCAT Model 375 AFE 125Hp Chipper** John Deere Agri Implementscc (T/A Hoffman's farm implements) PO BOX 60 Otjiwarongo Tel: +264 067 302 738 daan.johndeere@gmail.com • tevrede@africa.com.na	*N$ 498 000* *N$ 592 000* *N$ 898 000*
Laitilan Chippers Laitilan Metalli Laine Oy, Garpintie 130 23800 Laitila www.laimet.com Tel: +358 (0) 2856014 laitilan.metalli@laimet.com • www.eusaeko.de	
Pezzolato Chippers Otjiwarongo Motors & Tractors Massey Ferguson & Mr.Thorsten Kopp Otjiwarongo, Namibia Tel: +264 67 303 041 massey@mweb.com.na • www.tractors-namibia.com	
Bandit Chippers Burgers Okahandja Tel: +264 62 500370 • manager@burgersafrica.com Otjiwarongo Tel: +264 67 307478 • manager.otji@burgersafrica.com Swakopmund Tel: +264 64 462084 • swakop@burgersafrica.com Walvis bay Tel: +264 64 205 378 • walvis001@burgersafrica.com www.burgersafrica.com ABC Bandit Chippers Mr Willem van der Merwe 2 - 4 Joubert Street, Worcester, 6850, Western Cape, South Africa T: +27 23 342 1212 hugo@banditchippers.co.za • info@abcbanditchippers.co.za www.banditchippers.co.za	

FURTHER RESOURCES

1st Edition of this Brochure: De Wet, M.J. (2015). *Compendium of harvesting technologies for encroacher bush in Namibia". DAS Brochure on Harvesting Namibian Encroacher Bush. www.n-big.org/advisory-services*

Boys, J.M. & Smit, G.N. (2020). *Development of an Excel Based Bush Biomass Quantification Tool. Final Report to the GIZ Bush Control and Biomass Utilisation Project.*

Bush Information System – A modern decision support tool to tackle bush encroachment in Namibia. (2023). *Ministry of Environment, Forestry and Tourism/Namibia Statistics Agency.*

Cunningham, P. & Detering, F. (2017). *Determining age, growth rate and regrowth for a few tree species causing bush thickening in north-central Namibia. Namibian Journal of Environment 1 A: 72-76.*

DAS. Encroacher Bush Species of Namibia. *www.n-big.org/advisory-services*

De-bushing Advisory Service (2017). *Bush Control Manual. www.n-big.org/advisory-services*

De Klerk, J.N. (2004). *Bush Encroachment in Namibia, Report on Phase 1 of the Bush Encroachment Research, Monitoring and Management Project, Ministry of Environment and Tourism, Windhoek, http://www.the-eis.com/data/literature/Bush%20Encoachment%20in%20Namibia_deKlerk2004_1.pdf*

Forest Stewardship Council FSC (2020). *The FSC National Forest Stewardship Standard for the Republic of Namibia. https://connect.fsc.org/document-centre/documents/resource/418*

Honsbein, D. & Njembo, S. (2020). *Labour-Based Encroacher Bush Harvesting Guidelines. www.n-big.org/advisory-services*

Joubert, D. & Zimmermann, I. (2017). *Decision support system on how to control bush thickening by Acacia Mellifera in Namibian savanna rangelands. www.n-big.org/advisory-services*

MAWF & MET (2017). *Forestry and Environmental Authorisations Process for Bush Harvesting Projects. based on the study "Strategic Environmental Assessment of large-scale bush thinning and value-adding activities in Namibia" (2016), compiled by the Southern African Institute for Environmental Assessment (SAIEA) with funding by MAWF/GIZ Support to De-bushing Project.*

Ministry of Environment, Forestry and Tourism. (2022). *National Strategy on the Sustainable Management of Bush Resources 2022-2027. www.n-big.org/advisory-services*

Namibia Nature Foundation (2016). *An assessment of the economics of land degradation related to bush encroachment in Namibia. Commissioned by the Support to De-bushing Project implemented by Deutsche Gesellschaft für international Zusammenarbeit (GIZ). www.n-big.org/advisory-services*

Nott, C., Boys, J.M. & Nzehengwa, J. (2019). *Reviving Namibia's Livestock Industry - Regenerative Livestock Production – Trends, Key Profit Drivers, Case Studies & Recommendations. Based on Namibia Rangeland Management Policy (NRMP): A 2019 Edition. http://www.agrinamibia.com.na/wp-content/uploads/2019/10/NRMPS-Revised-Strategy-2019-Rangeland-Best-Practices-final.pdf*

Perche, J. & Stoldt, M. (2020). *Finance Mechanism Review to Fund Post-Harvest Treatment Measures. Commissioned by the MEFT / GIZ BMCC II Project*

Perche, J., Van der Waal, C. & Boys, J. (2020). *Aftercare Cost-benefit Analysis. Commissioned by the MEFT / GIZ BMCC II Project. https://www.n-big.org/advisory-services?wpfb_dl=117*

SAIEA (2016). *Strategic Environmental Assessment of large-scale bush thinning and value addition activities in Namibia. Commissioned by the Support to De-bushing Project implemented by GIZ. www.n-big.org/advisory-services*

Smit, G.M., Schneider, M.B. & Van Eck, J. (2015). *Detailed assessment of the biomass resource and potential yield in a selected bush encroached area of Namibia. DAS Brochure Quantifying Harvestable Encroacher Bush. . Commissioned by the Support to De-bushing Project implemented by GIZ. www.n-big.org/advisory-services*

Stoldt, M. & Perche, J. (2020). *State of Knowledge on Post-Harvest Treatments. Commissioned by the MEFT / GIZ BMCC II Project.*

Trede, R. & Patt, R. (2015). *Value Added End-Use Opportunities for Namibian Encroacher Bush. DAS Brochure Adding Value to Namibian Encroacher Bush. www.n-big.org/advisory-services*

Van der Waal, C. & Stoldt, M. (2020). *Environmental Assessment of Post-Harvest Treatment Measures. Commissioned by the MEFT / GIZ BMCC II Project. https://www.n-big.org/advisory-services?wpfb_dl=116*

IMPRINT

Commissioned by: Namibia Biomass Industry Group

With funding by: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH Bush Control and Biomass Utilisation Project

First published: 2015

Authors: M.J. de Wet Pr. Eng.
NRGen Advisors, Stellenbosch, South Africa
in association with
WML CONSULTING ENGINEERS (PTY) LTD, Windhoek, Namibia

Updated: 2023

Authors: Colin Lindeque, Mirja Stoldt & Juliette Perche

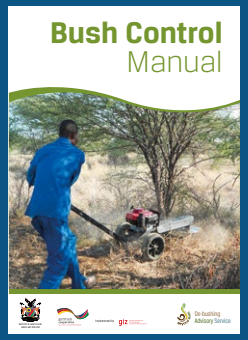
Photos:
Cover Colin Lindeque
p.4 Left: GIZ/Tim Brunauer, Right: GIZ/Johannes Laufs
p.6 C. Mannheimer, B. Curtis, K. & S. Roberts and P. Horn
p.7 Top and centre: GIZ/Tim Brunauer, Bottom: GIZ/Johannes Laufs
p.8 Nico Smit
p.9 Left: GIZ/Johannes Laufs, Right: GIZ/Tim Brunauer
p.19 Caroline von Zimmermann
p.20 GIZ/Tim Brunauer
p.21 GIZ/Frank Gschwender
p.25 Colin Lindeque
p.29 Colin Lindeque
p.36 GIZ/Tim Brunauer
p.41 TreeCycle, Langebaan

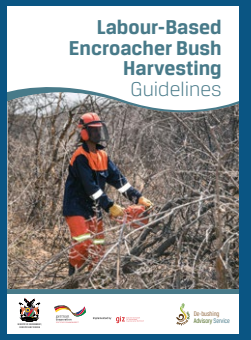
Design & Layout: Edith Wasserfall

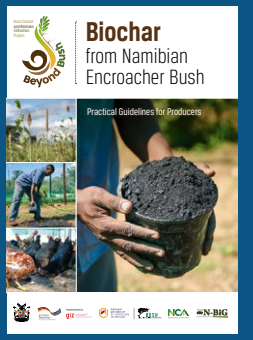
Print: John Meinert Printing

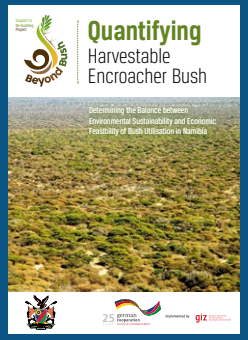
We thank the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH Bush Control and Biomass Utilisation Project – a bilateral cooperation between the Namibian Ministry of Environment, Forestry and Tourism (MEFT) and the German Federal Ministry for Economic Cooperation and Development (BMZ) – for their support in publishing this brochure.

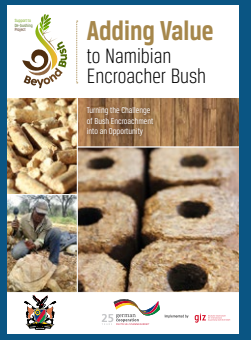
Visit **www.n-big.org/advisory-services** for key sources on bush control and biomass utilisation.

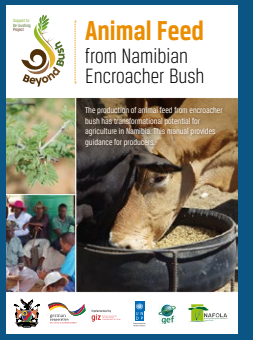


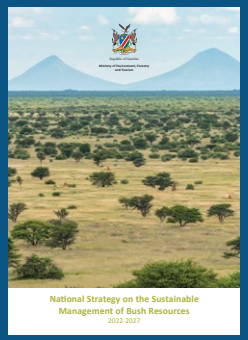


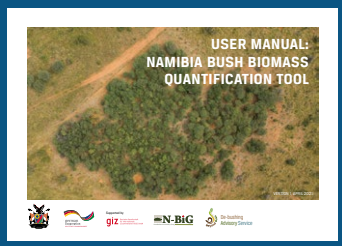












Bush encroachment in Namibia considerably impacts biodiversity, soils, water availability and livelihoods of people. The biomass market is expected to grow both domestically and internationally over the next decade. The increasing demand for biomass can provide considerable incentives to rehabilitate bush encroached and degraded landscapes in Namibia.

This brochure explores practical methods for encroacher bush harvesting, processing and aftercare to ensure cost-effective and sustainable bush-biomass value chains.