Support to
De-bushing
Project

Beyond Bush

Harvesting Namibian Encroacher Bush

Compendium of Harvesting Technologies for Encroacher Bush in Namibia

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25 YEARS german cooperation
DEUTSCHE ZUSAMMENARBEIT

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

Introducing the **Support to De-Bushing** Project

Namibia is affected by bush encroachment on a massive scale. The phenomenon currently affects some 26 to 30 million hectares of farmland in 9 of the country's 14 regions. That amounts to roughly 30 per cent of Namibia's land area. Bush encroachment has lowered the livestock capacity of rangeland by up to two thirds. It further results in severely reduced biodiversity and limits the recharge of groundwater.

Despite the negative impacts, **the encroacher bush has developed into a huge biomass resource,** estimated at about 200 to 300 million tonnes. Measures used to combat bush encroachment create positive opportunities for the Namibian economy, such as the use of the resource for electricity generation and value chain development in other sectors. De-bushing therefore offers the potential to increase agricultural productivity, economic growth, employment and energy security, without competing with food production.

In line with the Fourth National Development Plan (NDP4) and the National Rangeland Management Policy and Strategy of 2012, **the Support to De-bushing Project** aims to strengthen the restoration of productive rangeland in Namibia. It identifies value chain opportunities to trigger large-scale de-bushing activities. Its focus is closely aligned to the National Industrial Policy of 2012 and the Growth at Home Strategy, which promote domestic value addition for local resources. The project will foster institutional development in the biomass sector and provide support to improve the legal and regulatory framework for large-scale bush control.

The Support to De-bushing Project runs from 2014 until 2017 and is a bilateral cooperation between the **Namibian Ministry of Agriculture, Water and Forestry (MAWF)** and the **German Federal Ministry for Economic Cooperation and Development (BMZ).** It is implemented by the **Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH**.

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WHAT IS THIS BROCHURE ABOUT?

This brochure presents and compares **methods of encroacher bush harvesting**. It is based on the study "Compendium of harvesting technologies for encroacher bush in Namibia" (2015) by M.J. de Wet.

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Encroacher Bush Species

Bush encroachment is severely hampering the red meat industry of Namibia and is negatively affecting biodiversity and the recharging tempos of certain aquifers. At the same time, there is a considerable market demand for biomass in the world.

The removal of encroacher bush from Namibian rangelands would not only be regarded as an attempt to restore the savannah and its biodiversity, it would also be advantageous to the subsurface water resources of affected areas. Methods to economically harvest this biomass need to be showcased and documented. Researchers suggest that bush species and savannah type should be studied first before they are cleared. Sickle-bush (Dichrostachys cinerea), for example, should not be slashed because that would stimulate further growth and thickening. It would therefore be best for each de-bushing operator to seek expert advice prior to implementing a de-bushing programme.

A de-bushing programme will consist of the following components:

- Survey the area and determine the best (most appropriate and economical) method of de-bushing with a clear understanding of the impact on the environment.
- Determine the best post-harvest value adding application as a method to cover or reduce the cost.
- Determine the best aftercare method to prevent regrowth.

This brochure will supply the reader with practical methods of harvesting encroacher bush and converting bush into biomass chips – currently the fastest growing biomass product in Namibia.

ENCROACHER BUSH SPECIES

RANKING	SCIENTIFIC NAME	POPULAR ENGLISH NAME	AFRIKAANS NAME	EXTEND [%]
1.	**Acacia mellifera**	Black-thorn Acacia	Swarthaak/Hakkiesbos	45%
2.	**Colophospermum mopane**	Mopane	Baster Mopane	20%
3.	**Dichrostachys cinerea**	Sickle-bush	Sekelbos/Papierwiel	14%
4.	**Acacia reficiens**	Red-thorn	Rooihaak	9%
5.	**Terminalia sericea**	Silver Cluster-leaf	Vaalbos/Geelhout	8%
6.	**Terminalia prunioides**	Purple-pot Terminalia	Deurmekaarbos	4%

Market Overview

Currently, only few industrial-scale uses of encroacher biomass are developed in Namibia. However, an increase in demand can be expected in various sectors.

CURRENT AND FUTURE BIOMASS USERS IN NAMIBIA

ITEM	APPLICATION	CURRENT ESTIMATED SIZE OF THE INDUSTRY [T.P.A.]	FUTURE (2025) ESTIMATED SIZE OF THE INDUSTRY [T.P.A]	PREFERRED FORMAT OF BIOMASS IN-FEED
1.	**Firewood for heating & cooking**	600,000 – 1,000,000	800,000 – 1,200,000	Logs (dry and fumigated for exports)
2.	**Charcoal industry (Lumpy charcoal as final product)**	85,000 to 100,000	400,000[1]	Dry logs
3.	**Charcoal industry (Briquettes)**	± 10,000	± 150,000	Charcoal fines and Biochar (small pieces of char)
4.	**Cement industry**	>70,000	>120,000	Chipped/grinded
5.	**Wood fired boilers for agri-industrial, thermal & power generating purposes[2]**	>7,000	>300,000	Chipped/grinded[3]
6.	**Torrified wood coal**	unknown	unknown	Chipped/grinded
7.	**Poles and building material**	>4,000	>5,000	poles/logs
8.	**As animal feed supplement**	>3,000	>6,000	Growth points chipped
9.	**Biochar, compost & related**	>1,000	>10,000	Chipped & fines
10.	**Activated carbon from biomass**	Nil	>30,000	Biochar and small pieces of char

1 A recent study finds that charcoal production can be upscaled by a factor of four, if production is modernised (DECOSA, 2015)

2 Industrial biomass energy applications (wood fired boilers generating high pressure steam for agri-industrial and power generating use) show the largest anticipated growth.

3 Most of the biomass applications prefer woody biomass in "chipped" or grinded format.

Grinded biomass and chips – the fastest growing biomass products in Namibia.

Categories of Harvesting Methods

Current de-bushing and tree felling methods used in Namibia can be divided into six groups and vary in their degree of mechanisation.

1 Manual & semi-mechanised

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

- Axe, panga, pruning and pruning shears, hand saws
- Trolley with power driven saw type cutters or bit type circular cutters
- Tractor drawn slasher (PTO driven)
- Multi-circular saw PTO driven (Limited application)
- Hand held chain saws (Limited application, mainly because of the bush shape and high abrasive de-bushing conditions in Namibia)

2 Conventional medium to large scale mechanised operations

Large scale mechanised equipment mainly employed for quick de-bushing, without harvesting the biomass:

- Bush roller mounted on frontend loader (Also used as aftercare)
- Mulching machines mounted to excavators, wheel or track driven
- Bulldozer/grader/tractor with blade (High risk of soil disturbance, but is often used because of its quick and visible results)
- Chain between two tractors or dozers

Horizontal saw tree feller (Courtesy Inventec, Otjiwarongo)

Mechanised bush harvesting operation (Courtesy WoodCo, Okahandja)

Browsers feed on bushes and thereby contribute to natural bush control

3 Chemical

Root, foliar and stem-absorbent herbicides and glyphosates, without harvesting the biomass:

- Chemical spraying by hand pump
- Chemical granules applied by hand
- Chemical aerial spraying by aircraft
- Chemical granules drop by aircraft

It is generally felt that the above chemical methods would be gladly phased out by farmers if a better alternative can be found. Harvested biomass has a market value which could cover the harvesting costs and which could restore grazing areas in a more sustainable way than chemical methods.

4 Biological control

A biological de-bushing method, without harvesting the biomass:

- Use of browser
- Browser interaction with fire
- Fungi-related natural die-off
- Natural enemies
- Bacterial applications to accelerate the rotting process of felled biomass, tree stumps and root systems (Requiring a humid climate and generally more than one application)

5 Highly mechanised

A highly mechanised method of bush clearing/ thinning with the primary aim to harvest the biomass:

- Skidsteer harvester equipped with horizontal rotary cutter or circular sawblade
- Three wheel loader equipment with buncher and hydraulic cutter
- Hydraulic grab and or buncher with blade cutter
- Hydraulic grab and tree puller/bush lifter (for soft, wet sandy soils and riverbed clearing)
- Bush combined harvester and grinder plant on tracks with shuttle bucket

6 Other methods

A fire orientated method of bush clearing, without harvesting the biomass:

- Flame throwers
- Controlled veld fires
- Fire-herbivory interaction

The Harvesting Process

A Train of Tools: Wood chips will most likely become the most popular form in which biomass will be traded in future in Namibia. The focus is therefore on harvesting methods and equipment which cut and clear the encroacher bush areas and chip or grind the bush into an easy to transport marketable product. For this harvesting process a "train" of tools and equipment is required.

1. Bush and tree felling tools and equipment

Trees/bush can be cut or felled using a host of apparatus. The bush-pick is widely used in Namibia for labour based manual tree felling operations. Mechanised tree felling can start with a small trolley equipped with a belt-driven circular saw, moving up to a large excavator equipped with a grab or buncher and hydraulic cutter/shearer with the ability to fell trees at a tempo of up to four hectares of medium density (± 15 t/ha wet) acacia mellifera in an eight hour shift.

Hydraulic grab and cutter fitted to an excavator (Courtesy WoodCo, Okahandja)

2. Stacking in windrows to dry

To dry, cut trees should ideally be stacked on top of one another in an orderly fashion and with the least amount of ground and soil contamination. The dry climate of Namibia is ideal for drying out the felled trees and bushes to moisture contents as low as 14 per cent H20. It is furthermore believed that certain tree species – the acacia mellifera in particular – are crushed and grinded better (using less energy and causing less blockages through a horizontal infeed drum grinder) when dry. Dry and harder wood species are often easier crushed or grinded by means of an impact action (like an impact mill drum grinder with horizontal and controlled infeed) or in some cases, by a tub grinder with top loading gravity in-feed.

Stacking encroacher bush in windrows to dry

Process of feeding biomass into the chipper/grinder (WoodCo)

Close-up of Large grinder infeed channel (Courtesy TriCycle, Langebaan)

3. Feeding the chipping / grinding operation

The logs and branches are fed into the chipper/grinder manually or mechanically. A machine similar to the Bell three wheel logger is often used for this purpose. Smaller chippers are generally fed by hand, but by the time production of chips starts to exceed 20 to 30 m^3 per shift, mechanical feeders are required. A mechanical feeder grabs the trees from the stacked windrows with a hydraulically operated buncher or grab and feeds the bush, stumps first, onto the walking floor of the grinder and into the infeed roller(s).

Large grinder infeed channel (Courtesy TriCycle, Langebaan)

4. The chipping / grinding operation

This is the most difficult and costly part of the infield operations and is often the part where most of the down time occurs. The selection of the chipper or grinder is critical and must suit the throughput requirements and the type of tree/bush to be harvested. Small gravity feed wet wood chippers are generally fed by hand and the wood is cut with blades bolted to a high inertia drum which also acts as a flywheel and pneumatic blower to blow the chips out and into a correctly positioned container.

Larger feeders are generally equipped with a horizontal infeed system with hydraulically operated reversible rollers to control the infeed tempo to the grinder. The final product can be blown out. On the larger machines an out-loading conveyor is installed.

A heavy duty screen forms part of the drum mechanism of a chipper/grinder to allow the grinding operation to continue until the wood fibres have reduced sufficiently to pass through the drum screen.

Shuttle trailers (Courtesy WP Chippers, Worcester)

2 × 110 m³ biomass transport trucks at Ohorongo Cement

5. Shuttling

Once chipped, the woody load needs to be shuttled from the chipping operation to the point of transfer. Wood chips have a bulk density of between 240 to 300 kg/m³ and therefore need large trailer type containers. It's generally found more advantageous to do infield chipping and shuttle the chips, than to cart logs and trees out to a central chipping station.

WET CHIPPING VERSUS DRY GRINDING

Some operations do wet chipping of bush at the point of harvesting and then transfer the wet chips to a central point where the chips are dried mechanically and further processed into a dry correctly sized biofuel. It is however expected that most biofuel processing operations in Namibia would try to utilise the dry climate to dry off the felled bush to a moisture content of <15 per cent prior to grinding or chipping. In fact, some of the hardwood species like Acacia mellifera (Black-thorn/Swarthaak) and Colophospermum mopane, are crushed and milled (grinded to a wood fibre) with less energy, blockages and mechanical difficulties when dry.

6. Transferring chips onto on-road trailers

Once the chips are near the point of transfer, they are transferred onto 100 to 110 m³ on-road trailers. This point is called a transfer station. Wood making and chipping operations close to the point of use (<25 km) can be loaded into off/on-road shuttle cars to eliminate double handling and only a change of tractor type (from off-road to on-road) takes place at the transfer station.

Commercial operations would most likely make use of large (110 m³) trailers that can be pulled behind the grinder using a dolly-wheel-connecting-assembly. This trailer is collected at the grinder by a shuttling tractor when full and taken to the transfer station, where an on-road horse hooks the trailer and drives off to the point of use on public roads.

7. Transporting

The final product is transported on public roads to the point of use. High volume (up to 110 m³) three axle walking floor trailers are used for this purpose because of the low bulk density (240 – 300 kg/m³) of the dry wood chips.

1

2

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4

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PICTURES

1
The "Bosut" felling machine with hydraulic motor driven horizontal saw blade (courtesy Peter Weder, Groot Aub)

2
Horizontal saw blade of the "Boscut" felling machine (courtesy Peter Weder, Groot Aub)

3
Typical chipper blades

4
Small hydraulic buncher cutter used at the Cheetah Conservation Fund, Otjiwarongo

5
Close-up of grinder teeth (courtesy Treecycle, Langebaan)

6
Acacia/Senegalia Mellifera cut to the ground

7
Trolley saw in action – vertical logger (courtesy Inventec, Otjiwarongo)

Ten Felling and Chipping Methods

Dry wood chips can be produced using a variety of different equipment configurations, ranging from manual to highly mechanised harvesting. The following table provides a comparison of ten possible configurations.

ITEM	DESCRIPTION OF TYPICAL HARVESTING METHOD	TREE FELLING EQUIPMENT SUPPLIERS			CHIPPING EQUIPMENT SUPPLIERS		CLAIMED CHIPPING TEMPO measured/day using 1 chipper & optimum crew [t chips/day]	ESTIMATED CLEARING TEMPO per 8h day [Ha/day]	ENVIRON-MENTAL IMPACT
1.	**Bush pick, tree felling hand saw, manual gathering and feeding of small hand drawn wet wood chipper (BP)**	Bush picks, hand saws, pruning shears available from Agra and hardware outlets for agri-equipment			Small 20 hp Pezzolato wet wood chipper from: Otjiwarongo Motors & Tractors	Small 20 hp TomCat hand fed chipper available from: Burgers Equipment, Otjiwarongo	3-5 or 16 m^3/d	0.5 to 0.6	Low
2.	**Horizontal and vertical saw, hand trolley mounted, manual gathering and hand fed chipper (BP)**	Small horizontal/vertical blade cutting trolley with 13 ph. Honda engine. Inventec, Otjiwarongo			PTO driven Pezzolato from: Otjiwarongo Motors & Tractors	35 hp TomCat from: Burgers Equipment, Otjiwarongo	7-9 or 28 m^3/d	0.8 to 1.2	Low
3.	**Tractor drawn PTO-driven slasher, for small bushes and follow-up after care (Cut material left on land – no further processing). More for aftercare of certain species**	Otjiwarongo Motors Tractors Agents for the Massey Ferguson and related equipment	Plaisance Equipment, Windhoek & Razorback Bushclearing, Centurion, SA		Not practical for harvesting chips. Mulch is left on the ground.		N/A	2 to 5	Low
4.	**Light duty excavator (skid steer) with turbo saw, manual gathering and feeding into PTO driven grinder (BP)**	Forklift & Allied Equipment, Windhoek Agents for the Gehl skid steer	Burgers, Otjiwarongo Agent for the LiuGong range of felling equipment		Rovic Leers, Cape Town Agent for the Pezzolato wet wood chippers or Otjiwarongo Motors & Tractors	Burgers Equipment, Otjiwarongo Agent for TomCat chippers, made in Worcester, SA	12-14 or >50 m^3/d	2.0 to 3	Medium (tracks)
5.	**Medium duty excavator on tracks with turbo, saw and tree clamp/stacker plus self-propelled medium duty grinder. OR: Three wheel loader fitted with grab and hydraulic cutter (BP)**	Bell three wheel loaders/ cutters. Bell Equipment, Airport City, Cape Town & TreeCycle, Langebaan for Trevi Benne shearers	Burgers, Otjiwarongo Agent for the LiuGong range of felling and related equipment		Bandit Beast Grinders by Shaughn Frost, Langebaan, South Africa	Burgers Otjiwarongo Agents for TomCat drum chippers and the smaller Bandit range	20-30 or >80 m^3/d	2.5 to 4	Medium (tracks)
6.	**Heavy duty excavator on tracks with hydraulic cutter blade and tree clamp/stacker tree loader plus heavy duty self-propelled heavy duty grinder (BP)**	Burgers Otjiwarongo LiuGong Agents & TreeCycle, Langebaan, SA for Trevi Benne tree felling shearers	WoodCo, Windhoek Agents for the Wood-cracker (Westtech) felling tools and hydraulic shearers			Morbark Grinders Winn, Michigan, USA	30-50 or 120 m^3/d	3 to 4.5	Medium (tracks)
7.	**Bush roller attached to front end roller for crushing bush onto ground. Cut material left on land – no processing into chips**	Ombengo Energy Windhoek	Plaisance Equipment Rozorback Bushclearing Centurion, SA		Could be used as an harvesting operation with manual collection of biomass		N/A	4 to 10	Low to Medium
8.	**Bulldozing and ground clearing [Once pushed over trees are gathered and tub grinded or equivalent grinding which can endure some sand]**	Nico Pretoruis Plant Hire, Windhoek	Burma Plant Hire, Windhoek		Vermeer Equipment Suppliers, Brett Park Johannesburg, SA,	Morbark Tub grinders, Winn Michigan, USA	Chipping not primary function 20-30	5 to 8	High
9.	**Heavy duty hydraulic tree lifter (Sandy areas and river basins) and tub-grinder application**	Westtech bush/tree clearing equipment, WoodCo, Windhoek	Trevi Benne Hydraulic shearers, TreeCycle, Langebaan, South Africa		Vermeer Equipment Suppliers, Brett Park, Johannesburg, SA	Morbark Tub grinders, Winn Michigan, USA	2-8	2 to 4	Low in sandy rivers
10.	**Heavy duty self-propelled tree feller, grinder combined harvester.**	All in one Combined Harvesters supplied by AHWI, Germany	All in one Combined Harvester from Bandit Remus, Michigan, USA		All in one Combined Harvesters from AHWI, Germany	All in one Combined Harvester from Bandit, Remus, Michigan, USA	20-40	3 to 6	Medium

Items marked BP are regarded as best practice equipment from a harvesting perspective.

Top 5 Harvesting Methods for Namibia

For the Namibian context five different harvesting methods are recommended . These have a low to moderate level of required capital investment and range from bush picks to heavy duty excavators.

	FELLING	STACKING	CHIPPING /GRINDING	SHUTTLING	TRANSFERRING	AVERAGE MONTHLY ESTIMATE dry tonnes per month
1.	**Bush pick (Axe-pick combination) + handsaw + large pruning shears** **3** Operators	No real stacking takes place, Branches are cut by the pruning shear to fit the chipper **2** Operators	Smaller branches are fed into a small 20 ph. wet branches chipper mounted onto a trolley. Chips are collected in bulk bags on a trailer. Can chip up to 100 mm logs. Up to 16 m³/day chip production Using stacking crew	Bulk bags on trailer are drawn by a small tractor to the transfer station **0.5** Operators	Bulk bags are loaded with hi-up crane (or similar) on a long distance truck to a depot for drying and further processing **0.5** Operators	$ Level of investment: **Low** Crew total: **6** **± 80**
2.	**Trolley saw set (2 × horizontal + vertical) + large pruning shears** **4** Operators	As above **2** Operators	As above, using 35 ph. wet wood chipper PTO driven. Can chip up to 125 mm logs; up to 28 m³/day chip production **2** Operators	As above **0.5** Operators	As above **0.5** Operators	$ $ Level of investment: **Moderate** Crew total: **9** **± 140**
3.	**Skid steer multi-purpose light duty excavator with hydraulic motor drive cutter blade/'turbo' saw** **1** Operators	As above **3** Operators	2 × PTO-driven (55 ph. tractor) chippers/ grinders into bulk tipper bin trailer. Can chip up to 200 mm logs. Up to 22 m³/day per chipper **0.5** Tractor driver + stacking crew	Same tractor pull bulk bin to transfer station **0.5** Tractor driver	Bulk bins tip into bunker with lorry feeder conveyor **1** Supervisor/Handyman	$ $ $ Level of investment: **High** Crew total: **6** **± 220**
4.	**Multi-purpose medium duty excavator with hydraulic blade cutter & tree grab stacker** **1** Operator	Cut trees/bushes are stacked by the multi-purpose exactor immediately after cutting Same crew as felling operation	Dried bushes are loaded into the PTO driven drum grinder (200 ph.) which pneumatically blows chips into roll-on-roll-off bulk bins on off-road trailer using Bell logger or similar to feed chipper. Can chip up to 200 mm logs; >120 m³/day **2** Operators	Same or additional tractor pulls bulk bins to transfer station **1** Operator	Roll-on-roll-off bulk bins are transferred onto long distance horse and trailer No additional crew	$ $ $ Level of investment: **High** Crew total: **4** **± 600**
5.	**Multi-purpose heavy duty excavator with hydraulic cutter & tree grab stacker** **1** Operator	As above Same crew felling operation	As above, using high torque self-propelled heavy duty grinder. Grinder conveys chips into 110 m³ bin on/off road trailer chassis. Can chip 200 mm logs if required; >160 m³/day **2** Bell logger operators + **1** grinder operator	Propose built long distance tractor pulls on/off road trailer to transfer station for signing out **1** Operator	Same shuttle system move onwards to remote offloading point without any double handling No additional crew	$ $ $ Level of investment: **High** Crew total: **5** **>800**

SEE THE FOLLOWING PAGES FOR DETAILS

Comparing Top Ranked Harvesting Methods

Typical Biomass Costs

delivered over a distance of 100 km

HARVESTING ACTION	TYPICAL COST BREAKEVEN PER ACTION (ROUNDED OFF)		
	SMALL SCALE OPERATIONS <2,200 t.p.a. [N$/t]	COMMERCIAL SCALE OPERATIONS [N$/t]	REMARKS
Felling	N$ 170/t	N$ 140/t	**Commercially:** By turbo saw or hydraulic cutter fitted to an excavator to fell the bush **Small scale:** By hand or trolley saw
Stacking (and drying)	N$ 20/t	Included in felling	Assume sun drying takes place in the field
Feeding the chipping operation	N$ 90/t	N$ 70/t	**Commercially:** By three wheel logger or equivalent **Small scale:** By hand, often trimmed to fit the chipper
Chipping/Grinding	N$ 310/t	N$ 360/t	Dry chipping/grinding takes place
Shuttling ± 5 km	N$ 90/t	N$ 60/t	Chips are transported with off-road trailers from the point of harvesting to the transfer station
Transferring	N$ 30/t	N$ 10/t	Chips are transferred onto a public road system
Transporting to the point of use (100 km) with empty return load	N$ 150/t	N$ 140/t	A 100 km delivery distance is taken into account
TOTAL PRODUCTION COST DELIVERED OVER 100 km (VAT EXCLUDED)	**N$ 860/t**	**N$ 780/t**	

Best Practice

Biomass harvesting methods are regarded as best practice when they are

- Easy to operate, clean and maintain
- Reliable and well tested under the harsh, dry and dusty Namibian conditions
- Do not disturb the soil too much when operating (low environmental impact)
- Can select the encroacher trees amongst other protected tree species and when
- Each component of the harvesting train can be employed to maintain a steady pre-selected throughput measured in tonnes per hour or cubic meters per hour, in order to be used economically

Summary of Case Studies

CASE STUDY	DESCRIPTION OF OPERATION [m³/day]	THROUGHPUT (chips only), [t.p.a.]	CAPITAL REQUIRED [N$ million]	TOTAL COST P.A. [N$]	TOTAL PRODUCTION BREAKEVEN cost of biomass chips at farm gate [N$/t]
1.	**Small scale, mostly manual** [16 m³/day]	800	0.5	744,000	930
2.	**Light duty, semi mechanised** [28 m³/day]	1,400	1.3	1,272,000	910
3.	**Medium duty, full mechanised** [120 m³/day]	6,000	9.0	4,800,000	800
4.	**Heavy duty, fully mechanised** [160 m³/day]	8,000	13.5	6,120,000	770
5.	**Fully commercial dry grinder operation** [400 m³/day]	20,000	20.4	13,680,000	680
	levelised average production costs (VAT excluded) at farmgate				**N$ 720/t**

Five Case Studies of Harvesting Methods

From small scale to larger commercial operations, using specific equipment and a single chipper per set up

Case Study 1: Small scale, mostly manual

Chipping of 16 m^3/day or 800 tonnes per annum

This operation consists of manual felling, stacking and feeding actions; only the chipping operation is done with a chipper with hydraulic infeed. It can theoretically do wet logs up to a diameter of 150 mm, but for Namibian conditions it is advised to limit the chipper to logs of <100 mm. The chipper can, when continuously hand fed with biomass, produce 16 m^3 of chips per 8 hour day. This represents a total tonnage of between 3.5 and 4.5 tonnes of chips per day depending on bush species and moisture content. The capital cost of the above chipper is approximately N$ 230,000 (VAT excluded) delivered to Burgers, Otjiwarongo by the TomCat chipper factory from Worcester, SA.

Chips are blown by the chipper into 1 m^3 bulk bags positioned on a trailer next to the chipper. The trailer is manoeuvred by a small lightweight 25 hp tractor which is also used to move the chipper from time to time to remain close to the felled trees and off cut stacks. The bulk bags are hoisted up at the transfer station to the waiting on-road bulk trailer and by opening the bottom discharge end of the bulk bag, unloads its contents.

Manual bush pick used here for sickle bush clearing (courtesy Roads Authority of Namibia)

DESCRIPTION OF PLANT & ACTIVITY 800 t.p.a. or 80 t.p.m. chips plus 30 t.p.m. logs	CAPITAL COST	INSTALL-MENT	STAFF	FUEL	MAINTE-NANCE	TYRES	SHARP-ENING	INSUR-ANCE	OTHER (CONT.)	CAPEX + OPEX N$ P.M.	COST tonnes of chips at farm gate
Felling 4 × Set of bush picks 2 × Hand saws 2 × Pruning shears + protective clothing	5,000				500						
Stacking and Feeding: Manual											
Chipping 1 × 20 hp TomCat 125 AFE hydraulic infeed chipper with blower for wet logs up to 125 mm and 16 m^3/day on trailer	230,000			3,500	2,000	1,500	2,000	400			
Shuttling 24 × Bulk bags (starter stock) 2 × Light weight off road trailers for 4 bags cycle, N$ 40,000 each 1 × Light weight 25 hp tractor, N$ 120,000	200,000			1,500	1,000	1,500		400			62,000 × 12 / 800 t.p.a.
Transfer Airhost, compressor, I-beam and crawl to load trucks by discharging bulk bags	65,000				500			200			
STAFF											
1 × Supervisor/chipper operator, N$ 7,000 pm			7,000								
4 × Tree fellers, N$ 3,600 pm each			14,400								
4 × Stackers, trimmers, chipper feeders , N$ 2,000 pm each			8,000								
1 × Tractor driver/chipper operator, N$ 4,000 pm each			4,000								
TOTAL N$ (VAT excluded)	**500,000**	**10,900**	**33,400**	**5,000**	**4,000**	**3,000**	**2,000**	**1,000**	**2,700**	**62,000**	N$ 930/t

Case Study 2: Light duty, semi mechanised

Chipping of 28 m^3/day or 1,400 tonnes per annum

Two horizontal trolley saw cutters and one vertical saw cutter trolley by Inventec are proposed for this method. Stacking, trimming and chipper feeding is done by hand. A Tomcat 150 AFE Chipper or equivalent with the following specifications is recommended for this operation:

- 150 mm maximum infeed capacity
- 35 hp Perkins diesel Engine with 7" heavy duty over-centre clutch
- Double hydraulic infeed rollers (reversible)
- Variable infeed speed system to control chip size
- Mounted on off-road trailer with spare wheel
- Capital cost delivered to Burgers, Otjiwarongo: N$ 280,000 (VAT excluded)

The TomCat range of chippers are manufactured in Worcester, South Africa. TomCat SA are also the Agents in Africa for the smaller Bandit Chipper range and have appointed Burgers' Equipment in Otjiwarongo to cater for the Namibian market. The Pezzolato chipper Agency in Namibia is held by Otjiwarongo Motors and Tractors.

Shuttling and transfer is done by means of 1 m^3 bulk bags positioned on a tractor drawn purposely built trailer

DESCRIPTION OF PLANT & ACTIVITY 1 400 t.p.a. or 140 t.p.m. chips plus 150 t.p.m. logs	CAPITAL COST	INSTALL-MENT	STAFF	FUEL	MAINTE-NANCE	TYRES	SHARP-ENING	INSUR-ANCE	OTHER (CONT.)	CAPEX + OPEX N$ P.M.	COST tonnes of chips at farm gate
Felling											
2 × Hand operated 13 hp Inventec trolley saws, N$ 25,000 each											
1 × Vertical saw trolley (13 hp), N$ 20,000				2,000	1,000	500	2,000	200			
Spare saw blades, pruning shears and protective clothing	100,000										
Stacking and Feeding: Manual											
Chipping											
1 × 35 hp TomCat 150 AFE or Pezzolato PZ 150 PTO driven hydraulic infeed chipper with blower discharge for wet or dry logs to 150 mm (28 m^3/day) on trailer, N$ 280,000				4,000	2,500	1,500	4,000	1,200			
1 × 40 hp Tractor to pull chipper, N$ 330,000	600,000										106,000 × 12 / 1,400 t.p.a.
Shuttling											
100 Bulk bags (starter stock), N$ 500 each (second hand)											
2 × Trailers for 8 bulk bags per cycle, N$ 50,000 each				3,500	2,500	1,500		1,000			
1 × 40 hp Tractor, N$ 330,000	480,000										
Transfer											
Airhosts, compressor I-beam and crawls to load trucks by discharging bulk bags	120,000				500			400			
STAFF											
1 × Supervisor/Handyman/Chipper operator, N$ 15,000 pm			15,000								
2 × Bulk bag trailer/tractor operators, N$ 4,000 pm			8,000								
4 × Stack/pruners/feeders, N$ 2,000 pm each			8,000								
3 × Trolley saw operators, N$ 4,000 pm each			12,000								
TOTAL N$ (VAT excluded)	**1,300,000**	**28,300**	**43,000**	**9,500**	**6,500**	**3,500**	**6,000**	**2,800**	**6,400**	**106,000**	N$ 910/t

Case Study 3: Medium duty, fully mechanised

Chipping of 120 m³/day or 6,000 tonnes per annum

Felling and stacking is done by one medium duty (9 – 12 t) excavator available from Liebherr, LiuGong, BobCat or similar. The track type excavator is equipped with a C250 Woodcracker or a WT005 Trevi Benne, complete with rotator, baseplate and connected to the hydraulics of the excavator. Once felled and dried off, the bush is collected with a Bell logger equipped with grab and forestry tyres and fed into a commercial drum chipper. Roll-on-roll-off bins of 25 m³ capacity each are used to shuttle the chips from the chipper to the transfer station, pulled by off-road tractors. From the transfer station, public road transport is done by on-road tractors.

Fully mechanised harvesting – excavator with grab and hydraulic shearing blade

DESCRIPTION OF PLANT & ACTIVITY 6,000 t.p.a or 600 t.p.m. chips	CAPITAL COST	INSTALL-MENT	STAFF	FUEL	MAINTE-NANCE	TYRES	SHARP-ENING	INSUR-ANCE	OTHER (CONT.)	CAPEX + OPEX N$ P.M.	COST tonnes of chips at farm gate
Felling											
1 × Medium duty excavator (LiuGong 906 D, BobCat or Liebherr equivalent) on tracks with grab and hydraulic shearing blade with buncher, N$ 775,000 + N$ 295,000				7,000	3,000	2,000	1,000	4,000			
Protective clothing and infield workshop facilities, N$ 130,000	1,200,000										
Stacking and Feeding:											
1 × Three wheel Bell logger with bunching grab and forestry tyres	790,000			5,000	2,500	1,500		1,200			
Chipping											
1 × Drum chipper for logs up to 250 mm with own 200 hp diesel engine drive on trailer. Throughput >120 m³/day				12,000	6,000	5,000	8,000	3,800			
1 × 55 hp Tractor to pull chipper, N$ 400,000	2,600,000										
Shuttling											400,000 × 12 = 6,000 t.p.a.
12 × Roll-on-off bulk bins of 25 m³, N$ 120,000 each = N$ 1,440,000											
4 × Off road trailers, N$ 280,000 each = N$ 1,120,000				10,000	4,000	8,000		7,000			
4 × Tractor 55 hp, N$ 40,000 each = 1,600,000	4,160,000										
Transfer											
Bulk bins onto public road (Marshalling yard)	250,000							600			
STAFF											
1 × Supervisor and Mechanic/Welder, N$ 30,000 pm			30,000								
1 × Felling operator, N$ 7,000 pm			7,000								
1 × Feeding operator, N$ 7,000 pm			7,000								
1 × Grinder operator, N$ 8,000 pm			8,000								
4 × Tractor operators, N$ 6,000 pm each			24,000								
8 × Machine cleaners/helpers, N$ 2,000 pm each			16,000								
TOTAL N$ (VAT excluded)	**9,000,000**	**196,000**	**92,000**	**34,000**	**15,500**	**16,500**	**9,000**	**16,600**	**20,400**	**400,000**	**N$ 800/t**

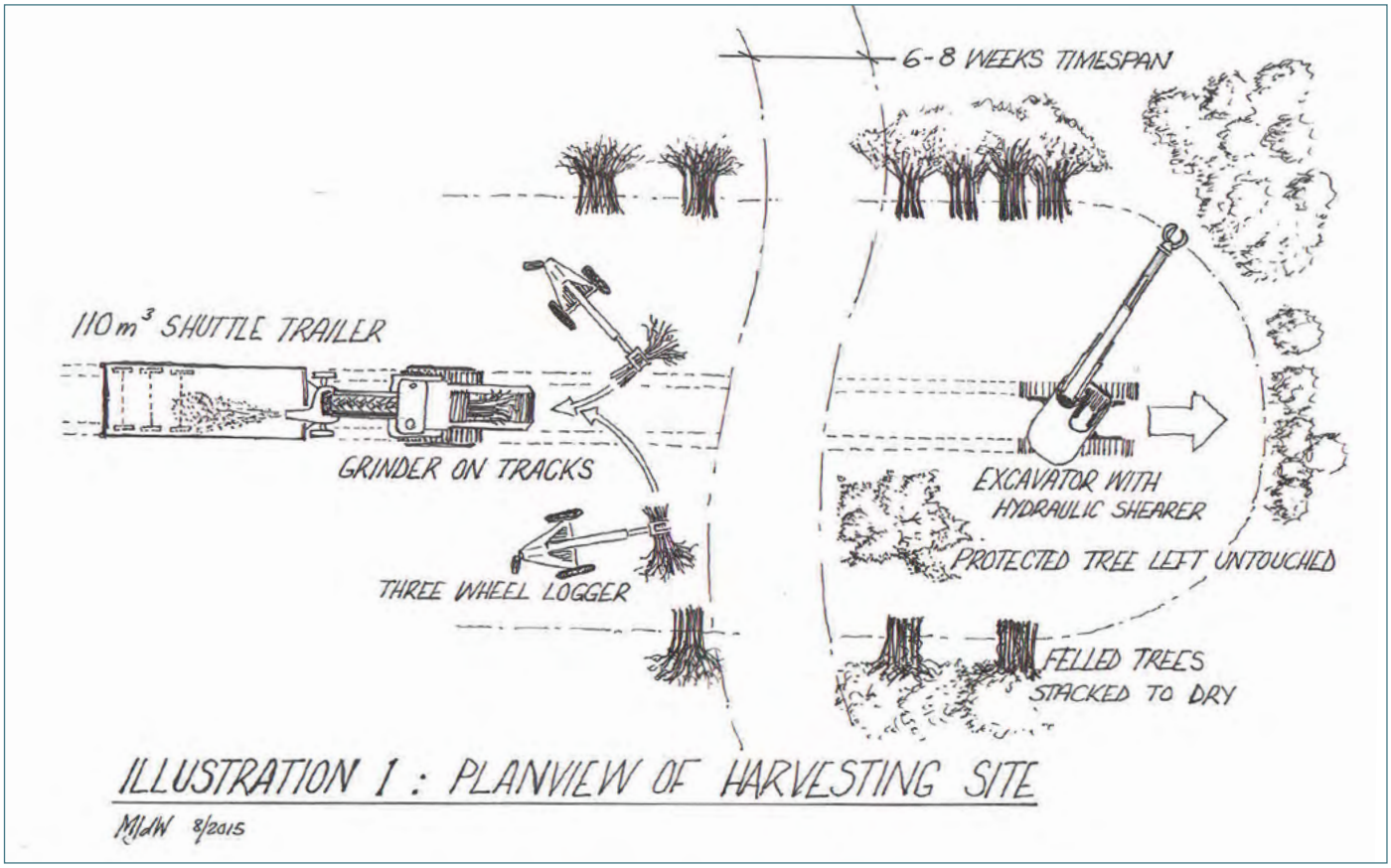
Case Study 4: Commercial scale, fully mechanised

Chipping of 160 m³/day or 8,000 tonnes per annum

The table illustrates an abbreviated breakeven of a 160 m³/day and N$ 13.5 million capital outlay commercial operation, using high lift trailers to shuttle the chips from the Pezzolato chipper to the transfer station.

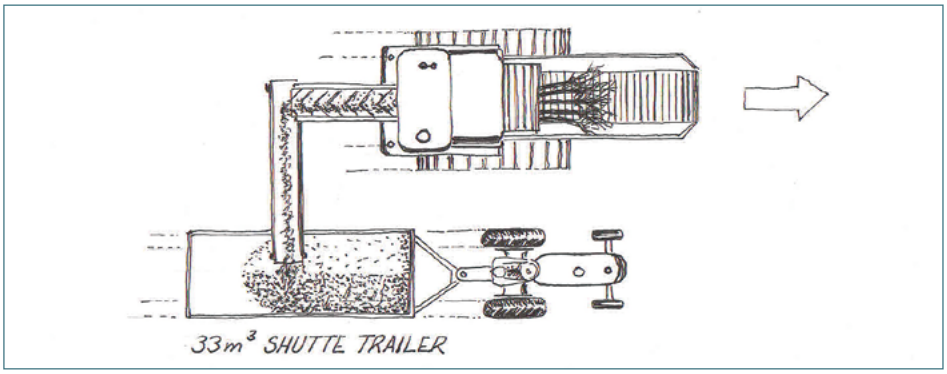
Three wheel loader with bunching grab (courtesy Africa Biomass, Worcester)

DESCRIPTION OF PLANT & ACTIVITY 8,000 t.p.a. or 800 t.p.m. chips	CAPITAL COST	INSTALL-MENT	STAFF	FUEL	MAINTE-NANCE	TYRES	SHARP-ENING	INSUR-ANCE	OTHER (CONT.)	CAPEX + OPEX N$ P.M.	COST tonnes of chips at farm gate
Felling 1 × 10 t excavator on tracks with grab and hydraulic shearing blade + spare blade				7,000	2,500	1,500	1,000	2,000			
Protective clothing	1,500,000										
Stacking and Feeding: Stacking with above machine Feeding with 2 × light duty three wheel loader with bunching grab, N$ 700,000 each	1,400,000			9,000	5,000	3,000		2,400			
Chipping Self-propelled 250 hp horizontal Pezzolato grinder on tracks (heavy duty). Through-put >160 m 3/day	4,500,000			14,000	8,000	1,500	10,000	7,600			
Shuttling 8 × Purposely build high volume (25 m³) high lift trailers with on/off road capability, N$ 400,000 each = N$ 3,200,000 4 × Off-road shuttle tractors, N$ 650,000 each = N$ 2,600,000	5,800,000			12,000	6,000	10,000		9,000			510,000 × 12 / 8,000 t.p.a.
Transfer High lift trailers side tip chips into 100 m³ on-road trucking systems Allow for marshalling yard and emergency spares	300,000										
STAFF											
1 × Supervisor and Mechanic/Welder, N$ 30,000 pm			30,000								
1 × Felling operator, N$ 7,000 pm			7,000								
2 × Feeding operators, N$ 7,000 pm each			14,000								
4 × Shuttle drivers, N$ 6,000 pm each			24,000								
6 × Machine cleaners/helpers N$ 2,000 pm each = N$ 12,000 pm			12,000								
TOTAL N$ (VAT excluded)	**13,500,000**	**294,000**	**87,000**	**42,000**	**21,500**	**16,000**	**11,000**	**21,000**	**17,500**	**510,000**	N$ 765/t



Case Study 5: Large commercial scale

Chipping of 400 m³/day or 20,000 tonnes per annum



Scenario Description

A large biofuel user requires 20,000 tonnes of wood chips per annum (equivalent to 400 m³/day for 10 months of the year) from an encroacher bush harvesting area some 100 km away from the point of use.

Harvesting Layout

The chipper/grinder plant is following in the tracks left by the excavator some six to eight weeks earlier, to minimise soil disturbance, while "paving the way" for the large three axel (tyre) shuttle trailer. The trailer can be used both off-road as well as on public roads and is thus saving double handling at the transfer station. An off-road tractor collects the shuttle trailer at the grinder and after removing the off-road dolly-wheel-assembly, the trailer is hooked behind a horse for its overland public road journey to the user. It should be noted that this arrangement has not yet been tested in Namibia and could have the following challenges:

- The removable dolly wheel assembly would be heavy to manoeuvre on site.
- The same engine driving the grinder, discharge conveyer belt and forward motion of the machine also needs to drive the chip flinger and pull the 110 m³ shuttle trailer – an exercise which could require more than the current 540 hp on offer for uphill scenarios.

This illustration shows an alternative layout to overcome the challenge of the engine but would require additional handling at the transfer station.

Breakeven and Bankability

In this scenario, dry wood chips can be delivered at a tempo of approximately 20,000 tonnes per annum or 2,000 tonnes per month to a user at a total production cost of N$ 780/t over a distance of 100 km from the harvesting site. Part of the breakeven costs include N$ 100,000 p.m. management fee for the equipment owner and main contracting party. Contracts of this magnitude will not happen before the following items have been agreed to between the biofuel buyer and producer:

- A long term (five years, renewable for a further five years) biofuel supply agreement has been signed, complete with biofuel quality specifications.
- The above agreement would be needed by the biofuel producer to obtain financing from a banking institution.
- An environmental impact assessment (EIA) that the biofuel can be harvested over the agreed time period at the required tempo without harm to the environment is required.
- A feasibility study with breakeven or cash flow analysis would be required by the bank.
- Proof that the quantities of raw biomass would be available from the producer's supply base for the duration of the contract.

DESCRIPTION OF PLANT & ACTIVITY (AS IN ILLUSTRATION 1) 20,000 t.p.a. or 2,000 t.p.m. chips	CAPITAL COST	INSTALL-MENT	STAFF	FUEL	MAINTE-NANCE	TYRES	SHARP-ENING	INSUR-ANCE	OTHER (CONT.)	CAPEX + OPEX N$ P.M.	BREAKEVEN cost/t of dry chips delivered to user
Felling and stacking equipment:											
1 × 12 t Excavators with ± 200 kW diesel engine on tracks, N$ 1,100,000	1,100,000			16,000	4,000	3,000	1,000	1,500			
2 × Hydraulic grab and shearing attachments with rotator and baseplate, N$ 350,000 each (one spare)	700,000				1,000		1,000	1,000			
1 × Mechanic dedicated and trained for this operation, N$ 40,000 pm			40,000								
2 × Operators, N$ 6,000 pm each, including grease and cleaning own machine (one Operator on standby)			12,000								
Feeding:											
2 × Three wheel Bell 225 loggers with Super Severe tyres by General capable of 300m³/day each, N$ 840,000 each	1,680,000			30,000	5,000	5,000		2,000			
2 × operators/greasers/cleaners, N$ 6,000 pm each			12,000								
Chipping/Grinding:											1,300,000 × 12 / 20,000 t.p.a.
1 × Bandit 2680 track Beast of 540 hp capable of 400 m³/day fiber production	8,810,000			60,000	30,000	4,000	15,000	13,000			
1 × Operation manager and chipper operator, N$ 20,000			20,000								
1 × Chipper cleaner/greaser, N$ 3,000 pm			3,000								
Shuttling											
2 × Dong Feng 60 kW (DF 804) off-road tractors to position shuttle trailers, N$ 280,000	560,000			20,000	2,000	2,000		1,000			
8 × 110 m³ high volume shuttle trailers, N$ 650,000	5,200,000				16,000	10,000		7,000			
1 × Dolly wheel assembly, N$ 220,000	220,000										
2 × Shuttle tractor operators, N$ 6,000 pm each			12,000								
Transferring											
Container type offices, ablutions, marshalling yard, protective clothing, etc	780,000										
Transport											
2 × Transport double diff horses, N$ 1,300,000 each	2,600,000			96,000	9,000	8,000		6,000			
3 × Lorry drivers and standby operators, N$ 7,000 each			21,000								
Backup spares and workshop:											
Wear parts, filters, tyres, stores, workshop Additional mechanic/welder	1,350,000		20,000								
Management fee:			100,000								
TOTAL N$ (VAT excluded)	**23,000,000**	**500,000**	**240,000**	**222,000**	**67,000**	**32,000**	**17,000**	**31,500**	**190,500**	**1,300**	N$ 780/t (Delivered)

1

2

3

4

PICTURES

1
Treecycle Grinding Clean air: exceptional dust during grinding (Courtesy TreeCycle, langebaan)

2
Pieces of wood after machine compartment was cleaned out

3
Machine cleaning in action (Courtesy Callie Steenkamp)

4
Exceptional dust during grinding (Courtesy TreeCycle, Langebaan)

Special 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 harvesting machines should not be underestimated. Unless relative good (stump free) infield roads can be made to the point of harvesting, forestry-type tyres are recommended. Foam filled and solid rubber tyres are also used for these harsh off-road conditions, but are often not found as cost effective as the special compound forestry-type tyres. Special tyre chains can also be used to protect the tyres.

Large operations use steel tracks on their tree felling and self-propelled grinding machines. The tracks of the grinder follow in the tracks (ground imprints) the excavator made when it felled the trees six to eight weeks earlier. The shuttle trailer (often pulled directly behind the grinder) also follows the above tracks.

Abrasiveness

Namibian encroacher bush types are classed as "hard wood" and this fact must be clearly stated when ordering chipping or grinding equipment. Blade type chippers need to be sharpened in-sito (blade edge passing with special sharpening tool) every three to four hours, even when wet chipping is done.
The negative effects of sand and termite nests in the wood on chipper wear parts are severe and need to be managed as best as possible, hence the reason for neatly stacking bush on top of one another and out of the soil prior to chipping.

Machine fires

Care should be taken to clean machines of dry wood chips and wood dust in engine compartments at least twice a production day to prevent machine fires. Machine (and veld) fires are seen as one of the highest risks of this industry. It is standard to fit fire extinguishers to every tree felling and chipping machine.

Air cleaners and radiators

Because of the amount of airborne dust, special care should be taken to prevent clogging up of air intake areas, with special reference to air filters and radiators. Air intake filters are often extended to a much higher position as the grinder in an attempt to be in a cleaner (less dusty) zone.

Clean air

Wood dust and dust in general is not only a problem to machines but also to humans. Care should be taken that operators wear dust filters over their mouths and noses.

Environmental Considerations

Large-scale bush control can only be implemented successfully if the environmental impacts of de-bushing operations are fully understood and considered.

Growing Resistance against Chemical Methods

Farmers and environmentalists are increasingly becoming aware of the devastating negative effects on savannah biodiversity when chemical de-bushing methods are used. Although the process is relatively quick and cheap, it invariably kills off far more than the trees targeted.

This brochure aims to provide an alternative to farmers and land care contractors. The consultants believe that most of the best practice mechanical means would provide a cost effective way to do bush harvesting. Not only do the mechanical means give harvesters a way to convert bush into sellable wood chips, they also have lower impact on the environment when executed correctly. Unlike chemical de-bushing where the farmer is left with virtually un-harvestable trees and bushes and a massive hot-fire hazard, mechanically harvested bush is sold off to cover the costs of the clearing operation, often at a small profit.

Protected Species Considered

Because wood chips can be made of small bushes as well as of the side branches and twigs of trees, there is no need to target the larger trees only. It must be stressed that it is illegal to cut any tree in Namibia with a trunk diameter of larger than 200 mm (or a circumference >628 mm). To date, some charcoal producers still target larger and even protected tree species to obtain larger logs for better yields of lumpy charcoal.

Best practice mechanical harvesting methods are geared to do selective de-bushing and because of the fact that chip production can be done with lower fuel consumption on <200 mm diameter trees, there should be no need to target larger trees. It goes without saying that none of the protected species should be allowed to be harvested.

PICTURES ON OPPOSITE PAGE

1
Farm in Otjozondjupa after aerial application of chemicals

2
The marula tree is a medium-sized deciduous tree and is protected in Namibia. Marula fruits are collected at the end of the rainy season and processed into a variety of products. (Photo: JMK).

3
The mopane tree provides many resources to rural communities. Livestock browse the trees; stems and longer branches provide timber for construction and fencing. (Photo: Roger Culos)


1

Thermal Processes and Future Charcoal Making

Best practice thermal processes, like wood fired boilers, hot gas pyrolysers and wood gasification, use wood chips as infeed and produce either a clean wood ash or biochar as out-feed. Wood ash and biochar are sought after soil conditioners and soil health enhancers. By using wood chips for example on a continuous infeed into a hot gas pyrolyser, the hot gas can be used to dry wood for other purposes, while producing biochar or activated carbon or charcoal. The point is that the thermal properties of the woody biofuel are then also used in a controlled fashion with nearly clear (mostly CO2 and water vapour) emissions, while producing valuable clean carbon derivatives.

An added advantage to the above process is that the whole bush can be utilised for the required infeed, emphasising the fact that the future of biomass harvesting is slowly moving towards 'chips' or a woody fibre processed at the point of harvesting and away from large logs. In other words, future charcoal production will swing to the manufacturing of briquettes from smaller biochar pieces and charcoal fines, rather than the infield kiln process where predominantly larger branches and logs are used to produce lumpy charcoal.

Lumpy charcoal is favoured by the charcoal buyers and packers. Larger and more advanced, higher yielding, centrally located retort type kilns which recycle the syngas for additional thermal energy can be seen as the next generation of sustainable charcoal making.


2


3

Soil Disturbance

Bush clearing with for example bulldozers and large graders is not regarded as restoring savannah in the true sense of the word. Biomass is often dozed onto a pile and burned without any form of utilisation.

Some of the large track propelled excavators and bush grinding machines are often regarded as harsh machines on the soil, but most environmentalists agree that smaller tyre equipped machines are worse. The larger commercial biomass harvesting machines can be planned to have the grinder driving on exactly the same tracks left by the tree felling excavator.

Soil disturbance with grader de-bushing

Branding Namibian Biomass Products

For the biomass from encroacher bush industry to grow, it will eventually have to adhere to international environmental guidelines given by the FSC, ISO 14 000 and ISO 22 000. The essence of these guidelines can be summarised as follows:

- Target only the listed encroacher bush and tree species smaller than 200 mm diameter
- Do not generate visible emissions (smoke)
- Do not generate concentrations of toxic residues (tars)
- Disturbance of the biodiversity should be kept at a minimum
- Harness the thermal energy coming from the process as much as possible
- Replace the minerals taken from the soil in the form of biomass by returning clean ash and biochar into the ecosystem (as part of the sustainability process)
- Restore the grasslands and indigenous trees with active replanting methodologies (part of the sustainability cycle)
- Follow-up and aftercare is required of the cleared areas in a seasonal cycle to maintain a natural rhythm in the savannah restoration process

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

The bush roller in action (Courtesy Ombengu Energy, Windhoek)

Aftercare and Regrowth Management

There are two schools of thought on this topic. Some farmers feel that biomass harvesting should become a second crop to the farming business which must allow the harvested bush to regrow for 10 to 12 years before harvesting again. Others feel strongly that the grasslands must be restored and that regular follow-up and removal of regrowth should be managed.

Special care should be taken with sickle-bush which is stimulated when mechanically disturbed. Rapid regrowth from the disturbed root system of the sickle-bush will follow and densification will occur. One of the aftercare proposals made by the bush roller manufacturer (Ombengu Energy, Windhoek) is to do rapid roller passes over the young and sprouting sickle-bush to break off and crush its twigs to ground level during early autumn. Grass regrowth during the rest of autumn is allowed, while the crushed twigs are allowed to dry off. By late winter/early spring when the grass and twigs are all dry, this biomass is burned in a controlled fire, killing off most of the sickle-bush root systems. The same process is repeated the next year for the remainder of the sickle-bush which was not killed off by the first attempt.

Vegetation at the Waterberg in Otjozondjupa Region

Protecting the Biomass Resource

Care should be taken to ensure the continued protection of the indigenous shrubs, bushes and trees. The volume of unwanted encroacher biomass available is however so immense that even at tempos of 1,000 tonnes per day to feed say 5 × 10 MW wood fired power stations, the current resource would last more than 300 years assuming no regrowth and access to only say 50 per cent of the 26 million hectares of infested areas.

It is however suggested that the best way to protect the resource would be to give biomass an agricultural value, while at the same time provide the necessary specifications for the biomass product to adhere to. Suppliers of biofuel would in other words stand to lose their fuel supply agreement to their client (e.g. Ohorongo Cement, NamPower, O & L Energy, etc.) if any protected tree material is found in the wood chip supply.

Sustainable Harvesting

It is important to note that the following items form part of long term sustainability:

- **Good governance:** The industry should be well managed and controlled
- The **environment** should gain in the process, implying a best practice approach to restore the grasslands and indigenous trees and the natural biodiversity
- The most appropriate and **best practice technologies** and methodologies 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 work flow, safe working conditions and skills development
- The full value chain should be **profitable** and economical to commercial as well as SME operations

Once biomass has reached the status of an agricultural commodity at a benchmark value of say N$ 700/t for clean, dry chips at the farm gate, this new industry will show steady growth and good internal control for all role-players to comply to the 'rules of the game'

Findings

A mechanised biomass harvesting industry is still in its infancy. However, good progress has been made over recent years. Equipment suppliers are available in Namibia and South Africa to take this industry to its next level.

Equipment

A full range of biomass harvesting equipment is available in Namibia, from low cost to capital intensive, highly productive plant and equipment. Agencies, workshops and spares' back-up facilities exist for some of the above equipment and would certainly improve as the biomass industry grows.

Risks

The risks of mechanical harvesting equipment causing fires and of the winter savannah catching fire are high and require dedicated attention. Further risks include high wear on cutter tools due to the extreme abrasiveness of the imbedded silica, dust and termite nests in the dry encroacher bush and high tyre failures.

Key Players

Ohorongo Cement plays a leading role in the industry and requires more than 70,000 tonnes per annum of dry chipped biomass delivered to its plant north of Otavi at a market related price of approximately N$ 700 – N$ 800 per tonne.

NamPower has progressed well over the past two years to implement a biomass-to-electricity division as part of its long term renewable energy division, which could benefit the biomass harvesting and eventually the livestock farming communities of Namibia immensely.

Up-scaling

The profitability of the operation is volume driven. Pre-Feasibility Studies have indicated that when retail prices of electricity in Namibia start to exceed N$ 1.23/kWh, generating power from encroaching bush biomass could become viable. Approximately 40,000 tonnes p.a. of dry wood chips would be required per 5 MW of electricity generated through a wood fired high pressure (60 bar) boiler and steam turbine system.

One of the risks of upscaling biomass harvesting to the volumes required for energy generation was, until recently, that plants and equipment were not designed and not reliable enough for such large quantities – a fear which has been resolved over the past few years by harvesting productivity levels achieved by companies like WoodCo and WP Chippers in Namibia and South Africa respectively.

A commercial rechipping and transferring operation in action (courtesy WoodCo)

Recommendations for Prospective Biomass Producers

If the anticipated growth in biofuel demand in Namibia continues at its current rate, biomass harvesting will become a reality, while at the same time helping to restore the much needed productivity of the graze lands of the areas cleared. It is proposed that prospective biomass producers pay attention to the following recommendations:

- Start with a bankable business plan consisting of:
  - A detailed equipment selection plan after researching all options
  - 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 (allow for the harsher Namibian conditions; fuel consumption, wear on cutters, tyres, 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
- Visit harvesting sites and equipment suppliers to familiarise yourself with this developing industry and all the complexities of the chain of harvesting actions required
- Check the local technical back-up levels on spares, in-house knowledge and experience, with special attention to the chipping/ grinding operation
- Do not underestimate the abrasiveness (mainly caused by imbedded silica) and general difficulties of handling the Namibian bush and high volumes of low bulk density chipped material
- Compile a formal Request for Proposals, complete with throughput figures, technical and back-up specifications, general and specific conditions of contract and invite a minimum of three suppliers per key harvesting component to tender

Directory

FELLING EQUIPMENT

DESCRIPTION OF MACHINE	PRICE [N$] (VAT Exc.)	SUPPLIER DETAILS	BACKUP AVAILABLE IN NAMIBIA
Inventec tree cutting trolley. Hand operated two wheel trolley with belt driven circular saw	25,000	**Inventec Agricultural & Industrial Designs** Otjiwarongo +264 67 307 489 Mr Johan Theron, +264 81 124 1916 info@iventecnam.com www.inventecnam.com	Inventec has in-house design, manufacturing and repair facilities
Inventec log cutter. Hand operated two wheel trolley with belt driven vertical circular saw	20,000		Inventec has in-house design, manufacturing and repair facilities
Ghel skid steer loader Model R260, 50 kW, with Yanmar 3.3 liter turbo diesel engine and hydrostatic drive **Fitted with Turbo saw SB 3000 with hydraulic oil cooler and swing boom**	930,000 260,000	**Forklift & Allied Equipment CC** (FL & A) Windhoek +264 61 262 390 Mr Klaus Papendieck klaus@fae.co.na www.forkliftnamiba.com	FL & A has in-house as well as field service repair and maintenance facilities
LiuGong 906 D, 5.9t excavator with 39 kW Yanmar 3.05 liter diesel engine. Can be fitted with turbo saw or hydraulic cutter **Turbo saw SB300 with hydraulic oil cooler FL & A**	660,000	**Burgers Equipment & Spares** (BE & S) Otjiwarongo +264 67 307 487 3785 Mr Marius Cronje, +264 81 149 0713 manager.otji@burgersafrica.com www.burgersafrica.com	BE & S has in-house service, repair and maintenance capability
Woodcraker felling tools. A range of hydraulic tree felling shears with clamping devices are available, from clamp diameters of 900 mm up to 1 600 mm	200,000 up to 450,000	**WoodCo/Transworld Cargo** Windhoek +264 61 371 100 Mr Heiko Meyer, +264 81 249 7876 hrm@iway.na www.woodco.biz Mr Norbert Liebich +264 61 37 1101 n.liebich@transworldcargo.net	Advisory to new equipment and spares orders
Woodline Trevi Benne felling tools. A range of hydraulic tree felling shears with clamping devices are available from clamp diameters of 850 mm up to 1 , mm a	180,000 up to 400,000	**TreeCycle (Pty) Ltd** Langebaan, Western Cape, SA +27 22 772 0307 Mr Shaughn Frost, +27 82 338 8951 shaughn@treecycle.co.za www.treecycle.co.za	Advisory to new equipment and spares orders

EXCAVATORS CAN ALSO BE OBTAINED FROM THE FOLLOWING AGENCIES:

- **BobCat, SA:** Johan Claassen, Stikland, Cape Town Tel: +27 21 945 1423, jclaasen@bobcatsa.co.za
- **BobCat, Namibia:** 14 Rensburg Street, Lafrenz Industrial, Windhoek Tel: +264 61 333 000
- **Caterpillar:** Barloworld Equipment, 166 Mandume Ndenufayo Ave, Windhoek Tel +264 61 280 4811, www.barloworld.co..na
- **Komatsu:** Lafrenz Industrial, 43 Nordland Street, Windhoek Tel: +264 61 26 1281
- **Liebherr:** Mr Fanie Bosman, Windhoek +264 81 148 9947

CHIPPING & GRINDING EQUIPMENT

DESCRIPTION OF MACHINE		SUPPLIER DETAILS	BACKUP AVAILABLE IN NAMIBIA
TomCat Chippers: A full range of chippers are manufactured in Worcester, SA • 5.5 hp to 35 hp gravity feed applications • 25 hp to 50 hp hydraulic feed, drum applications		**Factory:** Tomcat Chippers, Worcester, SA Sales: Mr Frans Greyling, +27 72 292 1821, frans@tomcatchippers.co.za **Owner:** Mr Hugo van der Merwe, +27 83 442 7693 www.tomcatchippers.co.za **Namibian Agent:** Burgers Equipment & Spares, Otjiwarongo, +264 67 307 487 3785 Mr Marius Cronje, +264 81 149 0713, manager.otji@burgersafrica.com, www.burgersafrica.com	Factory in Worcester South Africa BE & S has in-house spares supply and advisory service capability
Bandit Chippers: From 48 hp to 213 hp drum-style chippers with hydraulic infeed (Note: Disc-type chippers not recommended for Namibian hard wood encroacher bush)		**Factory:** Bandit Industries Inc., Remus, Michigan, USA, www.banditchippers.com **Namibian Agent:** Burgers Equipment & Spares [BE & S], Otjiwarongo, +264 67 307 487 3785 Mr Marius Cronje, +264 81 149 0713, manager.otji@burgersafrica.com, www.burgersafrica.com **SA Agent:** Bandit Chippers Africa, Worcester, SA, +27 23 342 1594 Mr Hugo van der Merwe, +27 83 442 7693 hugo@banditchippers.co.za, www.banditchippers.co.za	BE & S has in-house spares supply and advisory service capability
Pezzolato Chippers: Drum chippers (PTH Series) from 100 hp to 590 hp self-propelled and self-feeding machines		**Factory:** Pezzolato, Envie, Italy **Namibian Agent:** Otjiwarongo Motors & Tractors [OM & T], Massey Ferguson Dealer Mr Thorsten Kopp +264 67 303 041 www.tractors-namibia.com **SA Agent:**, Rovic Leers, Cape Town, SA, +27 21 907 1700 Mr Marius Ras Pr. Eng., +27 82 453 4808 marius@rovicleers.co.za, www.rovicleers.co.za	FL & A has in-house as well as field service repair and maintenance facilities
Bandit Beast Grinders: • Model 1680: 160 hp -275 hp (Towable or track driven) • Model 2680: 365 hp – 540 hp (Towable or track driven) • Model 3680: 400 hp – 800 hp (Towable or track driven) • Model 4680: 875 hp – 1200 hp (Towable or track driven)		**Factory:** Bandit Industries Inc., Remus, Michigan, USA www.banditchippers.com **Africa Agent:** TreeCycle (Pty) Ltd, Langebaan, Western Cape, SA, +27 22 772 0307 Mr Shaughn Frost, +27 82 338 8951, shaughn@treecycle.co.za, www.treecycle.co.za	Shaughn Frost, with the assistance of Africa Biomass Company, Worcester, can assist with spares, maintenance & operator training
Ritlee Chippers and Morbark Tub Grinders:		**Africa Agent:**, AfrEquip (Pty) Ltd, Pietermaritzburg, KwaZulu Natal, ,SA, +27 33 386 5034 Mr Marc Custers, marcc@afrequip.co.za, www.afrequip.co.za	
Vermeer		**USA Factory:** Vermeer Corporation – Agriculture, Pella, Iowa, USA, www.vermeer.com **SA Agent:** Vermeer Equipment Suppliers (Pty) Ltd, Johannesburg, SA, +27 11 608 0893, www.vermeer.co.za	
Heizohack Hydraulic infeed drum chipper from 30 ph. to 300 hp		**UK Factory:** Fuelwood Ltd, Warwick, United Kingdom +44 1926 484673, sales@fuelwood.co.uk, www.fuelwood.co.uk	
TEREX Hybrid Chippers The hybrid Terex drum chipper is suitable for trunk wood as well as untreated rootstocks. • Model: THC 465 Log chipper, 462 hp or 653 hp • Model THC 465 Root chipper, 462 hp or 653 hp		**USA Factory:**Terrex Environmental Equipment, Farwell, Michigan +1 800 953 5532, www.terex.com/enviromental-equipment **Africa Agent:** James Kamau, Mfangano Solutions, +27 82 747 1920, +27 11 440 2072 James@mfangano.co.za, www.mfagano.co.za	

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Beyond Bush

Encroacher bush harvesting can be conducted in a sustainable manner in Namibia. It can be profitable, especially at commercial scale, while restoring the grazing capacity and biodiversity of the savannah.

This brochure explores practical methods for encroacher bush harvesting, from manual and semi-mechanised to large-scale operations. The authors find that most of the mechanical best practice methods provide a cost effective way to conduct bush harvesting. Today, appropriate technology is available to convert bush into sellable wood chips. When executed correctly, environmentally friendly harvesting is possible.

The authors call for a unified biomass harvesting and savannah restoration industry.