

Support to
De-bushing
Project

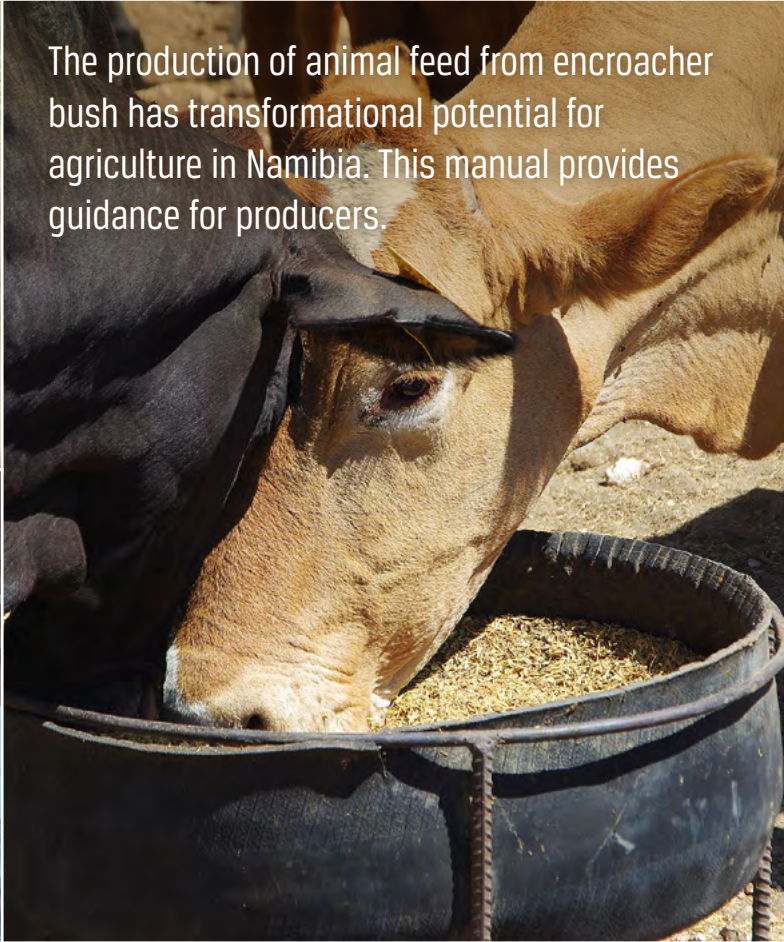


Animal Feed

from Namibian Encroacher Bush



The production of animal feed from encroacher bush has transformational potential for agriculture in Namibia. This manual provides guidance for producers.



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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 country's rangeland production capacity by up to two thirds. It has further resulted in reduced biodiversity and limits the recharge of groundwater.

Despite the negative impacts, **the encroacher bush is 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**.



Animal Feed

from Namibian Encroacher Bush

Bush based animal feed production is a viable option for Namibian farmers, as extensive research has shown. This manual provides guidance for producers.



WHAT IS THIS BROCHURE ABOUT?

From April 2016 to July 2017 **animal feed production** and **animal feeding trials** were conducted at three research sites in order to establish the **viability of encroacher bush as main component of such feed**.

This manual is based on the report "Encroacher Bush to Animal Feed - Viability of Bush Based Feed Production in Namibia" (2017) – a research project of the Ministry of Agriculture, Water and Forestry (MAWF), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and United Nations Development Programme (UNDP) – Sustainable Management of Namibia's Forested Lands Project (NAFDLA).



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Bush Based Animal Feed

Bush encroachment hampers agricultural productivity and threatens the livelihoods of many Namibians. Today, more than 30 million hectares of Namibian rangeland are affected. The shortage of grass for livestock is a direct consequence and it is further intensified in times of drought.

The dire shortage of animal fodder is reflected in Namibian trade statistics. In 2016 animal fodder ranked as the eighth largest import good, with total fodder imports valuing close to 4 billion NAD, equivalent to the gross value addition of the entire agricultural sector. If the bush itself can be used for animal feed production, a win-win situation is created. Fodder availability improves and the rangeland benefits from bush thinning.

A number of Namibian farmers produce bush based animal feed already today. The results of these pioneer activities are remarkable and suggest that bush based feed works especially during droughts as emergency feed, but also as supplement feed. Various farmers report that the production of bush based fodder has saved their herds during recent periods of drought.

Inspired by the anecdotal stories of these farmers, an extensive research into bush based animal feed was implemented.



1. Weighing of animals during the feeding trials 2. Data capturing 3. Bush based feed mix



Bush encroached rangeland at Waterberg in the Otjozondjupa Region

Is bush based feed an option for you?

- Your farm is bush encroached?
- You do not have enough forage material to sustain your livestock?
- You have recurring droughts? You have noticed that the average annual rainfall you receive has decreased over the past five years or longer?
- You have challenges in marketing your livestock because of their poor body condition?
- You have difficulties finding new areas on your farm where your livestock could graze? You find it challenging to lease land from someone else?
- The quality of your grazing has weakened? You need to find alternatives to sustain your livestock or you will be unable to continue with livestock farming?
- You have harvesting and milling equipment available or could rent such rather cheaply and quickly?

If the answers to the above questions are "yes", this manual is for you. This manual is intended to assist livestock producers and Namibian farmers in bush based feed production. The manual cannot cover every farmer's or livestock producer's specific needs, but gives an overview of the production process and possible diets.

PLEASE BE AWARE:

- **Animal feed production is complex and if implemented wrongly the health and life of animals are at stake.**
- **This manual provides concrete recommendations for implementation, but we strongly advise that you consult an expert before starting your own production.**
- **The authors of this publication cannot be held liable for any harm or damage caused during the production of bush based feed or by its application.**

Farmers' Experiences

A total of twelve livestock producers from commercial farming areas were found to have successfully used bush based animal feeds. The main reasons for the farmers to produce this feed were drought, prolonged periods of little rain, and lack of sufficient fodder on the farm.

- Bush based animal feed is not a new concept in Namibia. Most of the farmers only started to produce bush based animal feed around 2012. Some, however, report they produce bush based feed since the 1980s.
- The majority of the farmers rear more than 700 animals at the same time. The number of animals is influenced not so much by farm size, but rather by managing capacity, herd sizes, rangeland management practices, available personnel, and funding requirements.

Motivation

- Many farmers consider bush based animal feed a solution to overcome drought periods on their farm, safeguarding their herd from starvation. Their main aim is to provide survival rations of feed to their animals.
- Other farmers are convinced that bush based animal feed production is a viable business option and is suitable for application throughout the year, also during years with good rainfall.

Species

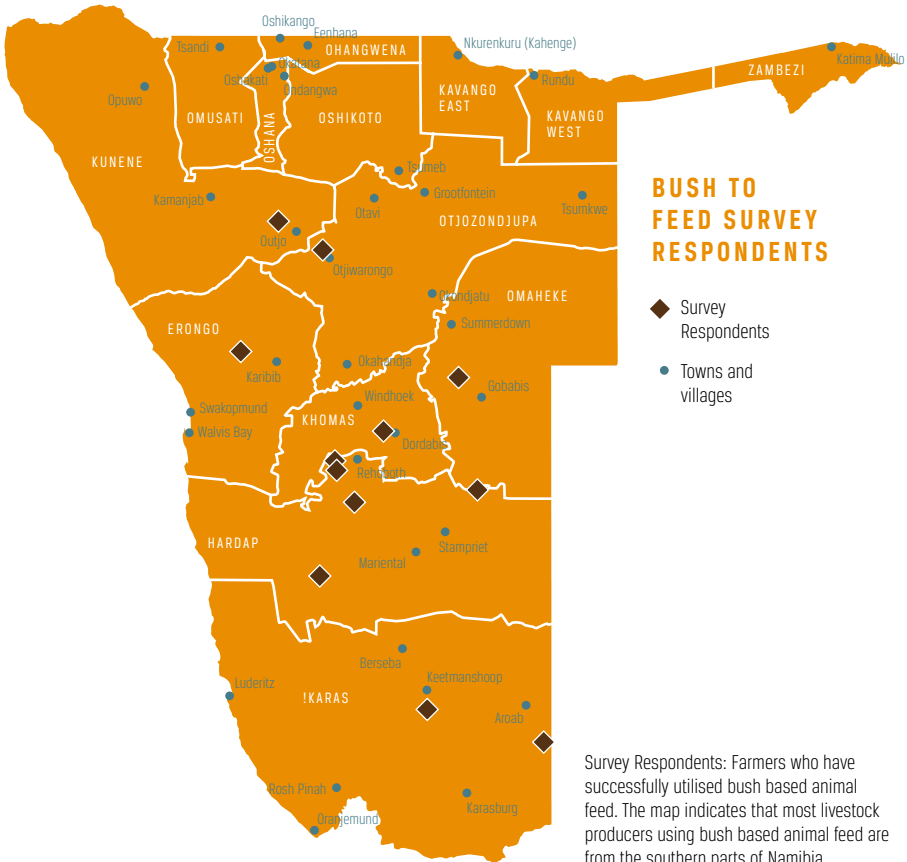
- In the southern parts of Namibia the predominant species utilised to produce bush based animal feed is *Catophractes*

alexandri (Gabbabos). *Acacia mellifera* (*Senegalia mellifera*, Black Thorn) and *Dichrostachys cinerea* (Sickle Bush) are also being used. Species such as *Vachellia karoo*, *Grewia bicolor*, *Terminalia sericea*, *Terminalia prunioides* (Purple Pod Terminalia or Deurmekaar Bos), *Prosopis* (Mesquite) and *Rhigozum trichotomum* are also suitable for making bush based animal feed.

- The farmers explain that not only the abundance of a certain bush species on their farm determines whether they are using it for bush based feed. They also considered factors like ease of handling of the bush material (e.g. thorns), the tastefulness of the bush material (palatability), and on-farm available equipment and logistics to harvest, process and store bush based animal feeds.

Supplements

- All farmers add supplements to the milled/processed bush molasses is the most used supplement. This was followed by various forms of PEG (like crystalline PEG or Browse Plus™), Bush Improver Lick™, Rangeland Grower™ and/or Enermol™.
- Livestock producers are also aware that natural supplements can be used to improve taste and digestibility. They



use Lucerne, maize, *Vachellia erioloba* (Camelthorn) and *Prosopis* pods, bran, Brewers spent, cotton seed and other types of oil cake as well as dried and milled Prickly Pear cladodes.

- Different minerals and/or chemical substances are also mixed into the bush based animal feed, mainly to ensure better digestibility and provide a balanced diet. Supplements and/or additives mentioned were ammonium chloride, urea, phosphorus and calcium.

Costs

- Farmers provide between 500 g and 1.2 kg of feed to each animal on average per day. The cost of producing bush based animal feeds on their farm ranges between 0.4 to 7 NAD/kg.
- These costs were based on various methods of harvesting, processing, drying and in some cases storing of the bush based fibres for the feed. Furthermore, various methods were used to mix the bush fibres with the supplements. Some farmers mentioned that they even pelletize the feed mixtures for improved durability of the feed.

Producing Bush Based Animal Feed

This chapter provides advice on the production steps of bush based feed. It is advised to carefully consider which recommendations are suitable for your specific context and to consult an expert in case of uncertainty.

1 Understanding the components: lignocellulosic biomass

Wood is a complex lignocellulosic biomass and consists of plant cell walls composed of lignin, cellulose and hemicellulose. Wood has strong walls as bushes and trees grow much taller than grass. Therefore, wood has very high lignin content.

Although grass is also made of lignin, cellulose and hemicellulose, its structure is far less complex and therefore its degradation in the rumen of an animal is much faster. Grass has thin cell walls and leaf tissue and is thus of higher forage quality.



Processed encroacher bush material

In the Namibian context, the source of lignocellulosic biomass would be mainly encroacher bush. Naturally, ruminating animals do not eat such material unless they have an affinity to browse trees, bushes or shrubs during the early growth season. They would choose to eat the fresh sprouts only.

Lignocellulosic biomass is a source of fibre. Neutral Detergent Fibre (NDF) is the most common measure of fibre used for animal feed analysis. NDF measures most of the structural components in plant cells (i.e. lignin, hemicellulose and cellulose) but not pectin.

More wood in the feed means higher fibre content, lesser freely accessible nutritional content (fat, protein, energy) and lesser digestibility. However, farmers can assist the animal by treating the wood fibres first so that the strong wall structures are broken down. Alternatively, farmers can add supplements to the feed to make the fibres more digestible.

When producing bush based feed it is therefore important to know:

- Younger bushes are less lignified and are more nutritious. Their protein content is higher. Leafier material achieves better results.



Encroacher bush at Okondjatu, Otjozondjupa Region

- Branch size has a major influence on the nutritional value. It is best to use branches with a diameter of less than 2 cm (commonly referred to as "broom stick size").
- To keep the nutritional value of the feed consistent, it is best if the harvested bush is uniform in terms of age and branch size.
- If practicalities do not allow the above, laboratory analyses should be conducted on the harvested bush so that variations in nutritional values can be balanced through the addition of supplements or mineral/chemical additives, like PEG, urea, calcium and phosphorus.
- The MAWF Directorate of Research and Development (DARD) offers chemical analysis for bush material and feed mixtures at a nominal fee (see contact details at the end of this brochure).

SPECIES TESTED

During the trials, the focus was on the utilisation of wood fibres from Black Thorn Bush (*Acacia mellifera* / *Senegalia mellifera*) since the largest part of bush encroachment in the country is caused by this species. However, farmers' experiences and the research showed that also other tree and bush species are a good source of fibre for animal feed. The research investigated the usefulness of the following species, which is also consistent with the experiences of several livestock producers:

- Purple Pod Terminalia (*Terminalia prunioides*)
- Kudu Bush (*Combretum apiculatum*)
- Bush-Willow (*Combretum collinum*)
- Sickie Bush (*Dichrostachys cinerea*) and
- *Grewia* spp.

The following table provides an overview of tested bush and grass samples. Note that these results are context specific and values will differ according to location and season, among other

factors. A comparison with typical grasses as available during the summer (Table 1) and dry months (Table 2) is also provided.

TABLE 1

Chemical composition of six encroacher bush species and grass in the **summer months**

| Month sampled | Species | Moist | Ash | Fat | CP | CF | ADF | NDF | OMD | ME | Ca | P |
|---------------|-----------------------------|-------|-------|------|-------|-------|-------|-------|------|-----|-------|-------|
| April 2016 | <i>Senegalia mellifera</i> | 4.66 | 5.31 | 2.66 | 12.40 | 36.92 | 47.17 | 55.66 | 46.4 | 6.5 | 1.113 | 0.046 |
| | <i>Combretum collinum</i> | 4.64 | 7.49 | 3.17 | 13.00 | 29.34 | 33.21 | 45.86 | 39.4 | 5.3 | 1.656 | 0.063 |
| | <i>Dichrostachy cinerea</i> | 4.61 | 4.74 | 2.24 | 10.50 | 29.96 | 35.30 | 46.67 | 35.0 | 4.8 | 0.759 | 0.090 |
| | <i>Grewia flava</i> | 4.69 | 5.96 | 4.93 | 11.55 | 29.54 | 40.06 | 51.61 | 43.8 | 6.6 | 0.636 | 0.198 |
| | <i>Grewia flavensis</i> | 5.02 | 4.89 | 3.47 | 8.62 | 32.00 | 44.47 | 53.90 | 43.9 | 6.4 | 0.821 | 0.037 |
| | <i>Terminalia sericea</i> | 4.76 | 8.80 | 2.56 | 11.95 | 24.15 | 34.54 | 45.04 | 38.2 | 4.9 | 2.054 | 0.068 |
| December 2016 | <i>Senegalia mellifera</i> | 5.59 | 6.56 | 2.75 | 15.50 | 31.79 | 40.76 | 54.53 | - | - | 1.585 | 0.024 |
| | <i>Combretum collinum</i> | 5.23 | 7.17 | 3.24 | 11.10 | 26.87 | 34.18 | 43.33 | - | - | 1.775 | 0.022 |
| | <i>Dichrostachy cinerea</i> | 6.15 | 4.76 | 2.24 | 13.60 | 30.85 | 41.38 | 55.99 | - | - | 1.034 | 0.016 |
| | <i>Grewia flava</i> | 5.99 | 6.10 | 1.78 | 8.70 | 32.24 | 47.09 | 58.72 | - | - | 1.508 | 0.015 |
| | <i>Grewia flavensis</i> | 6.12 | 5.27 | 1.84 | 8.63 | 35.83 | 48.47 | 58.79 | - | - | 1.281 | 0.016 |
| | <i>Terminalia sericea</i> | 6.25 | 6.44 | 2.75 | 9.95 | 26.89 | 32.41 | 44.84 | - | - | 1.658 | 0.019 |
| March 2017 | Grass* | 7.73 | 11.55 | 1.84 | 10.65 | 27.16 | 31.09 | 54.49 | - | - | - | 0.17 |

Moist = % Moisture (100 - Moisture) = % Dry Matter; Ash = % Ash (100 - Ash) = Organic Matter; Fat = % Fat; CP = % Crude Protein; CF = % Crude Fibre; ADF = % Acid Detergent Fibre; NDF = % Neutral Detergent Fibre; OMD = % Organic Matter Digestibility; ME = Metabolizable Energy (MJ/Kg); Ca = % Calcium; P = % Phosphorus

. = data not available

*The grass indicated in the table was a composite sample of grasses in a grazing camp. The majority of the species were annuals.

Generally, during the summer months, the Crude Protein (CP) content of the bush species is above maintenance level for ruminants. However, the digestibility and energy (ME) is low because of the high indigestible fibre content (ADF) which makes the available nutrients in the bush material inaccessible to the animals. To increase the digestibility, farmers have two

options, either to pre-treat the bush material to reduce the fibre or reduce the proportion of the bush to the concentrate/supplements in the feed mixture. With the pre-treatment of the bush material, the nutritional value should be sufficient and farmers can still feed the material without the addition of supplements.



Bush based fibres in a Bos-tot-Kos machine, during the dry season (July 2016)



Bush based fibres from a Bos-tot-Kos machine, during the summer season (January 2017)

However, it is important to note that during the dry season the nutritional values of bush generally drop below maintenance levels as seen in the Table 2, but it is still acceptable for bush based feed production. Therefore,

it is highly recommended that farmers add energy (e.g. molasses, Enermol™ and Opuntia (cladodes) and protein (e.g. urea, camelthorn pods) supplements to increase the nutrient levels.

TABLE 2

Chemical compositions of six encroacher bush species and grass in the **dry months**

| Month sampled | Species | Moist | Ash | Fat | CP | CF | ADF | NDF | OMD | ME | Ca | P |
|------------------------|-----------------------------|-------|-------|------|------|-------|-------|-------|------|-----|-------|-------|
| | <i>Senegalia mellifera</i> | 5.06 | 6.12 | 2.38 | 6.47 | 35.43 | 46.49 | 63.10 | 47.4 | 6.6 | 1.686 | 0.074 |
| June/July 2016 | <i>Combretum collinum</i> | 5.76 | 10.75 | 2.14 | 7.43 | 30.57 | 42.46 | 49.57 | 38.6 | 4.8 | 3.589 | 0.065 |
| | <i>Dichrostachy cinerea</i> | 5.43 | 6.25 | 1.59 | 9.75 | 39.91 | 57.23 | 70.95 | 43.3 | 5.8 | 1.382 | 0.040 |
| | <i>Grewia flava</i> | 5.96 | 6.58 | 1.78 | 7.29 | 40.43 | 52.56 | 55.65 | 44.8 | 5.7 | 1.945 | 0.051 |
| | <i>Grewia flavensis</i> | 5.66 | 4.05 | 1.31 | 6.15 | 45.90 | 60.36 | 61.07 | 33.7 | 4.7 | 1.189 | 0.053 |
| | <i>Terminalia sericea</i> | 5.80 | 10.15 | 1.90 | 6.30 | 33.61 | 48.05 | 55.47 | 42.1 | 5.3 | 3.196 | 0.047 |
| September/October 2016 | <i>Senegalia mellifera</i> | 3.42 | 4.31 | 2.45 | 9.55 | 40.03 | 49.78 | 63.11 | 38.1 | 5.4 | - | - |
| | <i>Combretum collinum</i> | 3.03 | 11.14 | 1.21 | 5.75 | 32.01 | 44.34 | 51.17 | 37.5 | 4.5 | - | - |
| | <i>Dichrostachy cinerea</i> | 3.78 | 4.23 | 1.77 | 9.09 | 35.90 | 52.28 | 55.36 | 38.9 | 5.4 | - | - |
| | <i>Grewia flava</i> | 3.49 | 5.33 | 1.03 | 5.75 | 38.56 | 53.79 | 65.20 | 36.0 | 4.8 | - | - |
| | <i>Grewia flavensis</i> | 3.13 | 5.33 | 1.11 | 4.95 | 41.42 | 56.87 | 64.43 | 33.3 | 4.4 | - | - |
| | <i>Terminalia sericea</i> | 3.12 | 7.57 | 1.01 | 5.85 | 30.21 | 44.03 | 49.58 | 39.4 | 5.1 | - | - |
| April 2016 | Grass* | 7.93 | 10.02 | 1.32 | 5.03 | 38.15 | 42.70 | 72.08 | - | - | - | 0.24 |

*. = data not available

2 Harvesting bush

A harvesting permit is required for all harvesting operations. Details can be found in the brochure "Forestry and Environmental Authorisation Process for Bush Harvesting Projects" available

for download at www.dasnamibia.org. A decision has to be taken regarding the harvesting method used, based on the machinery which is available or can be bought or rented.

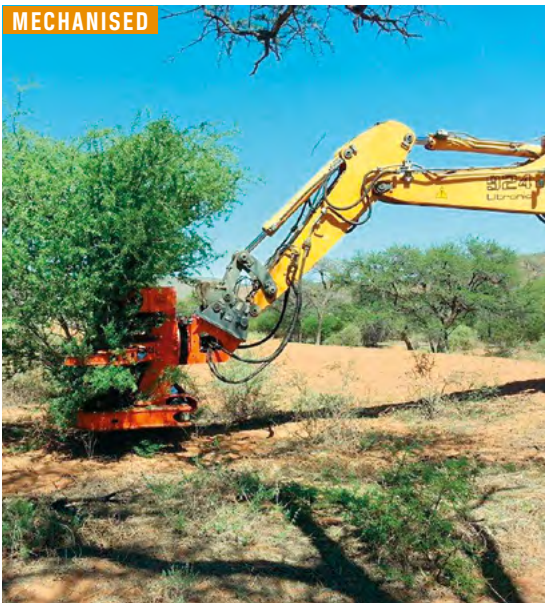
Overview of Harvesting Methods



Example of equipment for manual bush harvesting



Example of semi-mechanised bush harvesting, worker with Bosvreter machine



Example of semi-mechanised bush harvesting, worker with brush cutter (right)

Example of fully mechanised bush harvesting, excavator with hydraulic shear



| Type | Description | Costs |
|------------------------|--|--|
| Manual | <p>Tools include: axes, machete (panga), backsaw.</p> <p>Low skill requirements; knowledge is needed with regard to the type of bush to be harvested.</p> <p><i>Output:</i> One worker can harvest roughly 1 ha per week. This includes de-branching to obtain the material useful for animal feed production.</p> | <p>NAD 350/ha direct labour costs per harvester</p> <p>NAD 250 worth of equipment per worker; lasts approx. 3 working months</p> |
| Semi mechanised | <p>Power tools include: brush cutter, chain saw, bosvreter</p> <p>Skills are required for safe use of equipment, maintenance and care of operations.</p> <p><i>Output:</i> Roughly ½ ha per day, per worker. Operating e.g. brush cutters or chain saws requires that workers only work ½ days with these tools. As workers get tired handling the tools it becomes dangerous to operate them.</p> <p>This includes de-branching to obtain the material useful for animal feed production.</p> | <p>NAD 350/ha direct labour costs</p> <p>NAD 10,000 per power tool, including replacement parts</p> <p>NAD 10 per working hour of operation for fuel and oil consumption</p> <p>Power tools last for > 1 year if well cared for.</p> <p>Chains and blades must be sharpened daily and exchanged after approx. 3 months of continuous production</p> |
| Mechanised | <p>Suitable equipment includes: 75kW machines like front end loader, loggers or excavators.</p> <p>This does not include de-branching to obtain the material useful for animal feed production. Either manual or semi-mechanised operations are additionally needed to obtain the bush material useful for feed production.</p> | <p>NAD 230-780/hr of operation on a rental basis, if farmer does not have equipment available (not including labour, fuel and maintenance costs) or</p> <p>NAD 615-2080/ha, including these costs.</p> <p>New equipment costs between NAD 500,000 for a logger and up to NAD 1,000,000 for a front end loader, of approx. 75k W capacity, large enough to extract bushes suitable for animal feed production.</p> <p>However, if the farmer does not have such equipment available on the farm, normally the cost of buying such cannot be amortised in a viable manner through animal feed production only. The rental option is a more cost effective option, especially as one wishes to harvest bush in the summer period only, for optimal nutritional value in the bush.</p> |

3 Milling and mixing

The branches and twigs should be processed to a milled, fluffy conglomerate of woody and leafy material. Two basic solutions exist to arrive at such milled bush based material: a simple farm solution where the farmer has a hammer mill available or the Bos-tot-Kos "all in one" solution (see information on page 7).

Milling of bush should be done at a central location. It is not practical to transport bushy material in its more or less original form.

For sheep, pass chipped bush material through a hammer mill with a 6 mm sieve. For cattle, feed the chipped bush materials through a stationary hammer mill. A 20 mm sieve would work best for a process in which the milled bush based feed mixture still needs to be pelleted. Fibres tend to break further during pelleting and therefore a bigger sieve size needs to be used. If fibres will not be pelleted, a 16 mm sieve is sufficient.

Please note that bush material does not have to be chipped before it is hammer milled. However, during the trial periods this was done due to the very high volumes to be produced for the trials (more than 30 tonnes of bush fibre material was

produced in less than 3 months). The 2-step approach, i.e. first chipping than milling, brings about cost efficiency. Some machines, like the Bos-tot-Kos machine, are a combination of chipping, milling and mixing equipment.

Hammer mill

The hammer mill should mill the woody and leafy material into milled material of lengths up to 30 mm. To obtain such fibre lengths, the preferred sieve size in the mill should be 20mm.

If the bush based feed should be fed to the animals on the same day, the farmer should optimally also have a cement mixer (or similar equipment) available. The bush fibres together with the supplements are fed into the mixer and, after adequate mixing, can be taken out and immediately fed to the animals.

If the intention is to first produce bush based fibres, the freshly milled fibres must be dried by spreading them out on a canvas in a layer of not more than 10cm thick. Under dry, sunny conditions, such fibres dry to a moisture content below 10% on a weight basis. Such low moisture content is necessary to prevent mould in the fibres during storage. Mould in the bush based fibres will cause unease and illness in animals.



Hammer mill at Farm Langbeen, Khomas Region



Community members at Okondjatu setting up the Bos-tot-Kos machine

Bos-tot-Kos

The Bos-tot-Kos offers a one-step approach by chipping (first step) and milling (second step) bush material and mixing it with supplements. The bush material can be fed into the mill and supplements can be added into the mixing drum. The ready-made bush based feed can be extracted through an opening in the drum at the bottom. Animal feed produced in this way must be fed to the animals on the same day.

Mixing

Thorough mixing of the different diet components is essential to avoid selective feeding by animals. For example, molasses tends to form balls with parts of the mixtures when not well mixed and animals can selectively feed on those balls. The particle size also influences this selection, e.g. when *Opuntia* is not grinded to the same particle size as the other feed components, it can be picked up by the animals easily.

In addition, a mixture with liquid molasses must first be dried again for pelleting. Otherwise the pelletizer becomes congested with sticky biomass which cleans with great difficulty.

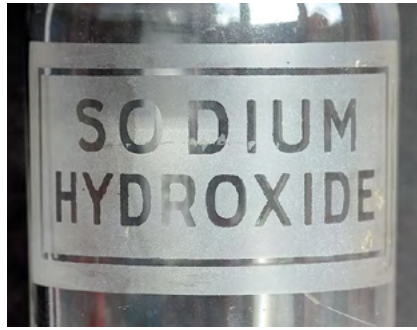


Milled bush material in container for manual mixing

| Type | Description | Costs |
|---|--|---|
| Hammer mill | <p>Low skills requirements.</p> <p>Use of personal protective equipment is essential to protect especially the eyes from back-firing twigs and branch material during the milling process.</p> | <p>Up to NAD 80,000 for a new hammer mill with an output of 750-1,500 kg/hr of milled material. The typical capacity would be between 15-45 kW.</p> <p>All these models are available on wheels or three-point hitch with a PTO shaft. They can also be stationery and driven by electric motors or diesel engines. Farmers generally prefer the version attachable to a tractor (hitch with PTO shaft), as it can be used in-field easily.</p> <p>For the small-scale farmer, the small hammer mill presents a cost effective, sensible and practical option. The benefits are low investment and low running costs, minimal maintenance, faster milling times and more hygienic milling conditions.</p> |
| Mixer | <p>Manual: Only an option when very few animals (less than 20) need to be fed with bush based feeds. It is then suggested that each portion of feed is mixed on a daily basis, directly in the feeding trough. Any type of cement mixer or feed mixer will do.</p> <p>In general, low skills are required. Particular skills are required for the consistent preparation of the diets themselves.</p> | <p>Cement mixer: from NAD 50,000 for a drum capacity of 150 litre; self-propelled with a two-stroke or petrol engine. This equipment is ideal for small farm operations with up to 100 animals to be fed daily.</p> <p>Feed mixer: NAD 100,000 for drum mixing capacity of up to 400 kg of feed. These are generally self-propelled with a small attached engine. These are best suited for large farm operations, where > 100 animals need to be fed daily.</p> |
| Bos-to-Kos hammer mill-mixer combination | <p>Medium skills for direct operation of the equipment.</p> <p>High skills required for maintenance of knives and other parts. As this equipment is a self-contained system driven by an additional small generator, daily manager supervision is required. After every 6 weeks of operation a full service is required. Knives must be checked at least weekly.</p> <p>Output: up to 2 tonnes of feed per day</p> | <p>NAD 750,000 for a full system.</p> <p>Components:</p> <ul style="list-style-type: none"> ● Tomcat chipper ● integrated hammer mill (incl. 3 sieves of which 12 mm is mostly used) and mixer ● 40 kVA Deutz generator ● Bosvreter for bush cutting ● Stihl brush cutter <p>The manufacturer and supplier of the equipment is South Africa based. There is no Namibian-based agent available which is a problem in case of dysfunction. Generally, third party equipment suppliers do not help in such situations due to warranty and guarantee matters. If the daily bush based fibre production is not at least 2,000 kg, this type of equipment is not cost efficient.</p> |



The chemical Sodium Hydroxide can be used to pre-treat wood fibre in order to increase its digestibility. Precautions must be taken, as high concentrations of NaOH will have negative effects on animal health.



4 Treatment of bush based fibres

Pre-treatment

Before adding supplements, the milled bush can be pre-treated to improve the digestibility and thus the nutritional value of the bush. There is a wide range of possibilities:

- chemical treatments: soaking in water with or without a weak acid like NaCl-solution, NaOH, KOH, fermentation induced by mixing the milled bush with a saturated sugar-solution or yeast,
- physical treatments: chipping, milling, pelleting and more,
- physio-chemical treatments: combining the afore-mentioned treatments,
- biological treatments: enzymes, white rot fungi, mushrooms, or more.

NaOH treatment

The most widely used method in Namibia is the pre-treatment of milled bush with "rumen soda" (Sodium Hydroxide or NaOH). The use of NaOH is the most feasible method under small to medium-scale farming conditions. Aspects to know about NaOH include:

- The use of NaOH lowers the already low nitrogen content in bush based feeds. This is why it is advisable to combine it with supplements.
- NaOH is used to make bush based feed more digestible. NaOH does not make bush based feed tastier (palatable). Palatability should be improved by using supplements like maize or milled chop and stover (leaves

NaOH TREATMENT TEST RESULTS

The pre-treatment of milled bush with a 2.5%-NaOH solution (based on weight of the milled bush) before adding supplements has worked well in the tests. The milled wood fibres were treated with NaOH after milling. The NaOH-dilution was mixed and then sprayed over the milled bush and mixed in. The mixture was left to ferment for two to four days.

Care must be taken when NaOH crystals are added to water. Tests showed it is easiest to take a 25-litre bucket, add the water first, and then add the NaOH dry matter into the water while stirring. It was found that if NaOH is mixed in larger quantities, the mixture becomes easily saturated and forms hard sediment at the bottom of the bucket. The mixture required constant stirring until all crystals were dissolved.

and stalks of field crops, such as maize or sorghum). Mixing with molasses and lick supplements like Rangeland Grower™ also assists palatability.

- The treatment of the milled bush with concentration values of higher than 3% (based on the weight of milled bush to be treated) should be avoided. The palatability of the bush based feed does not necessarily improve and animals increase their water intake. Also, macroscopic analysis of rumen tissue showed that it darkened at a level of 10% (on a weight basis). This suggests that higher than 3%-NaOH pre-treatment levels of milled bush may affect the rumen tissue health.
- The pre-treatment of bush based fibres with NaOH is potentially dangerous. The dilution process of NaOH with water generates heat. The mixture itself has a pH-value of 14 and thus is highly corrosive. Contact with bare skin may cause serious burns. Protective clothing and eyewear must be worn during the whole process.
- A wooden object is required to stir the mixture; a metal-type object would result in an unnecessary, heavy chemical reaction between the stirring element and the NaOH-mixture.
- The mixture must cool before use. All crystals must be diluted before the mixture is added to the bush-biomass.

Drying

Biomass pre-treated with NaOH must be sufficiently dried before supplements can be mixed in. The mixture can be dried in the sun. If the pre-treated bush is not dried before mixing it with supplements, there is danger that the feed will spoil – even if it is stored for only a few days. Another reason for drying is that the bush fibres lose the smell of the chemicals. Potassium as well as Sodium Hydroxide have a very strong odour, not liked by livestock. The drying process alleviates the smell to a great extent.



Harvested and milled encroacher bush spread out on plastic sheeting for drying



5 Supplements for bush based fibres

Supplements are mixed with bush based fibre material in order to produce a nutritious animal feed. The adding of supplements can be done with or without a pre-treatment of the milled bush.

For the purpose of formulating diets, farmers are encouraged to utilise the feed materials they have available on-farm and supplement them with commercial ones only when locally grown supplements are not sufficiently available. For commercial supplements, Rangeland Grower™ is interchangeable with Enermol™. Where Enermol™ is added, the farmer may exclude molasses, as Enermol™ already contains molasses powder.

Bush Improver Lick™ can be exchanged with PEG6000 or Browse Plus but may not exceed 2 grams per animal and day in total. However, if the farmer is not directly involved in the mixing process, it is suggested that rather Bush Improver Lick™ is utilised to prevent overdosing of PEG.

Please note that the below list of selected supplements is not exclusive. Specific commercial supplements are mentioned because they have been tested during the trials. Other commercial supplements may be equally suitable.

Polyethylene glycol (PEG)

Polyethylene glycol (PEG) is a polyether compound with many applications from industrial manufacturing to medicine. It is used in the feeding industry due to its activity as tannin binding substance. Tannins are considered to be anti-nutritional factors that can bind proteins, hampering their utilisation by the animals. PEG binds tannins, steering the protein clear for the animals' uptake.

The amount of PEG that can be included in such feed is limited to a few grams (normally less than 5g) per kilogramme of dry bush based feed. It is important that the instructions for inclusion of PEG in the feed are followed exactly, else animals could die. Consumption of pure, undiluted PEG is deadly. PEG may only be administered as part of a diet and is for ruminant feed only.

Opuntia (Prickly Pear)

Opuntia ficus-indica, commonly known as "Prickly Pear", is a cactus species widespread in semi-arid and arid regions of the Americas, Africa, Asia, Southern Europe and Australia. It is a valuable source of forage, water and energy for livestock in dry areas and has shown to be a good source of energy in animal feed in Namibia. In the tests, it was included in a diet at 10% on a weight basis. The cladodes of Prickly Pear should be chopped, dried and milled before being added to the bush based feed mixture.

Note: Fresh Prickly Pear cladodes do not mill well and will cause your equipment to be clogged, causing unnecessary stoppages.



Farm grown Opuntia (Prickly Pear) with irrigation system



Namibian *Vachellia erioloba* (Camelthorn) tree with pods. © Wikimedia: Potgietersrust, Transvaal, South Africa

Camelthorn pods

Vachellia erioloba pods, commonly known as Camelthorn pods, have been used by farmers for decades as a protein supplement for ruminants especially in winter months. The pods contain high protein content ranging between 14-18%. In the tests pods were added in two of the diets at 40%, on a weight basis. Farmers reported that even low inclusion rates have improved the nutritional value of the animal feed. It is important that the pods are milled to almost powder to assure they have the greatest nutritional value. If the seeds are not crushed or milled well, they will pass through the animals' stomach without being utilised.

Urea

Urea is a non-protein nitrogen (NPN), i.e. not natural protein source for ruminants. Microbes in the rumen are able to metabolise NPN compounds to produce ammonia which is used by the microbes for their protein synthesis. This protein will be available for absorption through the gastrointestinal tract. Thus, the microbes help the animal by producing the protein within the rumen during digestion and therefore supplying the ruminating animal with a source of energy. If the microbes are not supplied with nitrogen on a regular basis they die and the

animal will run out of a source of protein and thus energy.

Feed Grade Urea usually has a typical value of 287.5 percent equivalent crude protein for ruminants. In the tests urea was used in two of the diets at a 2% inclusion level, on a weight basis.

Non-Protein Nitrogen such as urea can be used as an alternative nitrogen source but natural protein, contained at high concentrations in Lucerne, fish oil or meal gives better results in terms of growth of animals. Natural protein can be readily digested by ruminants and is therefore a direct source of energy to the animal. However, as access to Lucerne and fish oil/meal is often limited in Namibia (especially Lucerne during drought periods), farmers revert to the use of Urea as a source of nitrogen for protein production.

Molasses

Adding liquid or watered molasses powder makes the bush based fodder more palatable. Molasses is a by-product of the sugarcane industry. It is used as feed supplement since it is inexpensive, increases palatability and decreases the dustiness in the feed during



Molasses used as ingredient for animal feed

mixing processes. Its metabolisable energy content is usually around 9 MJ/Kg; its protein content is around 6%. Molasses, being sugar-based, is a direct source of energy.

Note: Because of its tastiness and nice smell, it is eagerly eaten by livestock. Care should therefore be taken not to include it at levels higher than 15% on a weight basis in the bush based feeds. With a too high molasses content in feed, animals will tend to eat excessively, which may cause bloating and ruminating problems in the animals. The problems are caused when the bush based fibres get stuck in the oesophagus during the animals ruminating phase, then causing it to suffocate and possibly die. Farmers have reported such behaviour.

Rangeland Grower™

This is a commercial supplement based on natural protein sources (mainly oilcakes). It also contains abundant sources for energy (as it also contains molasses powder) and can be used both as energy and protein source. Its protein content is around 17%. Rangeland Grower™ can be used as a supplement in the bush based feed mixture or provided to animals as a lick.

Tip: It is recommended that regardless of the amount of bush based feed given to each animal daily, not more than 500 g of this supplement is provided per large livestock (cattle) per day. A reduced amount of approximately 100 g per small stock per day can be fed. The supplement or lick is rather costly, and feeding each cattle, goat or sheep with more will increase the farmer's operational costs unduly if a normal growth or maintenance feed is aimed for.

Bush Improver Lick™

This commercial supplement is a ready-mixed maintenance lick for ruminants that utilise bush resources. It is especially useful in dry or drought periods and when the bush is budding in spring time. This lick contains tannin inhibitors, like PEG, which bind tannins in the bush and improve its nutritional value. Its protein content is around 25%. However, as it contains non-protein nitrogen, hence it should be used with caution and fed according to instructions.



Pelleting dye of the pelletiser tested at Farm Langbeen



Inside view of the pellet press

6 Pelleting

A combination of first pre-treating the milled bush, then drying and mixing it with supplements and lastly pelleting it, is a great possibility to improve the palatability, digestibility and storability of bush based animal feeds.

Pelleting is especially recommended when the farmer wishes to supply bush based feed over the whole year. The feed pellets can be stored over a period of up to 9 months, depending on their content. A 10 mm pellet is optimal. The pellet-mixture should be moist, not wet.

It appears that not all pelletizers are able to handle bush as the material characteristics are considerably different to normal substances like Lucerne, grass or various types of hay. Some pelletizers generate too much heat during the compression process, which can change the characteristics of substances, for example of molasses. However, for wood fibres, heat is necessary. It helps the wood fibres bind with the supplements and among each other. In addition, the somewhat heated wood fibres assist with improved palatability and digestibility of the animal feed.

Further considerations are that the ideal machine should be easy to maintain and operate by semi-skilled labourers in rural environments. Thus, typical extruder pelletizers seem to be less suitable for the use in on-farm production systems. Appropriate care should be taken to purchase a machine that is:

- able to pelletize bush,
- does not generate extreme heat during the process,
- can pelletize molasses sprayed on roughage in a liquid form,
- can pelletize roughage with fibre lengths of larger than 12 mm, and thus produce pellets with a diameter of at least 10 mm,
- is easy to operate in African rural environments, and
- is easy to maintain.

Pelleting is best accomplished by installing the equipment close to the storage shed in a place where three-phase electricity is available. In the start-up phase, peak electrical output is required. For example, a 3-6t/day-pelletizer would require at least 65kW at start-up and 55-60kW during operation.



Bush based animal feed pellets directly after production



Full view of the Jones pelletiser tested at Farm Langbeem

EXPERIENCE WITH THE JONES PELLETIZER

For the trials, the Jones Pelletizer, a South African development was used. It is considered a suitable and simple to operate and easy to maintain machine. The operating temperature of the pelleting chamber is between 50 and 60 degrees Celsius. The size of roughage can be between 6 and 20 mm resulting in major cost savings in milling cost. The machine seemed to be not very sensitive to humidity in the roughage and little difficulties were experienced when pelleting molasses fluid in the mixture.

The Jones Pelletizer utilises a vertical-pressing process to pelletize, resulting in reduced spillage. The machine is equipped with a strong magnet eliminating any metal from entering the pelleting chamber. An oil circulation pump lubricates the bearings and, as a safety mechanism, the machine will not start-up before the circulating pump is circulating oil to the bearings. A disadvantage identified is the setting of the roller/dice tolerance but it was possible to easily train staff members to do this adjustment.

| Type | Description | Costs |
|-------------------|--|---|
| Pelletizer | <p>Semi-skilled labour is key for daily operation. Skilled labour is required for maintenance and adjustments.</p> <p>Skilled labour is also recommended during start-up of the machine on a daily basis.</p> <p>Output: 800 – 1,200 kg/hour</p> | <p>NAD 250,000</p> <p>It should be ensured during procurement that all parts of the machine are available. Key parts are:</p> <ul style="list-style-type: none"> ● 60-65 kW s/d starter with oil circulating pump, ● 12 mm die ● 2 Magnet blocks set in a housing ● 250 mm trough sliding belt conveyer complete with intake hopper and intake screw ● 250 mm trough sliding bed feeding belt conveyer to cooler container ● Cooler incl. fan with bag of slide at bottom ● electric starter, incl. cabling system |



Open drying of feed mix on plastic sheet at Okondjatu



Storage facility at MAWF Omatjene Research Station

7 Storing of milled bush material and bush based feed mixes

Both milled bush and bush based feed mixes should be properly dried before being stored. It is recommended that the moisture is reduced to 12% or less.

Farmers should use storage/packaging materials that allow ventilation of the milled bush or feed mix to minimise the growth of mould. Storage of the milled, dried feed can for example be done in 1m³ bags, thereafter weighing some 350 kg. Second hand bags can usually be obtained from bulk operators, e.g. sugar packers.

When preparing your storage facility:

- prevent direct contact with sunshine and moisture
- ensure ventilation
- provide protection from insects and rodents

Material should not be stored longer than one winter season. Longer periods of storage can lead to spoilage, which reduces the feed quality and its shelf-life. Especially mixed feed is prone to attract rodents or become rancid (especially when it contains ingredients such as molasses or oilseed cakes). Pest control not harmful to livestock is a possible remedy.

8 Calculations and costs

Calculating operations

- Determine the heads of cattle that need to be fed.
- Determine the diet you wish to provide to your livestock – maintenance or survival during droughts or production based.
- It is suggested that you provide 3 kg of bush based feed per animal per day (see explanation on page 18). [insert page link](#)
- Establish which equipment you have available and consider which equipment you may need to rent or buy before you can get started with animal feed production.
- Determine the capacity (highest possible throughput per day) of your hammer mill.
- Determine how you will mix your daily/weekly rations. Determine thus the mixing volume capacity. You can mix far less bush based feed in one drum on a weight basis than you would normally do with cement.
- Determine the capacity for drying and storage (roofed shelter) of your produced/ milled bush material.
- Determine how many bags you have for packing either your milled, dried bush and/or storing the prepared bush based animal feed for a period of time.



Worker with cattle: infrastructure, labour and equipment available influence the production

- Consider the transport needs of your operations (moving the equipment in the field and the material from the field to a location for further processing, drying and/or storage).

Labour costs

- Workers need to be paid at least farm workers minimum wage.
- All workers need to receive personal protective equipment (PPE).
- The normal working hours for farm workers apply, on average 198 working hours per month (i.e. 5.5 days per week).
- Sunday work is necessary for feeding livestock, but not for producing bush based animal feed.
- Determine if your workers are trained on harvesting and milling bush.



Labourer feeding machine with selected bush branches

Example of a cost calculation

The following table provides a sample calculation for bush based feed production. It is based on the assumptions that 500 heads of cattle are to be fed for one month and a Bostot-Kos machine is used (note that more simple production technology leads to decreased costs). A large number of cattle was used for the calculation to demonstrate economies of scale. Farmers with significantly lower number of animals can consider to produce feed in cooperation with neighbouring farmers to achieve similar efficiencies. Moreover, it was assumed that the farmer will have some of the proposed equipment available on the farm and will not only buy such once the drought is eminent. The calculations are further based on commercial supplements, as opposed to natural supplements that might be available on farm. Such commercial supplements are normally more readily available to the farmer during a situation of drought, than natural supplements like Lucerne, or camel thorn pods. See pages 26-29 for an overview of proposed diets.

BUSH BASED ANIMAL FODDER - COST CALCULATION TOOL

download at www.dasnamibia.org

| | | | | AMOUNT | UNIT | | |
|-------------------------|------|------------|-----|---------------------------------|---------------------------|-------|----|
| 1. Heads to feed | | | | | | | |
| Cattle | 3.00 | kg per day | 500 | cattle to be fed / day | 85 % bush inclusion level | 1,275 | kg |
| Sheep | 1.00 | kg per day | 700 | sheep to be fed / day | 0 % bush inclusion level | - | kg |
| Other livestock | 1.50 | kg per day | 0 | other livestock to be fed / day | 0 % bush inclusion level | - | kg |

Step-by-step explanation

1. Choose the type of animal you want to feed; use a separate worksheet for each type of animal, i.e. each type of diet
2. Estimate the daily feed consumption per head
3. State the planned bush inclusion level

| 2. Fixed costs for operating equipment* | | | | | | | |
|--|--------|------------|--|-------|-----------------------------|-------------|---------------|
| Bos tot Kos machine | 585.00 | NAD per hr | | 2,200 | kg fibre production per day | 2.13 | NAD/kg |
| 2 Mowers | 37.93 | NAD per hr | | 7,650 | kg bush harvesting per day | 0.04 | NAD/kg |
| Chainsaw | 10.85 | NAD per hr | | - | kg bush harvesting per day | - | NAD/kg |
| Brush cutter | 11.29 | NAD per hr | | - | kg bush harvesting per day | - | NAD/kg |
| Circular saw | 19.78 | NAD per hr | | 7,650 | kg bush processing per day | 0.02 | NAD/kg |
| Front-end loader | 152.86 | NAD per hr | | - | kg bush harvested per day | - | NAD/kg |
| Excavator | 780.00 | NAD per hr | | - | kg bush harvested per day | - | NAD/kg |
| Hammer Mill | 71.74 | NAD per hr | | - | kg bush harvested per day | - | NAD/kg |
| Small Scale Mixer (400L) | 2.93 | NAD per hr | | - | kg feed mixed per day | - | NAD/kg |
| Large Scale Mixer (6m ³) | 20.61 | NAD per hr | | - | kg feed mixed per day | - | NAD/kg |
| Pellitiser | 42.16 | NAD per hr | | - | kg feed pelleted per day | - | NAD/kg |
| Sub-Total | | | | | | 2.19 | NAD/kg |

4. Decide on the type of machine(s) you are going to use (selection on separate spreadsheet)

*Note:
The amount of bush to be harvested is higher than the required fiber for the feed. This is because not the entire bush is used for the animal feed, but only the smaller branches, twigs and leaves. In this calculation the factor 6 was applied; while 1,275 kg of bush fiber are required for the feed, 7,650 kg of bush need to be harvested.



3. Cost of harvested and processed bush material

| | | | | | | | | | |
|----------------------------------|-------|-------------------|--------|-------------------------------|-------|-----------------------------|------|--------|--------|
| Bush harvesting labour (total) | 2 | persons × | 172.00 | costs per day ÷ | 3,528 | kg bush harvested per day = | 0.10 | NAD/kg | |
| Bush harvesting fuel (Diesel) | 10.71 | price per liter × | 171.36 | costs per day ÷ | | kg bush produced per day = | | NAD/kg | |
| Bush harvesting fuel (Petrol) | 10.82 | price per liter × | 86.56 | costs per day ÷ | | kg bush produced per day = | | NAD/kg | |
| Bush harvesting (hour) | | | | costs per equipment per day ÷ | | kg bush produced per day = | | NAD/kg | |
| Bush chipping/milling labour | 2 | persons × | 172.00 | costs per day ÷ | 2,100 | kg bush harvested per day = | 0.16 | NAD/kg | |
| Bush chipping / milling (diesel) | 10.71 | price per liter × | 14.54 | liters used per day ÷ | 2,100 | kg bush produced per day = | 0.07 | NAD/kg | |
| Sub-Total | | | | | | | | 0.34 | NAD/kg |

- ▶ 5. Insert number of people employed for harvesting
- ▶ 6. Insert number of people employed for chipping/milling
- ▶ 7. Amend diesel/ petrol costs if applicable
- ▶ 8. Add the total daily output of your labourers (harvesting, processing)

The tool calculates the total cost of harvested and processed bush material per kg; this number is a good indicator of the **value of your bush material**

Total cost of harvested and processed bush material 214.46 NAD/100 kg

4. Costs of additives/supplements

| | | | | | | | | |
|-----------------------|----------|--------------------|----|-----------------|----|---------------------------|-------|------------|
| Enermol | 192.00 | Price per bag ÷ | 40 | kg per bag × | | kg added per 100kg feed = | | NAD/100 kg |
| Enerfeed | 252.00 | Price per bag ÷ | 40 | kg per bag × | | kg added per 100kg feed = | | NAD/100 kg |
| Bush Improver Lick | 206.16 | Price per bag ÷ | 50 | kg per bag × | | kg added per 100kg feed = | | NAD/100 kg |
| Camel thorn pods | 2.50 | Price per kg | | | | kg added per 100kg feed = | | NAD/100 kg |
| Rangeland grower | 222.33 | Price per bag ÷ | 50 | kg per bag × | | kg added per 100kg feed = | | NAD/100 kg |
| Urea | 195.00 | Price per bag ÷ | 50 | kg per bag × | 2 | kg added per 100kg feed = | 7.80 | NAD/100 kg |
| Molasses without Urea | 152.88 | Price per bucket ÷ | 25 | kg per bucket × | 13 | kg added per 100kg feed = | 79.50 | NAD/100 kg |
| Molasses with Urea | 163.00 | Price per bucket ÷ | 25 | kg per bucket × | | | | NAD/100 kg |
| Opuntia | 1.30 | Price per kg | | | | kg added per 100kg feed = | | NAD/100 kg |
| Browse Plus (PEG) | 1,480.37 | Price per bucket ÷ | 10 | kg per bucket | | kg added per 100kg feed = | | NAD/100 kg |
| NaOH | 14.91 | Price per bag ÷ | | | | | | NAD/100 kg |

- ▶ 09. Insert current retail prices and size of sales units (in separate spreadsheet)
- ▶ 10. Add the amount of additives and/or supplements for your mix



| | | | | | | | | |
|---|--------|----------------------------|------|---------------|--|-------------------------------------|--|-------------|
| Grass | 80.50 | Price per bale ÷ | 18 | kg per bale | | kg added per 100kg feed = | | NAD/ 100 kg |
| Lucerne | 95.65 | Price per bale ÷ | 18 | kg per bale | | kg added per 100kg feed = | | NAD/ 100 kg |
| Feedlot feed mix of your choice | 277.23 | Price per bag ÷ | 50 | kg per bag × | | kg added per 100kg feed = | | NAD/ 100 kg |
| Special bush supplement mix for pellets | 310.00 | Price per bag ÷ | 50 | kg per bag × | | kg added per 100kg feed = | | NAD/ 100 kg |
| Transport | 32 | Total cost for transport ÷ | 8000 | kg per load × | | total kg additives per 100kg feed = | | NAD/ 100 kg |

Total cost of additives/supplements **87.30** NAD/ 100 kg

Depending on your mix and source of additives/supplements, these can be a major cost factor

5. Cost of drying and mixing

| | | | | | | | | | |
|-------------------------------|-------|----------------------------|-------|-------------------------|-------|--------------------------|------|---------|---------|
| Feed Mixing (Fuel) | 10.71 | price per litre × | 20.00 | litres used per day ÷ | 2,100 | kg feed mixed per day = | 0.10 | NAD/ kg | |
| Transport to drying yard | 5.00 | km travel to drying yard × | 12.60 | price per km = | 63 | total distance travelled | 0.03 | NAD/ kg | |
| Drying labour to spread bush | 2.00 | hours to spread bush × | 5.00 | price per labour hour = | 10 | total costs for work | 0 | NAD/ kg | |
| Drying labour to collect bush | 2.00 | hours to collect bush × | 5.00 | price per labour hour = | 10 | total costs for work | 0 | NAD/ kg | |
| Transport back to mixing | 5.00 | km travel to drying yard × | 12.60 | price per km = | 63 | total distance travelled | 0.03 | NAD/ kg | |
| Mixing labour | 8 | hours to mix feed × | 10.75 | cost per hour = | 86 | total costs for work | 0.04 | NAD/ kg | |
| (Sum of all of the above) | | | | | | | | 0.21 | NAD/ kg |

▶ 11. Amend only if these costs do not apply to your operation or differ significantly

100.00 kg × 0.21 price per kg **Total drying and mixing costs per 100kg feed** **21.25** NAD/ 100 kg

6. Cost of pelleting

| | | | | | | | | | |
|----------------------------|-------|-------------------|--------|-----------------------|-------|----------------------------|------|---------|---------|
| Bush feed pelleting labour | 2 | persons × | 172.00 | costs per day ÷ | 2,100 | kg bush produced per day = | 0.08 | NAD/ kg | |
| Bush feed pelleting fuel | 10.71 | price per liter × | 20.00 | liters used per day ÷ | 2,100 | kg bush produced per day = | 0.01 | NAD/ kg | |
| (Sum of all of the above) | | | | | | | | 0.09 | NAD/ kg |

▶ 12. Reduce to zero, if you do not pelletise your feed

100.00 kg × 0.09 price per kg **Total pelleting costs per 100kg feed** **9.1** NAD/ 100 kg



| 7. Cost of bagging | | | | | | |
|--------------------|------|-----------------|---|---------------------|--|-----------------|
| Large bags | 7.80 | Price per bag × | 2 | bags per 100kg feed | | 15.6 NAD/100 kg |

► 13. Amend the price and number of packaging material that you use

| 8. Maintenance costs | | | | | | |
|------------------------------|--------|------------------------------|-------|---|--|-----------------|
| Lump sum for every 250 hours | 128.92 | Per service incl traveling ÷ | 1,083 | Average equipment capacities - maximum kg feed/ day | | 11.9 NAD/100 kg |

► 14. The maintenance costs are based on a general formula; only change if you have more precise figures for your production setup

| 9. Overhead costs | | | | | | |
|--|--|--|--|--|-------|-----------------------|
| Manager or owner & other administrator costs | | | | | 7 | % of total feed costs |
| | | | | | 24.54 | NAD/100 kg |

► 15. Change percentage, depending on whether a field manager or similar is employed to oversee production

| Total cost per 100kg bush based feed | | | | | | |
|--|----|--|--|--|---------------|-------------------|
| Add penalty for less than optimal production | 10 | % of production for penalty if daily production is smaller than 350kg feed mix per day | | | | 0 NAD/100 kg |
| Add profit, at least 20% | 20 | % profit | | | | 75.01 NAD/100 kg |
| Total sales price per 100kg: | | | | | 450.05 | NAD/100 kg |

► 16. Amend profit margin, depending on your business model and market

This is the total **value of your bush based animal feed**. Assess its economic viability by comparing this value with the sales price of alternatives, e.g. commercially available feed.

Diet Recommendations

The following recommendations on how to define feed diets must be understood with caution. No universal diet exists and local context factors must be taken into consideration.

Considering the feed purpose

All bush based mixtures should be formulated with consideration of the nutritional requirements of the animals to be fed. This includes the following factors, among others

- age (growing vs. mature)
- physiological status (pregnant vs. lactating) and
- production system (feedlot/intensive vs. grazing with supplementation)

PURPOSE OF THE BUSH BASED DIETS TESTED IN TRIALS

For the trials, the diets were meant to meet the following types of nutritional needs in livestock:

- Growth of young animals,
- Maintain the body condition, e.g. during the dry or winter season, and/or a period of drought, and
- Maintain the body condition in pregnant and/or lactating cows

The bush based diets tested and provided in this manual are not exhaustive. Farmers need to modify the maintenance and production mixtures according to available resources and nutrient requirements of the animals.

Such diets can then also contain natural supplements like camel thorn pod meal, bush based fibres, prickly pear, and/or commercial supplements. The priority should be to harvest on-farm natural supplements where possible and then augment the feed with the necessary commercial supplements.

When defining feed mixes, consult persons with relevant experience in feed formulation for guidance or make use of relevant literature, e.g. the Nutrient Requirement Tables for Beef Cattle and Sheep of the National Research Council (NRC).^{*} Further, consider to take a sample of your feed mixtures for laboratory analysis to confirm its nutritional value.

The MAWF Agricultural Laboratory can be of assistance in first testing the available biomass from your farm and then help to formulate a diet suitable for the animals to be fed. See contact details at the end of this manual.



Depending on the purpose of the feed, different mixtures apply

Considering daily feed intake

There is a distinct difference in daily feed intake among cattle, depending on their age and related factors. Young cattle, heifers and steers/oxen have a need for an increasing daily feed intake. As young cattle grow, this means that the amount of feed they need on a daily basis increases proportionately with their body weight increments. Therefore, more fodder needs to be produced during the period of growth and production of a young cattle herd. Regular, e.g. monthly, weighing of these animals is needed to ensure that they receive enough fodder continuously.



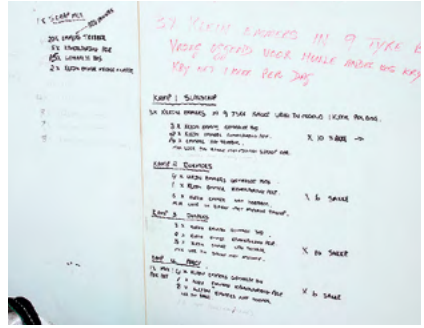
- Usually, weaned cattle weigh around 150-190 kg. Their total recommended daily feed intake needs would then range between 4.50 to 6.00 kg.
- There is a difference between covering the feed intake need for young cattle kept under intensive or semi-intensive and/or extensive feeding conditions. The formulation of feed intake of cattle reared in captivity (feedlot situation) would have to cover for the animals' roughage and energy feed intake needs in one diet. Here, the recommended total daily feed ration should amount to at least 4.5 kg and be fed ad lib. For young cattle roaming freely, part of the roughage and energy needs can be covered by grazing. The ration can be reduced after having taken into account the grazing or rangeland conditions and having weighed the animals for providing them with the bush based feed.

Depending age and feeding conditions of the cattle, the needed daily supply with bush based feed varies

Sheep feeding on bush based animal feed (left)



Noticeboard with planned feeding rations for groups of sheep (right)



Sheep

Sheep, other than goats, do not readily browse on shrubs and bush. Sheep prefer to eat grass. Their

affinity for bush based fodder is very low. However, they can be taught to eat bush based feed.

SHEEP FEEDING TRIALS

Intensive sheep feeding trials were conducted in the period of July 2016 to September 2016 on farm Langbeen, situated in the commercial farming area close to Dordabis.

The tests evaluated the growth performance of 36 growing lambs fed with different diets containing between 50% and 85% of bush based fibres and under intensive feeding conditions.

During the trials, freshly milled bush was mixed with a number of supplements and The sheep were grouped into six groups of six animals each and fed the following diets:

- 6 animals were used as a control group and received a mixture of grass (80%) and Lucerne hay (20%)
- 6 animals received a mixture of 85% bush material, 2% urea and 14% molasses
- 6 animals received the same mixture as above, with PEG 6000 (0.5 grams per animal/day) added in order to improve the palatability of the bush based feed
- 6 animals received a mixture of 50% bush material, 40% Camelthorn pot meal and 10% molasses

- 6 animals received a mixture of 50% bush material, 10% sun-dried and chopped *Opuntia cladodes* and 40% Camelthorn pod meal
- 6 animals received a mixture of 65% bush material, 15% Bush Improver Lick, 10% Rangeland Grower and 10% molasses

It was concluded that a total daily allowance of 1 kg of bush based feed is considered sufficient for sheep under intensive feeding conditions. Under extensive feeding conditions, the amounts can be halved.

Furthermore, positive growth results were achieved with natural supplements. This is particularly encouraging as most often such supplements are readily available on the farms. Especially farms in southern Namibia grow Prickly Pear and many river beds have Camelthorn trees.

The diet containing PEG, suggested for drought periods, was unable to maintain the weight of the animals. However, since only one inclusion rate of PEG was tested, more research of its inclusion rate in bush based diets may be needed.



Cattle

CATTLE FEEDING TRIALS

Feeding trials with cattle were carried out at the commercial farm Langbeen near Dordabis and at Omatjene Research Station near Otjiwarongo in the period from January to May 2017. Feeding at Omatjene took place under feedlotting conditions. Further feeding trials were conducted in an extensive feeding environment on communal farmland at Okondjatu in near Okakarara from September 2016 to January 2017.

The objectives of the cattle weaner intensive feeding trial were to evaluate the growth performance of 40 growing female and male cattle, 20 heifers and 20 steers respectively. They were fed different bush based diets, containing 50% of bush based fibres.

→ A group of 8 cattle (4 heifers, 4 weaner-bulls) were grazing only and no lick or supplement was provided.

- A group of 10 (5 heifers, 5 steers) were allowed to graze and were supplemented with licks (with Bush Improver Lick™ at 500g/animal/day in January 2017 and with Rangeland Grower™ at 500g/animal/day February to May 2017).
- Semi-intensive cattle weaner feeding trials were performed to evaluate the growth performance of 32 growing female and male cattle (weaners) which were fed different bush based diets containing 50% of bush based fibres as feed supplement, in addition to grazing.

Weaners at Farm Langbeen were fed with 900 gram rations daily throughout the trial period. Weaners at Omatjene Research Station had a daily feed intake of about 4.50 kg/day at the start of the trials, which increased to about 8-9 kg/day, depending on the individual growth pattern of each animal.



Grouping, vaccinating and ear-tagging of cattle before the start of the trials at Farm Langbeen, Khomas Region



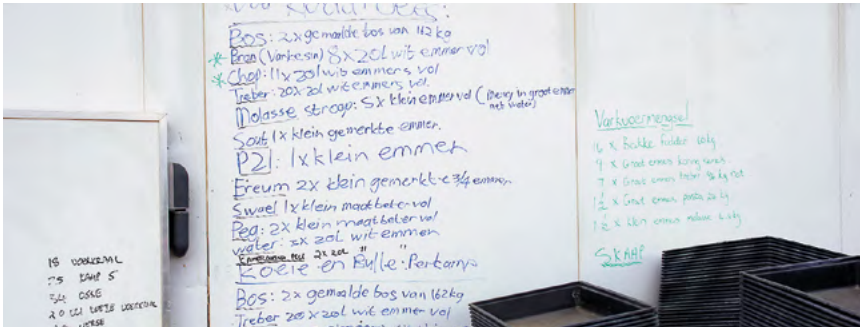
Young cattle feeding on bush based animal feed

Recommended bush based diets for young, growing cattle

It is recommended that the portion of bush based fibres in the feed should not exceed 50% as the metabolisable energy is rather low. The table

below shows various useful feed formulations. For ease of application towards an on-farm situation, all rations are provided on a 1,000 gram basis.

| Feed ingredient and its inclusion rate on a per 1,000 grams of total feed weight basis | Type of nutritional need in young, growing cattle addressed | | | |
|--|---|---|--|---|
| | 1. Diet, based on natural supplements for weaners/ young cattle | 2. Diet, based on natural supplements for weaners/ young cattle | 3. Diet, based on commercial supplements (pelleted bush based feed), untreated milled bush | 4. Diet, based on commercial supplements (pre-treated with 2.5%-NaOH, pelleted bush based feed) |
| Milled bush (e.g. <i>Senegalia mellifera</i>) | 500 | 500 | 500 | 500 |
| Rumen Soda (NaOH), administered a solution as part of the pre-treatment (ml on 500g-milled bush) | | | | 27ml |
| Camelthorn pod meal | 350 | 400 | | |
| Bush Improver Lick™ | | 100 | | |
| Rangeland Grower™ Or Enermol™ | | 200 | 250 | 250 |
| High Protein Concentrate™ (HPC30) | | | 150 | 150 |
| Molasses | 150 | 150 | 100 | 100 |



Noticeboard with notes on feed mixtures for cattle

Recommended bush based diets for cows (dry, pregnant and/or lactating)

Relating to maintenance feed for cows, dry, pregnant and/or lactating, it is recommended that they be weighted at the onset of the feed provision period. Their total daily feed needs are then also calculated based on 3% of the current body weight. Feed expressed in kilogramme equivalent units is then provided.

Usually, cows weigh between 420 and 500 kg. A total recommended daily amount of 12-15 kg of bush based fodder should be provided to each cow. However, the trials with maintenance diets

showed that as little as 3 kg of bush based feed per day can be sufficient (with a bush based fibre content of 85%).

Fodder needs of animals are very context specific and each farmer is advised to determine the most appropriate quantity of feed, taking aforementioned numbers as a guideline only. These numbers refer to total feed intake; in case forage is available, lower quantities for bush based feed apply.

| Feed ingredient and its inclusion rate on a per 1,000 grams of total feed weight basis | Type of nutritional need in dry, pregnant and/or lactating cows addressed | | | |
|--|---|---------------------------------------|--|--|
| | 1. Diet, pure maintenance feed | 2. Diet, based on natural supplements | 3. Diet, based on commercial supplements | 4. Diet, based on commercial supplements |
| Milled bush (e.g. <i>Senegalia mellifera</i>) | 850 | 650 | 840 | 750 |
| Camelthorn pod meal | | 250 | | |
| Bush Improver Lick™ | | | | 100 |
| Feed grade Urea | | | 100 | |
| Molasses | 150 | 100 | 150 | 150 |



Feed mix: milled bush fibres and supplements

Recommended bush based diets for all types of cattle

Diets are suitable as maintenance and growth/production feeds. They cater for the daily

minimum nutritional needs of the cattle and take costs into consideration.

| Feed ingredient and its inclusion rate on a per 1,000 grams of total feed weight basis | Type of nutritional need in cattle addressed | | | |
|--|--|--|--|---|
| | 1. Diet, pure maintenance feed based on commercial supplements | 2. Diet, pure maintenance feed based on commercial supplements | 3. Diet, production/maintenance feed based on natural and commercial supplements | 4. Diet, production/maintenance feed based on natural supplements |
| Milled bush (e.g. <i>Senegalia mellifera</i>) | 840 | 840 | 700 | 730 |
| Camelthorn pod meal | | | 200 | 100 |
| Bush Improver Lick™ | | 60 | | |
| Rangeland Grower™ | 60 | | | |
| Enermol™ | 100 | 100 | 100 | |
| Feed grade Urea | | | | 20 |
| PEG6000™ or Browse Plus™ | 2 | | 2 | |
| Molasses | | | | 150 |



Commercialisation of Bush Based Feed

Bush based animal feed is not a commodity product yet. Thus, anyone wishing to commercialise production should endeavour to obtain licences from MAWF to do so.

The key piece of legislation is the "Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act No 36 of 1947". This is a South African Act that was adopted by Namibia at independence. The Act governs the registration, importation, sale and use of farm feeds in Namibia.

Other legislation that must be considered includes national initiatives and regulations that are aimed to support trade in meat, in particular the export trade. The production of animal feeds must consider the prevention of undesirable residues in meat. Feeding of ruminant protein (e.g. bone meal) to ruminants is banned (Government Notice 199, Government Gazette No 1927 of 15th August 1998) – but fish oil and meal are allowed. The Namibian Standards Institute currently does

not have any standard relating to animal feeds and therefore is not involved in the animal feed industry in any way.

The enforcement agencies are the Ministry of Agriculture, Water and Forestry, represented by the Directorate of Veterinary Services as well as the "Registrar of Registration of Fertilizers, Farm Feeds, Sterilising Plants and Agricultural Remedies".

Namibia does not have Good Manufacturing Practice Legislation (GMP) legislation. However, given that the Namibian economy relies heavily on the export of beef, mutton, hides and skins, the livestock industry in general is well managed and controlled to ensure that processes meet European, US-American and Chinese procurement standards.



First commercially traded supplement mix for bush based feed produced in Namibia

Farmer's Story: Farm Langbeen

Bush based feed production is implemented by a small number of pioneering farmers. The story of Anton Dresselhaus and Farm Langbeen shows the transformational potential of the approach.

When a huge veld fire cleared 80% of the grazing area on his farm Langbeen in 2011, farmer Anton Dresselhaus was at the brink of giving up commercial cattle farming. At the time he had Limousin and Bonsmara cross-bred commercial cattle from his former stud breeding programme. With the natural forage largely diminished through the fire, could he wait and speculate that the grazing situation would improve again in time? Could he afford supplementary, commercial feed to keep his animals alive in the meantime?

His intuition told him otherwise and Anton Dresselhaus decided to start his own production of animal feed. He invested in a container for hydroponic grass production and started experimenting with feed diets. Since additional

roughage was needed for this fodder, he started adding shredded encroacher bush. Although the bush was equally affected by the fire, the 7,000 ha farm was still largely bush encroached. The main encroacher species included *Senegalia mellifera* (*Acacia mellifera*), *Vachellia reficiens*, *Dichrostachys cinerea* and several *Combretum* species.

Fungus and increasing seed prices made the production very costly and Anton Dresselhaus soon started feeding the bush itself. The concept of bush as main ingredient to animal fodder was born. Bush based feed production was not an entirely new concept at the time; so-called Boskos was commercially available in South Africa and a handful of pioneering Namibian farmers experimented with bush



Bush encroached rangeland at Farm Langbeen in the Khomas Highland



- 1 Pioneering producer of bush based animal feed, Anton Dresselhaus, during a field visit with the Progress Kashandula, national coordinator of the De-bushing Advisory Service.
- 2 Bush milling setup at Farm Langbeen
- 3 Shredded bush material with notable leaves, harvested during the rainy season

based feed production. But little was known about ideal diets, its commercial viability or the actual health impacts on animals.

Not held back by this uncertainty, Anton Dresselhaus started his own production. This move would prove vital for his farm in the coming years. "My decision to produce bush feed then saved my herd in the coming years. Little did I know that the period 2012 to 2016 would be so dry", says Dresselhaus. The recurring severe droughts that affected the entire country during that time period increased the challenges also at Farm Langbeen. The grazing situation did not improve as hoped and the encroacher bush became the single most important ingredient of the animals' diet. In order to accustom the animals to the new diet, bush based feed was always at the same time of the day. Feedlot animals received 11-13 kg and grazing animals 5-6 kg of bush based feed per day. In some diets the

content of shredded bush was as high as 90%. Although he would continue to refine the diets continuously, the feed proved to be a success early on. Not only did the animals survive, but also did they experience a monthly growth rate of 1.2 kg. Besides cattle, the feed also proved to be vital for sheep and game.

To date, a total of 150 hectares of land have benefitted from systematic bush thinning for animal feed production on farm Langbeen. This enabled the grass layer to recover and Anton Dresselhaus estimates that the grazing capacity on this land has improved by up to 75% over a period of five years.

The story of Farm Langbeen and Anton Dresselhaus stands for a daring new approach to animal farming in drought-ridden Namibia. It shows how a win-win situation can be created, in which fodder availability increases and productive rangeland is restored at the same time.

Notes

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The analysis, results and recommendations in this document represent the opinion of the authors and are not necessarily those of the GIZ and implementing partners.

For more detailed information on the research mentioned in this manual refer to:

- The potential for bush based fodder in Namibia - A literature review (2016)
- Survey on Animal Feed Production from Encroacher Bush in Namibia (2017)
- Encroacher Bush to Animal Feed - Viability of Bush Based Feed Production in Namibia (2017)
- Encroacher Bush to Animal Feed - Community Based Projects (2017)

Above documents can be found at: www.dasnamibia.org/download

Key Contacts

**Ministry of Agriculture, Water and Forestry:
Directorate of Forestry (DoF)**

Head Office Windhoek: 061-208711

Please inquire for numbers of regional offices

www.mawf.gov.na

Responsible for issuing of permits for harvesting, transporting, exporting and marketing of forest resources, including from bush encroaching species. Website includes downloads for applicants, explanation of requirements outlined in the Forest Act (2001). Various reports and articles of relevance to bush harvesting.

**Ministry of Agriculture, Water and Forestry:
Directorate of Agricultural Research and
Development (DARD)**

Head Office Windhoek: 061-2087067/78

www.mawf.gov.na

Undertakes livestock, crop and natural resource research within the communal and commercial farming sectors.

Offers chemical tests of bush material and feed mixtures at a nominal fee.

De-bushing Advisory Service (DAS)

9 Haydn Street, Windhoek West

061-242022

info@dasnamibia.org

www.dasnamibia.org

A national information sharing and capacity development platform, providing advice to farmers and SMEs on sustainable bush control and value addition opportunities.

The website has a number of downloadable documents, videos, and other information, relevant to decision making regarding bush control.

Namibia Biomass Industry Group (N-BiG)

Cargo City

5 Von Braun Street, Windhoek

061-242949

info@n-big.org

www.n-big.org

A non-profit organisation, representing businesses that harvest and process bush-biomass in the country. Support for members to access markets and facilitation of trainings on how to utilise harvesting machines among others.



Can animal feed be produced locally in Namibia, using encroacher bush as the main ingredient? A number of Namibian farmers produce bush based feed already today. Through an extensive research project the scientific proof of the viability of such feed was pursued and various diets were tested. The results of these pioneer activities are remarkable and prove that bush based feed works.

Such feed can serve as emergency feed during droughts, but also as supplement feed. Bush based feed has a transformational potential in Namibia, given the limited local availability of forage and a high dependency on imports. A win-win situation is created, if bush is used for fodder production as it not only provides an immediate remedy in times of fodder shortage, but also contributes to rangeland improvement in the long run.

This manual provides an overview of the production process, including harvesting, milling, mixing, pelleting and storing. Different diets for sheep and cattle as well as a cost calculation tool are provided.