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STRATEGIC ACTION PLAN FOR SUSTAINABLE BUSH VALUE CHAINS IN NAMIBIA

INCLUSIVE AND SUSTAINABLE INDUSTRIAL DEVELOPMENT

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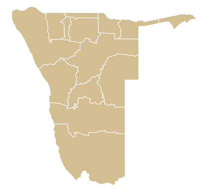


Vienna
August 2019

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

FUNDED BY

DONORS:
Ministry for Foreign Affairs of Finland
Baobab Capital (Pty) Ltd

GOVERNMENT COORDINATING AGENCY:
Ministry of Industrialization, Trade and SME Development

NATIONAL COUNTERPARTS:
Walvis Bay Corridor Group
Ministry of Agriculture, Water and Forestry of Namibia
University of Namibia, Namibian Meat Board

Acknowledgments

This Strategic Action Plan (SAP) has been prepared by Peter Christoph, UNIDO Senior Advisor on Industrial Development; Nico E. Willemse, UNIDO National Project Coordinator; Jukka Lähteenkorva, UNIDO Project Technical Advisor; Farrukhbek Alimdjanov, UNIDO Industrial Development Officer; and Gulnaz Azimbayeva, UNIDO International Expert, with the overall support of Kawira Anne Bucyana, Topias Taminnen, Ralph Liebing and Brigitt Roveti. A substantial contribution toward animal feed development was made by Maria Luisa de la Puerta Fernandez, a Lecturer at the University of Namibia (UNAM) and PhD candidate at the Aberystwyth University, UK.

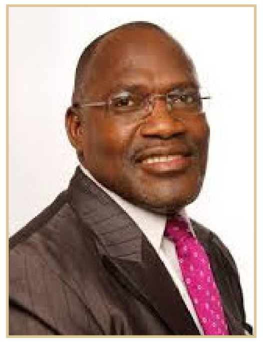
Special thanks are extended to the Ministry of Industrialisation, Trade and SME Development (MITSMED) in Namibia as the anchor institution and for their strategic and technical guidance. The Ministry of Foreign Affairs of Finland and Baobab Growth Fund (Pty) Ltd are thanked for their confidence in this pilot intervention, their financial contributions and general support for the UNIDO technical project, "Promoting sustainable bush-processing value chains in Namibia".

We duly acknowledge the Embassy of the Republic of Finland in Namibia for playing a key role in initiating this project, monitoring and supporting its implementation on the ground and linking with Finnish and Namibian academia and other R&D, technology and media partners.

The team expresses sincere appreciation for valuable strategic and technical guidance from the Members of the UNIDO Project Advisory Board, namely, Michael Humavindu, Deputy Executive Director of the Ministry of Industrialization, Trade and SME Development of Namibia; Vincent G. Louw, Deputy Director Forest and Botanical Research, Ministry of Agriculture, Water and Forestry; Gilbert Boois, Project Manager in the Walvis Bay Corridor Group; Goliath Tujendapi, Trade and Strategic Marketing Manager at the Meat Board of Namibia; Simon Angombe, Dean of the Faculty of Agriculture and Natural Resources at UNAM; Pieter de Wet, (outgoing) Acting Managing Director, Namibia Development Corporation (NDC); and Elaine Smith, Manager for Agricultural Research, at the Agricultural Bank of Namibia.

Acknowledgment and gratitude are expressed to the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) for the extensive work, including the programmes and projects being implemented in the areas of natural resources and economic development, in particular, bush control and value addition opportunities for bush encroachment in Namibia. The results of this work, such as valuable data and studies, were extensively referred to and used as the basis for development of this report.

Foreword



In 2014, Namibia launched a "Growth at Home" initiative that is committed to deliver inclusive and sustainable industrial development (ISID), to stimulate economic growth, promote trade and direct investment. This is in response to national priorities, viz-a-viz, reducing the annual trade deficit[1] through investments in manufacturing for import substitution, value addition of raw materials (minerals and other natural resources) and product development for export markets. The initiative is the implementation framework of the National Industrial Policy of 2012. It is foreseen that the Growth at Home Strategy would enable sustainable employment creation, skills development for a self-reliant and industrialized economy and increase economic participation by previously disadvantaged Namibians. To this end, Namibia also launched the Micro, Small and Medium Enterprise (MSME) National Policy: 2016-2021 in November 2016.

The United Nations Industrial Development Organization (UNIDO) technical cooperation project "Promoting sustainable bush-processing value chains in Namibia" is in line with the Ministry's Growth at Home Strategy, and the Government and people of Namibia are grateful to the Government and people of Finland, UNIDO, and local private sector partners for their support. This project resonates with pertinent national development goals and would contribute toward Namibia's achievement of the Sustainable Development Goals.

The Ministry is aware that bush encroachment is a regional challenge and ensured that UNIDO presented the project and its potential benefits during the "2018 SADC Industrialization Week". Namibia is leading the way in the region to define and mobilize environmentally, socially and economically viable bush value chains (BVC). Given the extent of encroachment across Southern African Development Community (SADC), and the occurrence of viable species and bush densities, it was proposed that SADC consider BVC as one of the priority regional value chains. At national level, BVC could enable countries to generate sustainable employment, develop capacities for an emerging agribusiness sector, recover rangelands, enabling higher rates of groundwater recharge, and improve local food security and availability of affordable animal feed.

Currently more than 90% of soybeans and more than 50% of maize and wheat are diverted for animal feed production annually. The UN Food and Agriculture Organization of the United Nations (FAO) estimated in 2017 that 821 million people across the world are undernourished daily with Africans making up more than a third of this. SADC's 2018 Regional Vulnerability Assessment and Analysis estimated that 14% of the region's population are undernourished, and suggests climate change impacts as the key driver of increasing food insecurity and reducing food production.

The Ministry is convinced that, once the pilot phase of this project proves commercial viability, it is worth scaling up nationally and replicating across SADC to improve our climate change resilience and adaptive capacities. We believe that this project can assist our country and region to advance toward low-carbon, high resilience and inclusive economies.

HON. TJEKERO TWEYA
Minister of Industrialization, Trade and SME Development of the Republic of Namibia

[1] Trade deficit between USD 1.4 to 1.7 billion/year. Source: Namibia Statistics Agency

Finland and Namibia have developed an exceptionally long and close relationship that dates back more than 150 years. Namibia became one of Finland's most important development partners, immediately after its independence in 1990. In Namibia, Finland is valued as a committed and reliable partner. Both countries are exploring new ways to strengthen cooperation with specific emphasis on trade and industrialization. While Namibia is endowed with natural resources and good market access to the region and world at large, Finland's competitive advantage is based on technology, innovation and knowledge that have been built by its world-class education system of high equality and opportunities for all.

Over the last decades, Finland has carried out versatile studies related to feed production, processing and use, including novel feeds and efficient use of by-product flows for all farm animals. Now, we are turning the fruit of these studies into reality, together with the United Nations Industrial Development Organization (UNIDO), Government of Namibia, Baobab Capital Ltd and a number of Finnish private sector and academic partners, in the form of a full-fledged business–technology model that helps Namibia develop sustainable production and value chains using the Acacia bush for a wide variety of products.

This technical cooperation project "Promoting sustainable bush-processing value chains in Namibia" contributes to both the national sustainable development objectives of Namibia and the United Nations Sustainable Development Goals. More concretely, bush-based feed has proven to be not only a drought relief feed, but also a more affordable production ration. By funding this initiative, the Government of Finland acknowledges the great potential of utilization of invasive bush species in the animal feed, food and pharmaceutical industries, as well as in energy production sectors, to generate jobs, food and income in Namibia.

Finland stands ready to continue supporting the current efforts towards environmental and climate sustainability in a drought-stricken Namibia by using encroaching bush to produce animal feed, energy, chemicals and other value-adding products. The Government of Finland and our national academia, R&D and private sector partners look forward to the successful functioning of the pilot plant and the opportunities it will offer to the wider communities, including women and marginalized people, as well as for business. We truly believe that by joining hands we will be able to leverage new and innovative potential for employment generation, environmental restoration, climate sustainability and economic development.

DR. MIKA VEHNÄMÄKI
Commercial Counsellor
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Table of Contents

Executive Summary

BACKGROUND INFORMATION

More than 60% of the population engages in agriculture on 78% of the total land surface. A domestic cereal deficit of 76% was reported for the previous two years, due to lower farming productivity, while in 2017, 300,000 cattle weaners at a value of N$1.6 billion were exported due to limited capacity to retain and raise. This limitation affects 206,000 households, including the macro-economic impact of the sector. Jointly with Namibian and Finnish partners, the United Nations Industrial Development Organization (UNIDO) through its technical cooperation project "Promoting sustainable bush-processing value chains in Namibia" is addressing this limitation, drawing extensively on existing information and data generated by the Government and development partners, by conducting in-depth analysis and investigation of the viability of inclusive and sustainable bush value chains for economic benefit and to contribute to rangeland restoration.

Covering an estimated surface of 45 million hectares, a harvest rate of 10 tonnes/ha would translate into a theoretical total biomass of 450 million tonnes. The actual availability of this biomass depends entirely on the species selected, suitable value chains, and end-use products, as well as the cost of harvesting, processing, and value addition/product development versus the potential benefits. Considerations of scale (individual vs. industrial), and the level of investment, and adoption of technology become important, in parallel with the risks inherent with developing a new product for which no or, at best, a semi-developed local market exists. The scale would determine whether a "multiplier effect" can be triggered for enhanced social, environmental, and economic benefits.

Observations, information, and data collected since 2017 suggest that potential exists in Namibia for a bush-based livestock feed, while demand also exists for an additional 100,000 tonnes of charcoal per year. However, this potential is also contingent on the competition in the domestic market from feed/supplement/additive manufacturers and importers with relatively long histories in Namibia. Furthermore, for variations in bush-based feed recipes, the accessibility and sustainability of supply and cost of raw materials (e.g., molasses) are critical risk factors.

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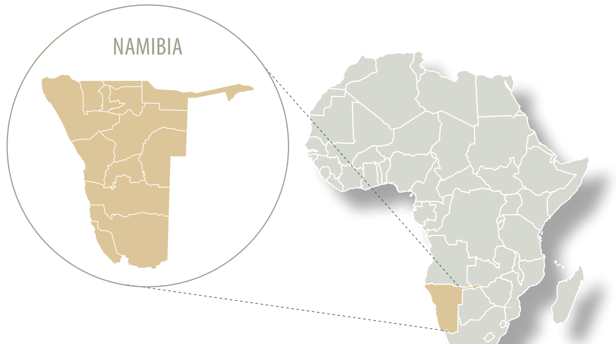


INTERNATIONAL DEVELOPMENT EFFORTS: SYNERGIES AND COHERENCE

Over the past five years, the Government of Namibia, with support from development partners, increased efforts commendably to address bush encroachment. The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) is implementing two synergistic projects on "Competitiveness for Economic Growth" and "Bush Control and Biomass Utilisation"; the former, in partnership with the Ministry of Industrialisation, Trade, and SME Development (MITSMED), is developing the capacities of government and industry to identify, investigate, and develop value chains; the latter, in partnership with the Ministry of Agriculture, Water, and Forestry (MAWF), is a second-phase project transitioning from a research and development intensive phase (2014-2017) toward practically improving bush control and biomass utilisation.

The University of Namibia (UNAM) plays an important role as a research and development partner and recently showed interest in the project from the perspective of innovation for sustainable development since it now has a legal business entity that can engage in public-private partnerships. The nutritional and mineral properties of five species of encroacher bush were analysed as part of the process of supporting the MAWF, the United Nations Development Programme (UNDP), and the NAFOLA Project. Six Master of Science students are engaged in thesis research topics relevant to the project, and some are conducting a survey on the current use and availability of livestock feeds. UNDP Namibia, in partnership with the MAWF, has been implementing the NAFOLA project financed by the Global Environment Facility (GEF), which targets community forests and piloted bush-based feed as a potential income-generating activity integrated with sustainable forest resource management. This project showed promising results as some cattle gained up to 1.6 kg of weight per day on bush-based feed.

BUSH AS A RAW MATERIAL SOURCE AND ITS EXPLOITATION

Nine species are recognized as the main encroacher bush in Namibia. They include three species of *Acacia* and two *Terminalia* among others. An important consideration is that for the selected end-use products, namely livestock feed and charcoal, and given an integrated production process that aims to reduce wastage, only some species may be appropriate in terms of nutrition and palatability. There are also 80 protected tree and shrub species to consider, for which special exemptions must be sought from the Directorate of Forestry, MAWF.

The cost of harvesting is influenced by the number of bush equivalents that can be accessed per day (or week, month, year) which becomes a factor to consider regarding viability. Hence, species selection and densities are important, while the topography and harvesting method would also influence access to the appropriate raw materials.

Based on observation as well as information and data collected, Acacia species are preferable, given that leaves and twigs smaller than 20 mm are suitable for livestock feed, and those larger than 20 mm are suitable for charcoal production. This combination implies that the entire process can be optimised since one harvest can supply both products. In addition, there would also be resultant by-products – tar and distillate – for which markets exist. The heat and gases from charcoal production can be used to dry chipped material to prepare it for milling. Hence, the production method and technology are important considerations, since modern retorts can increase charcoal production yield by up to 40% and modular feed production systems can produce up to 2.5 tonnes per hour.

REVIEW OF POTENTIAL END PRODUCTS AND PRIORITIZATION

Building on the MAWF/GIZ 2015 publication on "Value Added End-Use Opportunities for Namibian Encroacher Bush," supported by market and business intelligence information and data, the two end-use products and their value chains are prioritised and analysed in-depth. Bush-to-energy as an alternative renewable and affordable cleaner energy source, particularly for rural Namibia, and Arabic gum as a high-margin product with well-established regional and global value chains are positioned as additional value chains from the potential 15 identified in the 2015 report.

Bush-to-energy is particularly relevant in view of the 20 MW biomass power plant for which NamPower has full-scale feasibility and environmental assessments underway. Based on the current annual use of biomass material as fuel at Ohorongo Cement, the 20 MW plant would require about 160,000 tonnes of biomass per year. Industrial application for heat-consuming industries is another avenue where the economic benefit of generating heat and power in one process is attractive.

Gum Arabic, derived from *Acacia senegal*, is a natural emulsifier and a stabiliser commonly used in the paint, food, health, and cosmetics industries. Commercial gum farms are most popular in Sudan, Chad, and Nigeria, making them important to the economic development of Sub-Saharan African countries. Sudan accounts for about 80% of global gum Arabic production, with North America as the largest importer and growing markets in Western and Eastern Europe. France, Germany and the United Kingdom are the major re-exporters of processed gum.

MARKET-ORIENTED SOLUTIONS FOR COMPETITIVE HIGHER VALUE-ADDED PRODUCTS

To deliver new market-oriented and competitive solutions, it is critical for potential entrepreneurs to be aware of key parameters that should be considered. For the selected end-use products, the following evaluation parameters are proposed:

- selection of raw material input;
- markets for end-use products producing the benefits sought;
- potential competitiveness of selected end-use products;
- impact on overall bush biomass consumption by the production of end-use products;
- impact on employment generation;
- time-to-market for selected end-use products; and
- the potential multiplier effect.

With respect to the targeted end-use products, species selection and harvesting method are important considerations for bush-based feed (nutritional values and palatability) while not so important for charcoal. Selection would also enable the optimisation of investment and operations costs by converting 80% of 1 bush equivalent (more than 20 mm Ø) into charcoal and the remaining 20% (less than

20mm Ø) into livestock feed. Species accessibility and harvesting method are also important.

The viability of targeted end-use products relies heavily on existing markets and the benefits to the consumer. A market value exists for bush-to-feed, based on one commercial operation and another experimental one and on the data from feeding trials conducted by the MAWF, UNAM, and the NAFOLA Project. For charcoal, a well-established market exists with potential for growth.

The competitiveness of any new product with those existing in the market is important and depends on its price and quality relative to those of competing products. At present, livestock feed/supplements/additives are sold in 50kg bags at a price point of N$230 – 250.

The current market demand and the rate of bush conversion to end-use products are important considerations, bearing in mind that systematic thinning paves the way for rangelands restoration. There is demand for a livestock feed that is more affordable and delivers commendable benefits, particularly during years of drought. The extent to which this demand can be met depends on the availability of more detailed quantitative data for selected species.

Employment creation potential depends on the scale of an operation for the selected end-use products and on the extent to which technology rather than human capacity is used. The nature of bush distribution and density favours manual labour for harvesting over some mechanised approaches, particularly with respect to accurate selection. Hence, adding value by focusing on the supply of wood biomass would definitely provide opportunity for employment, while activities closer to the actual production of end-use products would provide less potential for employment.

Time to market is an important parameter to consider, since it depends on whether well-developed markets already exist and how fast a product can be brought to market. For livestock feed, a semi-developed market exists at best, since many farmers blend bush material with supplements/additives during droughts and there is a well-established commercial operation in the Otavi area. Building on this foundation, more awareness is needed, especially of observed product benefits (daily/weekly average weight gains) and of the role that de-bushing can play in rangelands restoration.

The potential multiplier effect of social, environmental, and economic benefits is possible, granted high demand for a new product such as animal feed that has been widely tested in the Namibian market, is priced competitively, and offers well-assessed benefits. Again, the scale and scope of an operation would also determine the extent of benefits and the potential increase in the number of beneficiaries. At the production level, the extent would be increased by an integrated process as described above while raising the yield from wood-to-charcoal (by up to 40%).

ENVIRONMENTAL IMPACT REVIEW

An article published in late 2017 in the peer-reviewed *Environmental Journal of Namibia* provides valuable guidance regarding possible environmental impacts of bush harvesting and thinning. Even though bush encroachment presents an environmental threat, the article describes the positive role that encroacher bush plays in the ecological and ecosystem functions by providing shelter/habitat for birds, insects, and other animals that act as natural fertilizers and soil mineralisers.

Hence, in addition to the direct impact of harvesting (i.e. soil disturbance) to produce both charcoal and livestock feed, there is a need to consider the wider ecological impacts of bush removal, while the production of end-use products may have further direct and indirect environmental and social impacts, both positive and negative.

Namibia has a sound institutional and policy framework to support the consideration, quantification, and assessment of impacts. Operators in the emerging bush value chains sector must consult with the Ministry of Environment and Tourism (MET) and adhere to the Environmental Management Act (EMA) and its regulations. The EMA requires the consideration of sector-specific legislation, including labour laws and regulations, particularly in view of human health and safety as well as work conditions.

Environmental and social impact considerations apply to the sites where end-use products will be manufactured, as well as to the activities and locations for bush biomass harvesting, pre-processing and transportation. As an introduction to the topic and to provide a context for the impacts of potential bush value chains, it is recommended to review the "Strategic Environmental Assessment of Large-scale Bush Thinning and Value-Addition Activities in Namibia". The following are considered as the key issues to consider and explore as part of detailed environment and social impact assessment:

- the level of knowledge necessary to allow accurate specific identification;
- bush selection and harvesting methods;
- removal of bush and the associated nutrients and minerals;
- negative aesthetic and visual impacts (potential impact on eco-tourism);
- loss and fragmentation of biodiversity;
- human health and safety; and
- the use and viability of additives and supplements.

Many people engaged in bush harvesting and thinning are aware of the key issues above and of the existing institutional and legal frameworks. As the provider of the enabling environment for sustainable development and economic growth, government can facilitate adherence to stimulate growth and avoid creating barriers that could affect cost, viability, and sustainable development potential.

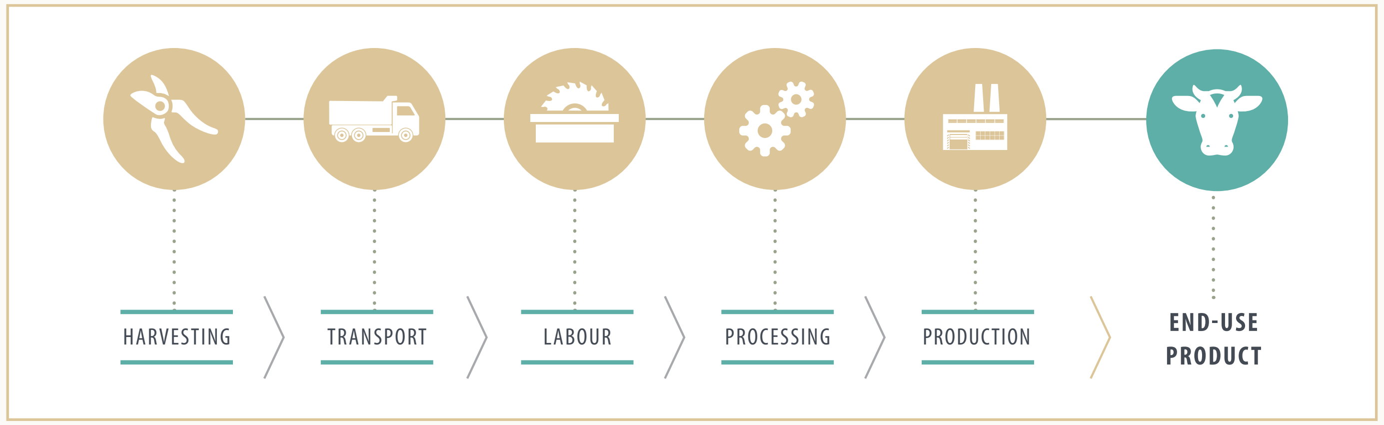
Poor groundwater replenishment and excessive water consumption by encroacher bush (up to 65 litres per day) that negatively impacts the growth of other vegetation, as well as influences the visual aspect of savanna (as an important factor for tourism), could be addressed through joint efforts of the government with the support of UNIDO.

IDENTIFICATION OF THE MARKET POTENTIAL OF BUSH-BIOMASS-BASED END-PRODUCTS

The market potential and indicative demand serve as guidance for species selection, which in turn is a function of abundance, viable density, and accessibility. Market potential may also suggest a "willingness to pay" on the part of consumers by using current market prices as indicators. The price to the consumer must incorporate all the costs of the value chain, including the capital investment required, and must allow production to remain profitable whatever the scale.

Hence, the harvesting method, transport, labour, processing, and production costs are critical for exploring the potential market, granted that demand exists for the end-use products.

The scale of the operation – whether individual or industrial – and the potential for an integrated, zero/minimal waste approach that delivers marketable by-products (tar and distillates) are important considerations when exploring market potential.



MARKET POTENTIAL OF ANIMAL FEED

Key considerations for the market potential of a bush-based animal feed include:

- compelling and balanced nutritional values (based on recipes);
- shelf-life comparable to that of similar products on the market;
- consistent quality through assurance and control;
- palatability and digestibility; and
- competitive and appropriate pricing.

With regard to nutritional values, the balance of ingredients to enhance or mitigate some properties of bush material is important in gauging market potential. Fibre content should be optimal for digestion, while prevailing opinions suggest that tannins can have positive or negative impacts on the digestibility of bush material and the absorption of nutrients. Acacia bush material delivers up to 16% protein, which is higher content than that of many existing feeds, and when that bush material comprises more than 85% of the feed, it leads to daily weight gains of between 0.6 to 2 kg, with an average of 1.2 kg/day. In a case where bush biomass comprised 58% of the feed and was fed daily at 3% of the weight of the cow, a weight gain of 427 kg was recorded over a 50-day period. The Meat Board of Namibia reported that daily weight gains of 1.2-1.8 kg are possible under irrigated grazing conditions by using an enhanced fodder. A "grower" bush-based feed trial conducted by the GIZ Support to De-bushing Programme recorded daily weight gain of up to 3 kg. GIZ sampled different bush species for the attractiveness to livestock, based on their nutritional values and palatability. The international average daily weight gain ranged between 500-700 g.

More data are needed on species nutritional values and variations therein according to geographic variations, followed by feeding trials over wider geographic areas with variable conditions to validate these initial results, in order to allow the delivery of market-relevant and attractive recipes. The current data serve as a proxy that suggests definite market potential, particularly based on the weight gains recorded, at a competitive price.

Shelf-life is an important indicator to access and unlock market potential. Current recipes provide between 6 to 12 months' shelf-life. It is important for the bush material to be dried completely after chipping to produce a dry bush biomass powder from the hammermill. Additives and product storage conditions are vital to safeguard shelf-life, which is an important indicator for business viability, from sustainable production, consumption, and loss/"product write-off" points of view.

A strong and acknowledged possible supplier is FeedMaster, which delivers an impressive annual output of 160,000 tonnes worth N$800 million, implying an average price per tonne of N$5,000. It caters to the entire ruminant market with 31 products for cattle alone, mainly supplements, concentrates, and additives. This company has existed in Namibia for 32 years and emerged from the biggest milling company in the country to derive economic benefits from the waste produced by the milling plant. FeedMaster products are available at all the agricultural product retailers, including some hardware stores and nurseries.

MARKET POTENTIAL OF CHARCOAL

The Namibian charcoal value chain comprises harvesters and small- to large-scale producers (including Makarra Bush Products) and processors (e.g., Jumbo Charcoal) that supply the domestic, regional, and international markets. With 6,000 to 10,000 participants in the industry, regulation is limited or non-existent, as indicated by the negative prevailing human and environmental health and safety issues. Jumbo Charcoal has been operating since 1983 and does not produce charcoal but rather procures unprocessed bulk charcoal by the tonne from producers. It absorbs the cost of processing, branding, and marketing to deliver final packaged market-specific products that are sold at a premium. A product of note is a "ready-to-burn" 2 or 5 kg bag of paraffin-treated charcoal sold on the UK market, which absorbs 22% of charcoal exports from Namibia. Given the weather in the UK, this product is ideal as it ignites with ease and allows a grill to be barbeque-ready in less than 20 minutes.

The Namibian Charcoal Association (NCA), with support from industry players, the MAWF, and GIZ, is in the process of reforming the industry and improving its coordination. This effort is applauded, and it must be recognised that with as many as 10,000 stakeholders, this requires time, resources, and support to achieve. The Namibia Biomass Industry Group, supported by the GIZ, provides access to information to raise awareness and capacity and to coordinate and facilitate the use of bush biomass, particularly linking farmers with harvesters/processors, as in the case of Ohorongo Cement.

Some 26 million ha of farmland are affected by bush encroachment, a development that has encouraged farmers to solicit small-scale charcoal producers to thin bush and produce charcoal. This informal engagement has its benefits but also comes with challenges pertaining to indiscriminate species selection, limited care and concern for human and environmental health, variable quality (size and density) of charcoal, delivering only 30-40% charcoal from total wood used. Kilns are relatively inexpensive (N$5,000 apiece) and easy to make, using flat 3-5 mm metal sheets in standard dimensions as sold to limit the cost of production. The sheets are rolled into a cylindrical shape.

There is potential for an additional 100,000 tonnes of charcoal per year, given the regional and global demand. This goal can be achieved with a relatively modest investment in a modern containerised charcoal retort that can achieve 40% higher yield than the current Namibian system without any significant human or environmental health impact concerns.

CONCLUSIONS AND IMPLEMENTATION PROGRAM

An integrated approach to charcoal and livestock feed production to optimise investment, production processes, and outputs/end-use products is proposed as an attractive viable approach to address market potential. This would be complemented by marketable by-products from charcoal production at no additional marginal cost of production.

Based on information and data from Finnish technological companies, the estimated investment cost for such a system would be in the region of N$10 million. This would comprise one modular and containerised bush-to-feed system that can deliver 2.5 tonnes per day, two containerised retort systems for charcoal production that deliver tar and distillates, and the equipment for selective harvesting, all presenting minimal negative social and environmental impacts. A time window of six months from date of order is required to deliver the technologies in Namibia, while the companies would provide on-site presence for installation, testing, commissioning, and capacity development.

To enable the demonstration of the above-mentioned proposed system, a practical strategic action plan is proposed with specific milestones, costs, and a completion timeframe.

- Integrated approach for charcoal and livestock feed production
- Investment, production and output optimization
- Technology adaptability: machines, equipment and systems
- Estimated investment cost of EUR 795,000-930,000
- Time window of 6 months for technoloy delivery

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Deputy Executive Director: Industrialisation & Enterprise Development
Ministry of Industrialisation, Trade & SME Development
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1

Introduction and Background

CONTENTS

Namibia is one of the most vulnerable countries in the world to the impacts of climate variability and change. The country's inherent vulnerability, due to its geographic position on the globe and sub-continent, is further exacerbated by an inherent water deficit and exposure to high temperatures during the summer/spring months (Sep-Feb). Evidence of climate variability and change includes a short, variable, and intense rainy season resulting in lower water availability and increased temperatures that have been above the global mean for the past 10 years. Farming ability has been reduced by up to 33% in some areas, while it is becoming increasingly challenging for the rural population to sustain livelihoods and income from accessible arable land that makes up less than 2% of the country's territory. Water is a high-value commodity in Namibia as only 1% of rainfall recharges underground aquifers, with the rest lost to evaporation and runoff. More than 60% of the population is engaged in some form of agriculture that supplies up to 40% of the country's food demand. As a sector, agriculture employs the highest number of people in the country and is the second highest contributor to GDP.

The above baseline is exacerbated by **bush encroachment**, which is the occurrence of high densities of woody species—particularly *Acacia* species and "Sickle bush"—that grow at the expense of endemic grasses and forage plants, thereby reducing the grazing potential and roaming space for livestock and wild animals and the capacity for crop cultivation.

At present, up to 45 million hectares in 13 of the 14 political regions are experiencing bush encroachment at an annual growth rate of 3.18%, resulting in some 1.5 million hectares of additional bush each year.[2] This encroachment translates into the following impacts:

- Reduction in rangelands and grazing areas;
- Poor groundwater replenishment and excessive water consumption by encroacher bush (up to 65 litres per day);
- Reduced food production capacity resulting in lower food security and higher malnutrition, especially when rural households need to increase expenditures to buy food;
- Lower employment in the agriculture and tourism sectors (including up- and downstream activity);
- Changes in local biodiversity leading to the disappearance of some species and appearance of others, as well as to species, community, and habitat fragmentation;
- Reduced potential for animal wildlife viewing due to dense vegetation that reduces visibility and restricts animal movement. This negative impact is being recognised in the tourism sector as it reduces the ability to sell "access" to animal wildlife and Namibia's popular "wide open spaces";
- Annual exportation of 200,000-300,000 cattle weaners at N$1.5 to 1.8 billion. If they were retained and raised to market size, Namibia could fetch an additional 40%, i.e., capture a total net economic benefit of more than N$2.2 billion per year, not to mention the employment opportunities for viable meat value chains (from feed lots and abattoirs through processing and value addition as final products).

Bush encroachment is still recognised as a formidable sustainable development challenge, but, in recent years, stakeholders have become more curious about socially, economically and environmentally viable opportunities. Hence, extensive bush control and utilisation of bush biomass could catalyse enhanced agricultural productivity, which would, in turn, strengthen the overall resilience of farmers and rural communities. The MAWF/GIZ-funded "Support to De-bushing Programme" proposed 14 viable bush-based value chains in 2015[3] with constructive guidance on requirements (investment, skills, technology) for ways to develop one or more value chains.

To harness the opportunities and address the challenges of bush encroachment, the Ministry of Industrialisation, Trade and SME Development (MITSMED) and the United Nations Industrial Development Organization (UNIDO) partnered in August 2017 on a project, "*Promoting sustainable bush-processing value chains in Namibia*." The project is jointly funded by the Ministry of Foreign Affairs of Finland and Baobab Growth Fund (Pty) Ltd, a local private sector partner.

Unlike previous and other existing projects that focus on assessments and scientific studies, this project aims to test and put into operation a sustainable and viable business model able to deliver marketable end-use products, generate employment, and contribute to economic growth and industrial development. The project is being implemented in two phases: phase 1 (Aug 2017 – Mar 2018) delivered a viability analysis – this Strategic Action Programme – that recommends investing in a demonstration plant to test actual viability, the technology, and to enable fine tuning and refining the products and business model; phase 2 (Apr 2018 – Nov 2020) entails the planning, facility start-up, and testing of the demonstration plant.

The direct outcomes of this project would include (by 2020):

Marketable, viable, and sustainable bush-based value chains and end-use products developed using best available market and business intelligence information and data;

Suitable, appropriate, and affordable technologies (imported, locally modified/adapted and manufactured) and know-how that enable sustainable harvesting in compliance with national laws and the Forestry Stewardship Council (FSC4); and

Namibians (individuals, institutions, and systems) that can: locally develop and maintain technologies; identify suitable technology and apply it appropriately throughout bush-based value chains; and train others in bush-based value chains to ensure high quality service delivery, product development, and use of technology.

[2] GIZ (2015) *Strategic Environmental Assessment of Bush Encroachment in Namibia.*
[3] GIZ (2015) *Viable Bush-based Value Chains.*

Based on an estimated 45 million hectares and an average harvest rate of 10 t/ha, the encroacher bush theoretically offers 450 million tonnes of biomass, not accounting for annual growth at 3.18%. This opens enormous potential for value-added production, while all stakeholders recognise the need for more detailed data on the extent of bush encroachment and species to enable better planning.

The current available data and local knowledge stratify the country according to species and approximate densities with the area between Windhoek, Outjo, Kavango East and Omaheke (darker shaded pixels below) regions being most viable for bush-based business. See map below.

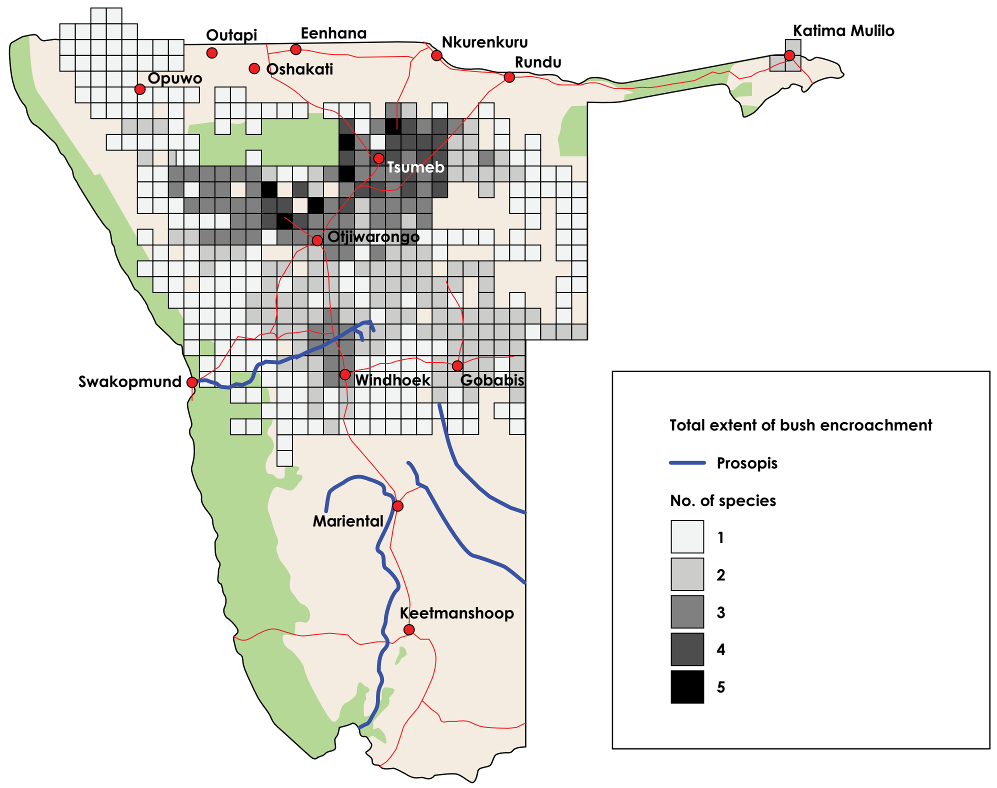


Figure 1.1 - Map of Namibia showing the highest densities of bush encroachment in the northern part of the country, where there is higher annual rainfall

Even though recognized as a challenge, encroacher bush plays important ecological roles in nature. Hence, there is a focus on extensive bush control instead of mass clearing of bush to address the challenge. The project has therefore become aware of the harvesting methods in use and their associated impacts[4] and would endeavour to employ the optimal solution to meet the bush biomass demands of the demonstration plant.

Of the 14 value chains that are presented as viable for Namibia, this project focuses on bush-based animal feed and charcoal. For both, there exist well-developed and tested markets in Namibia. Potential may be unlocked regionally and globally by showcasing Namibian data as a means of arousing curiosity in farmers who could participate in feeding trials. At present, the bulk of nutrition in all mainstream feeds comes from soybeans, wheat, and maize. The demand for animal feed is increasing –in parallel with the human population growth trend– with global production having reached 1 billion tonnes in 2016 and 2017 for the first time ever. The demand for food for human consumption is increasing in developing countries and emerging markets. As the middle class is growing in Africa, Asia, and South America, so is the demand for protein, while for the poorer households, maize, wheat, and soybeans are important nutritional components.

[4] This project drew extensively from research documents generated by MAWF/GIZ and accessible at www.dasnamibia.org and other partners such as UNAM and the UNDP/GEF/MAWF NAFOLA Project.

Arguably, animal feed is an important factor in the global food industry, enabling the economically-viable production of animal proteins throughout the world. Feed, as demonstrated in modern sustainable agriculture, is the largest and most important component for ensuring safe and affordable production of animal proteins. The main factors determining the composition of animal feed and their retail price are the prices of the raw materials, the nutritional value of the components, and the nutritional requirements of the specific animals, as well as the national legislative and regulatory environments.

The world's human population has been experiencing accelerated growth that will soon be exponential. Accelerating population growth is a major concern, particularly for policymakers, as it pertains to our ability to feed and provide fuel for the current 7.2 billion-plus people in our world.

BUSH BIOMASS AS FEED INPUT TO ENHANCE HUMAN FOOD SECURITY – Given the growing demand for food for the human population, competition between the food and animal feed industries for these inputs (maize, soybeans, and wheat) is increasing. This competition will intensify as the world population is projected to reach 9-10 billion by 2050. Growth in human population drives an increasing trend in animal protein consumption (especially beef). Hence, the demand for animal feed is expected to maintain the steadily increasing trend observed from 2012 to 2016. One solution is to find **suitable, affordable, sustainable, and palatable substitutes for maize, wheat, and soybeans** such that these can be comfortably available for human nutrition.

In Namibia and South Africa, farmers are known to have experimented with bush-based feeds – as early as 1970 – as a measure to survive years of drought. Two farm owners have gone into commercial and semi-commercial/experimental production: "BosPro Products"[5] emanating from the Outjo farming area is the first registered commercial bush-based animal feed containing 58% bush biomass, while the other farmer in the Dordabis area experimented with a bush-based feed comprising up to 85% bush biomass, producing maximum weight gains of up to 2.5 kg per day per animal.

Over the past five years, MAWF-supported projects developed bush-based experimental feeds and carried out feeding trials that enabled the recording of data on the nutritional and mineral values of bush species and the up-take ability and growth gains by livestock. Cattle, goats, and sheep were trial fed on 5 different recipes of bush-based feeds in the Omaheke and Kavango West regions. There is need for more trials across wider geographic areas covering livestock, animal wildlife, and other species such as horses.

A well-developed market for charcoal is jointly overseen by the MAWF and the Namibia Charcoal Association (NCA) and is characterised by an unmet annual demand of 100,000 tonnes, with between 6,000-10,000 producers, processors, marketers, and exporters engaged in the sector. Production efficiencies are low, at 30-40%, with enormous amounts of waste generated, adding to the many negative environmental and human health impacts currently observed in the sector.

In 2017, the NCA started a process of cleaning up the sector by offering more efficient, cleaner, yet rudimentary and affordable technologies, by verifying all persons in the sector and value chains, and by setting baseline health records.

To complement these efforts, this project will focus on an industrial-scale cleaner, 70% more efficient technology that would be integrated with the bush-based feed mill for an even more efficient and zero waste/circular economy[6] approach. The retort containerised system is thus designed to deliver (for example) 70 kg of charcoal for every 100kg of wood processed, without any CO_2 emissions and with distillates and tar by-products at no additional cost. Heat generated by the retort technology would be channelled to dry bush material in preparation for feed production. One hundred percent (100%) bush will be utilised; the leaves and twigs smaller than 20 mm in diameter are suitable for animal feed – comprising some 20% of total biomass per bush; while twigs and branches larger than 20 mm are suitable for charcoal (comprising some 80% of total biomass per bush).

The nutritional values in plants and bushes are higher during the rainy season; hence this period of the year (Sep-Apr) would be targeted for feed production, while charcoal production would be staggered over a 10-month period (Jan-Oct).

As mentioned above, a significant part of the sector clean-up by the NCA is the process of establishing National Forest Stewardship Council (FSC) standards for Namibia. Once the draft standards are approved, Namibian entities can become certified and would thus benefit from this standards certification and eco-branding to access European, US, and other potential markets. The standards are in the final stages of development and can be found on the Africa FSC website.

[5] www.bosproproducts.com
[6] https://www.ellenmacarthurfoundation.org/circular-economy

As alluded to above, a key focus of this project is to determine the sustainability and viability of manufacturing bush-based end-use products. Hence, the business model should suggest profitability through a reliable and market-based internal rate of return (IRR). The project is investigating the availability of supplemental raw materials (e.g., molasses, lucerne, prickly pear) in Namibia, the region, and worldwide to ensure that supply is sustainable and affordable at 30- to 50-year timeframes.

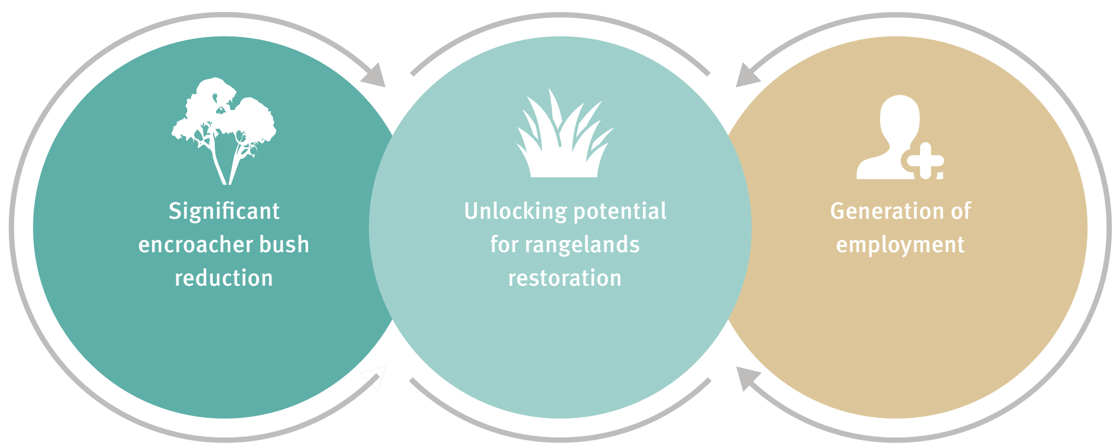
The demonstration plant would thus serve the purpose of showcasing the viability and sustainability of bush-based business, as well as the business processes, technology, and final products. This would generate awareness and interest among entrepreneurs who might have the appetite and/or resources to invest. Toward the end of the 12-month demonstration phase, a sound, tested business model and plan will be in place and ready for consideration by investors.

Various factors influence viability, for instance developed markets and readiness for new products, existing demand for different/affordable feed varieties, "time to market" as a reflection of business efficiencies and effectiveness, cost of raw materials (especially transport) and scale/size of production *(see below)*. In this case, viability also extends to achieving a "triple-win," i.e., restoring rangelands and improving groundwater replenishment, in addition to bush-based feed and charcoal production. Hence, it is important to consider the annual scale of production such that the magnitude of encroacher bush harvesting yields the desired positive impacts on rangelands and aquifers. Social benefits would include substantive employment generation and capacity development.

Along with viability is the need to consider the risks associated with bush-based business as an emerging industry and particularly with developing animal feed as a new end-use product. Viability increases and risks decrease when the desired species is found on flat sandy topography with bush densities at 5,000 bushes/ha or more and within close range (5-10 km) of an operation site. Hence, as these parameters change, they influence the viability and risk factors of the intended business and therefore require careful calibration in concert with data on the availability and cost of other raw materials for feed production.

A draft National Strategy for the Optimization of Rangeland Management and Encroacher Bush Utilization is in place and under consideration by the Cabinet for approval. Once approved, this joint Strategy by the Ministries of Agriculture, Water and Forestry (MAWF) and Industrialisation, Trade, and SME Development (MITSMED) will be the guiding instrument for the next five (5) years to address the challenges and unlock the opportunities of bush encroachment. The Strategy proposes the establishment of "BBH" as platforms to promote and facilitate participation and to serve as one-stop-shops for all issues concerning bush encroachment, its challenges, and opportunities in that area. The Namibia Biomass Industry Group (N-BiG) has been leading consultations to define the BBH concept for Namibia and to agree on key elements for establishing, operationalizing, and managing them sustainably. The site –a decommissioned Africa Portland Cement site 10 km north of Otjiwarongo– intended for the demonstration of this project's integrated bush-based feed and charcoal production system is well-placed to serve as a demonstration of a BBH. Another site, with a focus on bush-to-energy, is earmarked near Outjo, close to the Ohorongo Cement plant.

Operationalization of the National Strategy, introduction of the Bush Biomass Hubs concept, and planning for the demonstration of the production system are timely, as the project would gear up to achieve specific objectives and outcomes of the National Strategy while adding immense value to the BBH concept through a learning-by-doing approach and, lastly, delivering Namibia's first promising triple-win solution to bush encroachment.



2

Encroacher Bush: Viable, Sustainable and Suitable

Encroacher bush has historically been regarded as a challenge, and in recent years, more deliberately acknowledged as holding vast untapped potential social and economic benefits. A draft *National Strategy for the Optimization of Rangeland Management and Encroacher Bush Utilization* is a deliberate policy to unlock social and economic benefits. To harness the potential, it is important to gain as much knowledge and understanding as possible of the resource; the species and their distribution; nutritional, mineral, and other properties (e.g., calorific value); and the influence of soil composition and geology on nutritional and mineral properties.

VIABLE AND SUSTAINABLE – The sheer volume of encroacher bush and the variety of species (see below) suggest viability and sustainability, depending on the value chain and end-use products. The Namibia Nature Foundation (NNF[7]) estimated that a total net economic benefit of N$48 billion can be generated over a 25-year period. This estimation uses the following assumptions: 60% (15.8 million hectares) of 26 million hectares of bush encroached area can be targeted for bush thinning (i.e., suitable species for the intended end-use products). This activity could reduce bush densities by 67% over 25 years at an annual bush thinning rate of 5% (or 787,770 hectares) of the targeted area. The initial round of de-bushing (disregarding any follow-up measures) would be carried out over a period of 20 years, with the effects being captured over 25 years to allow for ecosystem services to reach their potential.

The table and map in this chapter provide information about the main encroacher species, those that are of lesser importance as encroachers (i.e., negligible to limited impact) and species that are invasive. To pursue a triple-win scenario – particularly to positively impact rangeland restoration and thinning bush to open up landscapes for animal wildlife movement – the target must be encroacher bush species of densities between 2,000 to 10,000 bushes per ha, with tighter focus on those areas where densities are higher than 5,000 bushes per ha and matching the desired species for the most part (*See map on next page* – note species as *A. mellifera*).

2.1 BUSH SPECIES DISTRIBUTION AND DENSITIES

The information and data below are drawn from all available sources for an accurate depiction of the bush encroachment situation in Namibia. The figure below shows species that are recognized as the main encroacher species in Namibia:[8]

Main encroachers	Less important as encroachers	Invasive species
Dichrostachys cinerea *Acacia mellifera* *Acacia reficiens* *Colophospermum mopane* *Terminalia prunoides* *Terminalia sericea* *Acacia nebrownii* *Rhigozum trichotomum* *Catophractes alexandri*	*Combretum collinum* (mainly in Zambezi Region) *Acacia hebeclada* (in areas of eastern Omaheke) *Acacia erubescens* *Acacia fleckii* (in areas of eastern Omaheke) *Acacia mearnsii* (black wattle – a patch in Otavi area) *Acacia nilotica*	*Prosopis sp* (They produce high yields of nutritious fodder, timber and fuelwood, but tend to form thickets in river beds and adjacent areas, where they outnumber and eliminate other indigenous species) *Leucaena leucocephala* *Lantana sp*

Figure 2.1 - Species and ecological roles

[7] NNF (2016) An assessment of the economics of land degradation related to bush encroachment in Namibia.

[8] GIZ/MAWF (2015) Strategic Environmental Assessment of Large-Scale Bush Thinning and Value- Addition Activities in Namibia.

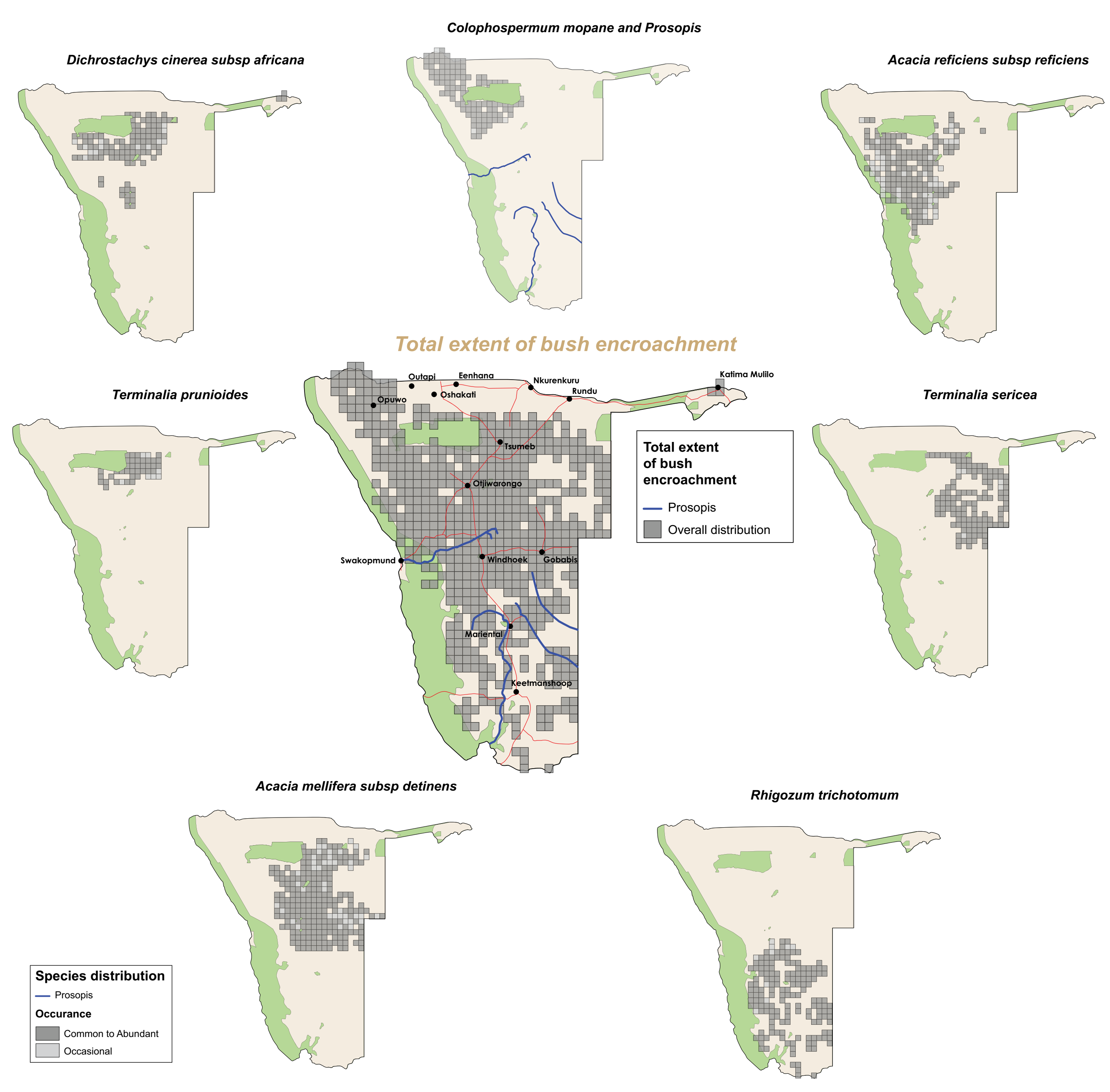


Figure 2.2 - Total extent of bush encroachment in Namibia with focus on main encroacher species

Targeting the main encroacher species for the development of end-use products, particularly the Acacia species, the above map and available local level data enhance planning to optimise efficiencies and reduce costs. The value chain that delivers the raw material at the plant is a major factor in determining time to market. From the above map, the distribution of the *Acacia mellifera*, which has shown resounding success so far as a main animal feed ingredient, overlaps with Otjiwarongo, where the plant would be situated. The MAWF/GIZ phase 2 project on Bush Management and Bush Control (BMBC) corroborated that tree equivalents per hectare (TE/ha) ranging between 4,000 to 12,000 overlap Khomas, Otjozondjupa, Kavango East and West, and the four central regions of the country. The species that overlap here (see above) include: *A. mellifera* (subspecies *detinens*) and *A. reficiens* (subspecies *reficiens*), *Terminalia prunoides* and *sericea*, and *Dichrostachys cinerea*. It is also estimated that biomass of 450 million tonnes could be accessed for bush-based value chains, not accounting for annual growth at 3.18%, signalling sustainability.

2.2 BUSH BIOMASS - SUITABILITY FOR FEED

All the above species (*A. mellifera, A. reficiens, Terminalia prunoides, Terminalia sericea* and *Dichrostachys cinerea*) have been analysed for their nutritional and mineral properties (see table below for illustrative purposes) and, based on these data, have been used in the formulation and testing of bush-based animal feeds.

Species	Moist	Ash	Fat	CP	CF	ADF	NDF	Ca g/kg	P g/kg	OMD	ME Mj/kg
A. mellifera milled	4,67	6,17	0,85	6,49	58,11	62,41	76,24	1,47	0,02	32	4,1
D. cinerea	6,49	6,11	1,93	10,7	33,77	49,84	56,66	1,15	0,25	47,2	6,5
A. mellifera 4 m tree	6,71	6,81	1,77	8,03	35,35	45,04	54,27	1,46	0,28	43,5	6,5
A. mellifera 2m bush	5,42	5,92	2,77	16,9	33,23	41,17	48,58	0,83	0,02	53,1	7,5
A. mellifera 16 months (regrowth)	6,86	8,13	3,15	13,5	24,7	29,56	39,21	1,32	0,3	62	8,7
A. Erioloba seed pods	4,54	5,61	2,24	17,55	27,77	25,12	32,27	0,5	0,02	61,5	8,7
T. serice A	4,76	8,8	2,56	9,75	24,15	34,54	45,04	2,05	0,07	38,2	4,9

Figure 2.3 - Illustration of the nutritional and mineral properties of encroacher bush species suitable for animal feed

Based on the nutritional and mineral analysis, bush material is found to be superior in terms of its crude protein (CP) (average of approximately 13.5% g/kg), although there is need to be wary of properties (e.g. tannins, woodiness, and fibre) that could result in toxicity and/or unpalatability (*see text below*). The five species proved viable for animal feed based on the feeding trial data and as briefly described below. This availability of a variety of species suitable for animal feed avoids the risk of reliance on one species and improves sustainability. The five species, along with supplements and additives, can deliver a wide array of animal feed recipes for field testing (e.g., complete feed, drought supplement, growth enhancer).

As mentioned above and demonstrated below, bush biomass <20 mm in diameter (leaves and twigs) will be used for feed, and the remainder (>20mm in diameter) will be converted to charcoal. The period of January to April is earmarked for the initial harvesting of biomass suitable for feed, and as shown below, the remaining biomass intended for charcoal will be collected simultaneously to enable processing of an entire bush except the rootstock.

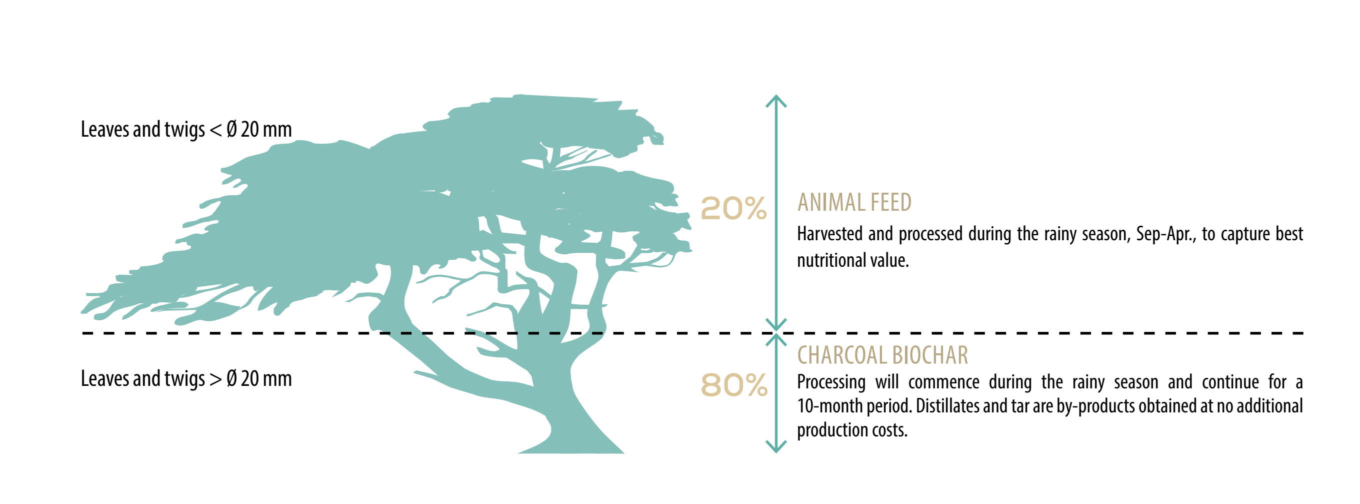


Figure 2.4 - Illustration of the zero-waste approach to use an entire encroacher bush

As mentioned above, production of animal feed is a specialised process, comprising the combination or blending of ingredients to deliver a well-balanced product palatable for target animals. Traditionally, bush biomass has not been used and is not yet mainstreamed in regionally and globally marketed animal feeds. Based on the *2018 AllTech Global Feed Survey*, soybeans, wheat, and maize are still the base components of most animal feeds.

Hence, considering bush biomass for animal feed requires a rigorous scientific and investigative process to ensure that bush-based feeds meet national and international standards and do not present a risk of any negative effects on animal health. The text below describes pertinent elements that this project has been investigating and would continue to investigate to deliver high quality, reliable feed.

FIBRE CONTENT

Fibres influence animal nutrition because their soluble and insoluble forms influence nutrient availability since they are partly fermentable and non-fermentable and influence water holding capacity and transit time. In nature, 50% of animal diets comprise the non-starch polysaccharide (NSP)-fibres. The solubility of the NSP-fibres depends on the feed raw material as both insoluble and soluble fibres play important roles in the gut of an animal. Soluble fibres are involved in viscosity development in the small intestine, a role that is considered anti-nutritional as it limits efficient absorption of nutrients, while on the other hand it can play a role to increase the intestinal villi health of an animal.

At present, under prevailing legislation, animal feed with fibre content not exceeding 68% can be registered. Namibian authorities assume that 68% bush material equates to 68% fibre, whereas measurements by UNAM and GIZ suggest that that fibre content is about half of the total biomass, i.e., for 68% bush the fibre content can be safely assumed to be 34%. For the five species mentioned above, the crude fibre (CF) measurements range between 20 and 60% (see Fig 3.2, column "CF") for twigs and leaves < Ø 20 mm, whereas CF above 70% has been recorded where bush material > Ø 20 mm has been used. At an average of 40% fibre, bush-based feeds would offer a close comparative to commercial mainstream feeds which have up to 50% NPS-fibres.

This project engages in ongoing sampling and monitoring to improve the knowledge and data about fibre content in bush and variation among species and within species due to variation in soil conditions. Research will also inquire if, like tannins (*discussed below*), fibre content increases or decreases with diameter size above or below 20 mm.

TANNINS

Tannin (or tannoid) is a yellowish or brownish bitter-tasting organic substance present in barks, twigs, and other plant tissues, consisting of derivatives of gallic acid. Tannins are generally toxic to ruminants but also serve a beneficial purpose by binding to proteins and protecting them from rumen fermentation, enabling better dietary use of proteins.

A. mellifera bush-based feed with tannin levels of between 5-10% has shown positive results during feeding trials as reported by UNAM, GIZ, and a private farmer. In some cases where bush material > Ø 20mm was used, negative effects were observed in livestock, including bloating and death. Development partners agree that more research and sample analyses are required to better understand the role of tannins and how best to regulate the concentration in animal feed. Tannins with high pH values (acidic) have negative effects on the rumen, while lower pH values (more alkaline) are better suited.

To make a distinction between these effects and to apply them properly to species selection and processing of leaves together with twigs, it is recommended that species that are considered promising be analysed for tannin content in leaves and twigs. Therefore, the next step will be to investigate in which species tannin has a favourable or negative effect, for which pH measurements may be an acceptable tool to determine maximum acceptable acidity values and desirable alkalinity values, as noted above.

More tannin sample data are needed for the feed-favourable encroacher species and to know what the regulation of tannins could mean. In the case of one of the major animal feed producers in Namibia, an ox died due to tannin poisoning as material > Ø 20 mm was milled and blended as animal feed. The contents of the rumen were found to be black.

UNAM, in partnership with Seinäjoki University of Applied Sciences, is continuing research and investigations that would also form part of the monitoring and data recording during recipe development and feeding trials.

From the above, one can summarise that:

- Bush material < Ø 20 mm is suitable for animal feed due to higher nutritional and mineral values, lower tannin concentration, and nutritious fibre content that can be regulated depending on the feed type.
- For optimal nutrient and mineral contents in feed, it is best to harvest during the rainy season as sampling shows the best values during this time.
- ↓68% Fibre content of up to 50% is comparable to that in commercial feeds while Namibian legislation does not allow registration of feed with fibre above 68%.
- Tannins are toxic to ruminants but are beneficial at the optimal concentration as they bind with proteins for more efficient dietary up-take.
- More research and field trials are needed to calibrate fibre and tannin in animal feed.
- A long-term dedicated research, monitoring, and evaluation programme is needed to develop a database on the process of designing and testing bush-based animal feed.

3

Targeted Bush-processing Value Chains

MAWF/GIZ conducted extensive research and analysis to determine a total number of possible bush-processing value chains (>30) and to narrow that down to a number that is achievable. Fourteen (14) were identified and a 15th, Arabic gum, added by this project, given regional and global trends in production, demand, supply, and application. The figure below presents the 15 most viable value chains.

CHARCOAL	WOOD CHIPS	COMPRESSED FIREWOOD	FIREWOOD	ANIMAL FEED
WOOD PELLETS	POLES	WOOD-CEMENT BONDED (WCD) PRODUCTS	MEDIUM DENSITY FIBRE (MDF) PRODUCTS	WOOD-SAND BOARDS
WOOD-PLASTIC COMPOSITES (WPC)	PARQUET	SHINGLES	TRADITIONAL MEDICINE	ARABIC GUM

Figure 3.1 - Fifteen (15) viable bush-processing value chains

Of the above value chains, some have been implemented for decades (e.g., charcoal), others can take off with ease (poles and wood chips), some more specialised ones are emerging with success (wood-plastic composites[9]) while other more specialised ones require more time and resource investment before implementing (MDF and WCB products). Commercial-scale charcoal has been produced in Namibia since 1983 with the emergence of Jumbo Charcoal, while end-uses such as firewood, wooden poles, and traditional medicines have been fabricated since time immemorial.

Biomass energy has taken off in Namibia while elsewhere, for example the 4 GWatt Drax biomass power plant in the United Kingdom, demand exists and is mounting for sustainable supplies of large volumes of biomass. Power plants like Drax have started surveying the world[10] for future biomass supply to sustain operations.

See the MAWF/GIZ publication on *Value Added End-Use Opportunities for Namibian Encroacher Bush* for a detailed presentation of recommended value chains.

3.1 INTEGRATED ZERO-WASTE FEED-CHARCOAL PRODUCTION

From the list of 15 value chains, two were selected for intensive viability analysis and for actual demonstration in 2019. To arrive at these two value chains, the evaluation parameters below were considered.

BUSH BIOMASS-TO-PRODUCT – RAW MATERIAL SELECTION

Only nationally identified and recognised encroacher bush will be targeted. For bush feed, some encroacher species (*A. mellifera*) fare better than others, based on feeding trial data. Mentioned above is the fact that leaves and twigs < Ø 20mm in diameter are most suitable for feed, and harvesting during the rainy season optimises the nutritional and mineral properties important for well-balanced feed. The harvesting of material suitable for feed production requires more care than species-indiscriminate bush harvesting for fuel for combustion purposes.

Harvesting cost is affected by the type of harvesting, the terrain, and the distance from the processing site.

There is a need for species selection criteria that extend to the size of the material needed for feed compared to that needed for charcoal. The N-BiG has estimated N$780/tonne as a reasonable price for raw material supply, which is worth noting and considering. N-BiG also provides a service on behalf of reputable and proven de-bushing entities to harvest and supply raw material.

[9] NamGreenWood, based on Walvis Bay, Namibia.

[10] Personal Communication, Colin Lindeque of N-BiG – remark during the first consultation on Biomass Hubs for Namibia.

MARKETS FOR END PRODUCTS AND ASSESSED BENEFITS

Each of the two end-products (animal feed and charcoal) was assessed for its market value, which is based partially on the provision of the quality required to attract consumers/retailers and to assure a sustainable market position. Hence, there is need to establish "acceptable foreseeable quality" and to market the benefits as evidenced by feeding trial data, in the case of animal feed. For charcoal, there exists firm market value: the benefits of the product are known and understood; there exists willingness to pay.

In the case of bush-based animal feed, there exists some preliminary market value due firstly to the historical use of bush material as feed or feed supplements, and secondly due to the increasing use of bush material as feed, even outside periods of drought. Market value is driven by product quality, which in the case of bush-based feed hinges on the nutritional and mineral values of bush species and the ensuing positive results from feeding trials (i.e., assessed benefits). Market value and benefits were further confirmed, although anecdotally, by a farmer who produces bush feed comprising 85% bush and has observed massive demand for the feed from surrounding farmers.

Eco-labelling/branding of the products – for example, "Sustainably Harvested Encroacher Bush" or "Value-Added Bush to Recover Rangelands" – and/or putting the nutritional values and/or publicising feeding trial data could unlock regional and global markets, expansion that would increase the general market value.

COMPETITIVENESS OF END PRODUCTS

Product competitiveness has been a key consideration throughout the viability analysis since it is a critical signal for business viability and sustainability. Competitiveness relates to:

- Market demand – existing and/or potential for a variety of existing products – more affordable, etc.;
- Pricing – compared to competitors with market share and based on market standards for volume (e.g. 50kg bags) at competitive prices (N$220-250/bag). In the case of bush-based feed, there are additional proven benefits that deliver "greater value for money" – daily weight gains possible with the feed and the added benefit of restoring rangelands;
- Quality – trial recipes show great potential to deliver quality that is comparable to or even better than what is available in the market. Quality is well-defined in the global animal feed sector in references such as the "2007 Feed Ingredients Standard for Producers and Processors of Feed Ingredients" and in the advice and guidance offered by the UN FAO Department for Agriculture and Consumer Protection.

Based on the feeding trials conducted thus far and the fact that farmers continue to invest in technology that can assist them with de-bushing and the utilisation of such bush, the eventual product is assumed to be competitive based on the following:

- Quality will be superior in terms of nutritional and mineral properties;
- Maximum weight gains by cattle will be exceptional at an average of 1.5 kg per day across three different data sets, with average weight gain between 500-700 g per day;
- Pricing will be competitive based on existing bush-based feed in the market with potential to be more competitive depending on access to markets, production scale, and cost of raw materials;
- Additional raw materials/supplemental/additives will be available at reasonable and competitive market prices – cost margins will decrease with bulk purchasing of molasses, maize, etc. It is important to confirm sustainability of supply and pricing.

The demonstration phase would invest ample time and resources to refine the competitiveness and to ensure quality.

IMPACT OF BUSH BIOMASS UTILISATION ON BUSH ENCROACHMENT

This project is developing a business model that would deliver triple wins, one of these "wins" being the restoration of rangelands. Recalling the MAWF/GIZ assumption that 60% of the total encroached area can be targeted, harvesting 5% (778,000 tonnes) per year could result in a 67% reduction of encroacher bush over a 20-25-year period (assuming no follow-up measures). Based on most recent scientific evidence,[11] this magnitude of restoration would be achievable only with carefully planned and implemented follow-up measures aided by a "contouring method" of harvesting, i.e., thinning encroacher bush in rows such that alternating rows are left unattended. It is critical to consider and factor in the annual bush growth at 3.18%.

The proposed Integrated Feed-Charcoal Production (IFCP) System would have a zero-waste approach to the use of each bush harvested: 20% of the raw material would be for feed and 80% for charcoal. An initial target of 4,444 metric tonnes of feed was set for 2019, only for demonstration purposes. This goal implies that the harvested biomass must be at least 5 times the volume for feed to deliver the above feed-to-charcoal ratios. Hence, the total biomass required would be 22,220 metric tonnes (mt) per year, of which 17,776 mt (80% of total biomass) would be reduced to charcoal.

[11] Zimmerman, I. et al. (2017) "The influence of two levels of de-bushing in Namibia's Thornbush Savanna on overall soil fertility, measured through bioassays."

It is currently estimated that 45 million ha are bush-encroached and that this area translates into 450 million tonnes of biomass. Over a 25-year period, this biomass would provide 18 million tonnes of harvestable biomass per year. Feedmaster, Namibia's only animal feed manufacturer, delivers some 160,000 mt of feed per year.

Assuming an extended IFCP production would commercially deliver between 30,000-50,000 mt of feed per year – to be competitive in the domestic market, this would translate into a total harvest of 150,000-250,000 mt per year. At this scale, the impact on reducing bush encroachment would be 1.4% per year of the 18 million tonnes of harvestable biomass after taking advantage of a certain multiplier effect.

Based on the existing biomass of encroacher bush and the annual growth rate, this project, the MAWF/GIZ project, and N-BiG, all estimated that up to 20 such operations could viably and sustainably exist in Namibia and together would deliver the impact required to reduce bush significantly and carry out extensive follow-up measures to restore rangelands. Furthermore, joint efforts would help to sustain the natural biodiversity and natural aesthetics, which support the tourism sector.

SOCIAL/SOCIO-ECONOMIC IMPACT

Creating employment will be an important outcome from efforts to significantly reduce bush encroachment, particularly as one of the "triple-win" social benefits. Here it is considered what types of employment could be created by the emerging bush processing sub-sector in general and specifically for the manufacture of animal feed and charcoal.

Type of Employment	Raw material supply	Raw material cleaning	Processing	Product development	Packaging and branding	Warehousing	Marketing and sales	Adm./Mgt.	Est. number per operation
Unskilled to Semi-skilled (50-75%)	15	4		2		2			23
Semi- to Fully skilled (15-25%)			2		2		1		5
Skilled to Tech. competencies (5-15%)							1	1	2
									30

Figure 3.2 - Employment type and estimated numbers for an operation producing 4,444 mt of feed

Figure 3.2 above breaks down the value chains into different steps in a logical sequence, starting with refining or improving the raw material and ending with the delivery of an end-use product. The figure indicates the type of employment created, the potential number of people in that category needed to perform the various steps, and the estimated total of each type for the overall operation. Since the above stated demand refers to 30,000 - 50,000 mt of feed, employment creation has to be multiplied accordingly. The profiles of the types of employment are as follows:

- 77% unskilled to semi-skilled – e.g. school drop-outs with technical competencies, general labourers with no or limited technical training, the general unemployed with capacity for learning;
- 17% semi- to fully-skilled – e.g. certified to uncertified technicians/artisans such as boiler makers, millers, food technicians, processing and production technicians;
- 7% fully skilled to technical competence – first or second degree holders with experience in project/value chain/supply chain/production management, or certified and experienced (more than 7 years) millers, processing and production technicians.

The consideration of employment creation is critical from a national development priorities perspective since national unemployment is at 28% with youth unemployment at 43%. The youth comprise more than 60% of the Namibian population; with capacity development and training, youth can be prepared to contribute to inclusive and sustainable industrial development.

The above employment projection is based on an industrial, technologically advanced production process that requires minimal human resources at the production plant (see section on business model and planning). This technology and the IFCP system have been chosen to enable large-scale bush thinning to lead to rangelands restoration. Hence, the short- to medium-term focus is to generate mass employment in harvesting, pre-processing, and processing materials.

The Acacia tree is known for both its ecological and economical importance. It is a valuable source of food, such as the seeds that are used as flour, as well as an energy source in terms of timber and other uses. With the growing market of Arabic gum, its importance has increased and numerous initiatives were launched for planting of Acacia trees to address climate change and desertification challenges. Such initiatives have also helped farmers by providing additional jobs as the Arabic gum harvesting is a labour intensive process, thereby also facilitating increased production in a systematic way throughout the value chain. As an example, Arabic gum sales have been an important source of income for about 6 million Sudanese, mainly small farmers. At the same time, the income of such producers could drastically increase through improved access to technologies and cooperative modalities among farmers to facilitate scale of production with better access to external markets, thereby providing an opportunity to improve the livehoods of the poor and address the poverty in the country.

TIME TO MARKET FOR SELECTED END-USE PRODUCTS

Time to market has two important considerations: (i) whether markets already exist and are ready to accept/absorb a new product, and (ii) the time it takes to deliver a product to market – i.e. production time.

The selected end-use products are bush-based animal feed and charcoal. The time to market for each of them is known. The value chain for bush-based feed is known, tested, and well-understood and would need to be refined based on the animal feed recipes that would be designed, blended, and tested. For the charcoal, a more efficient technology would be introduced in a well-developed functioning market that has a confirmed demand of 100,000 tonnes per year. Two prominent commercial operators showed initial interest in buying raw charcoal for processing, packaging, and sales to confirmed customers. Hence, for charcoal, the time to market considerations are positive.

For animal feed, it is important to note the following (*as mentioned above*):

- **Existing awareness and knowledge aid time to market** – Farmers (commercial and communal) have been aware of, and many have engaged in, conversion of encroacher bush to animal feed since the 1970s. Many farmers would consider buying bush-based feed at affordable prices to maintain their focus on farming and herd management, instead of making feed;
- **Existing, semi-developed, and emerging markets** – Based on supply of the major two producers providing up to 85% of bush-based animal feed in Namibia, there is an existing and slowly growing market. Neither of the producers possess professional sales and retail systems. However, one of them reported interest from surrounding farmers, who are willing to pay N$4,000-5,000 per tonne of the bush-based feed;
- **Assessed benefits and assured quality** – Feeding trials and nutritional and mineral analyses of bush material suggest that the feed can be successfully absorbed in the market and can secure a position;
- **Domestic, regional, and global demand** – Animal feed production has continued to increase (alongside human population growth), reaching 1 billion tonnes in 2016 and 2017, with growth in feed production in Africa the highest at an average of 30% for the years cited.[12] This trend is foreseen to continue even as human food demand is placing higher pressures to divert wheat, maize, and soybeans to human consumption instead of animal feed production. Hence, bush-based feeds can play a significant role in testing ways to address that shift;
- **Risk identification and management** – Once recipes are proposed, the value chain will be theoretically modelled and tested to arrive at a production time to market that will be tested and improved during the demonstration phase. It is important to thoroughly examine each step of the production process to ensure that all required equipment, capacity, and resources are available and to identify and mitigate any additional risk;
- **Potential for product acceptance/absorption** – There is an established animal feed market in Namibia that delivers some 160,000 tonnes of this product per year. In 2018, Namibia committed to increase meat production particularly for export markets such as China, the EU, and USA. The Namibian Development Corporation (NDC) and the Meat Board of Namibia, as project partners, can aid in establishing market presence, given the NDC has a cattle ranch project with more than 10,000 animals that can adopt the product and the Meat Board can encourage farmers to participate in feeding trials to raise awareness on the feed and its properties, as well as to confirm the "assessed benefits";
- **Eco-/sustainability branding (Namibian FSC) and international quality standards certifications** – To aid the process of establishing a domestic market and achieving regional and global market penetration and access, it would be to the advantage of these new products to brand themselves in such positive terms and to be certified as meeting national and international quality standards. Customers are aware that feed products deliver certain assessed benefits that they are willing to pay for.

MULTIPLIER EFFECT

This evaluation parameter considers the replicability of the business model, technology, and market approach to enable scaling up the triple-wins: social (employment, secure food and incomes); economic (local and regional economic development, macro-benefits); and environmental benefits (rangelands restoration, greater groundwater replenishment).

To leverage the multiplier potential for employment generation, rangelands restoration, and economic development, it is important to consider the replicability of value chains during feasibility assessment and business development. In the Namibian context, the following factors would be tested during demonstration as determining the quality of the multiplier effect:

- Existing demand/market for the end-use product;
- Effectiveness in addressing/tackling bush encroachment;
- Multiple sustainable development benefits – water, energy, food security, drought/climate change resilience;
- Generation of sustainable employment and decent incomes.

[12] AllTech 2018 Global Animal Feed Production Survey.

3.2 ASSESSMENT OF THE TARGETED VALUE CHAINS

CRITERIA	ANIMAL FEED	CHARCOAL
Bush selection	▪ Most encroacher bush species are suitable for bush feed – <20 mm diameter leaves and twigs, rainy season harvesting to optimise nutrition; ▪ Ongoing research on lignin, tannins, and palatability properties.	▪ Directorate of Forestry regulations for wood use for charcoal – size range from 20/25 mm in diameter to 180 mm; only encroacher species; ▪ For both feed and charcoal, bush selection will be influenced by the terrain, topography, and the general vegetation of a target area.
Market value of end-products	▪ The market value of the intended animal feed production is guaranteed by already available commercial feed production (at least 2 producers), which proves that demand is in place. Already existing production is of significant importance due to the influence on the shortening of the time-to-market period and will contribute to immediate sales; ▪ No standards currently exist for bush-based feeds, and registration as feed is limited to that comprising 68% or less bush biomass; ▪ It is important to develop viable feed recipes that can meet international feed standards and certifications; ▪ Awareness of and participation in bush-based feed production is increasing, according to selected local technology entrepreneurs who have sold more than 11 mobile bush harvesting and milling units between 2017 and 2018.	▪ Charcoal has an already developed market with confirmed market value and an annual demand of 100,000 metric tonnes; ▪ Potential exists for higher margin, value-added charcoal-based products, e.g. biochar, which is activated charcoal with several high value applications as filter material, as a pharmaceutical product (white charcoal), and after undergoing a torrefaction process, as a second-generation fuel. These markets are currently not developed in Namibia.
Potential competitiveness of end-products	▪ Limited sales experiences and evidence of "willingness to pay" are in place and suggest a potential strong competitive position with respect to currently produced blended bush-based animal feed products; ▪ With bush as the major input material, the cost of which depends on harvesting cost, one could assume reasonable margins can be obtained with commercial bush-based feed; ▪ In addition to competitive pricing, bush-based feed would be a win-win offer to the agricultural sector – providing feed and enabling rangelands restoration – this should be marketed/part of branding; ▪ Publishing of feeding trial data and nutritional and mineral properties of bush material could aid in establishing a competitive reputation from the onset.	▪ Charcoal is a competitive end-use product as confirmed by the existing market and its annual demand, along with increasing global demand for bush biomass; ▪ The proposed technology will achieve higher revenue margins per volume of bush processed as charcoal given the 30-40% higher efficiency than current technology in use (e.g., rudimentary hand-welded cylindrical kilns made of 3- or 5-mm sheet metal).
Impact on bush biomass consumption	▪ MAWF/GIZ suggest that 60% (15.8 million hectares) of 26 million hectares of bush encroached area can be targeted for bush thinning (i.e., suitable species for the intended end-use products). This approach could reduce bush densities by 67% over 25 years at an annual bush thinning rate of 5% (or 787,770 hectares) of the targeted area.[14] The initial round of de-bushing (i.e., disregarding any follow-up measures) would be carried out over a period of 20 years, with the effects being captured over 25 years to allow for ecosystem services to reach their potential; ▪ As mentioned above, a commercial plant producing up to 50,000 metric tonnes of bush-based feed per year would contribute 1.4% to the above proposed target, raising the question of the replication potential and multiplier effect.	▪ For the current production of approximately 180,000 tonnes of charcoal/year, currently an average bush mass of 900,000 tonnes/year should be considered, applying a conversion rate of 5 tonnes of bush/per tonne of charcoal based on very basic drum kiln technologies; ▪ This required bush mass converts currently to approximately 90,000 hectares of bush, considering an average bush mass of 10 tonnes per hectare of bush land; ▪ Considering (1) the current low level of production technology, (2) the predicted and unmet demand for a potential two- to three-fold production increase, a significant contribution to bush encroachment improvement will be achieved; ▪ Given the above, it could be assumed that approximately 225,000 hectares could be added to the total area treated for bush encroachment. If very selective bush harvesting is performed focusing on grazing land restoration, this area could add significantly to de-bushing.
Impact on employment	▪ Current production processes on individual farms are labour-intensive. Even with fully mechanised harvesting, there is significant manual work involved to separate the bush into its processing components; ▪ It is foreseen that 77% of total employment created to produce the target end-use products would be manual and semi-mechanised, mainly for harvesting and supplying material; cleaning; processing; and post-production packaging and storage; ▪ Time to market and the volume of biomass required to achieve a critical size for the intended product are important factors that determine the employment generation potential; ▪ An environmental and social impact assessment will estimate numbers of employees for one commercial scale operation and consider the multiplier effect for 5, 10, or 15 such operations.	▪ The baseline in the charcoal industry suggests that there is high potential for employment in this sector: 500 drum kiln installations are working and employ roughly 5-6,000 people directly/indirectly; ▪ Given the proposed retort charcoal production system, the employment potential at the system location is mostly in the harvesting and supply of processed raw materials; ▪ At the unit level, the current proposed technology comes semi-automated and employs 2 persons per unit for oversight and supervision.
Time to market	▪ Time to market is foreseen as viable for delivering a marketable product with potential for acceptance/absorption; ▪ Semi-developed market with growing awareness among farmers and increasing engagement in individual bush-based feed production can benefit from a high quality, standardised, and certifiable bush-based feed; ▪ Market the "assessed benefits," namely nutritional and mineral properties and weight gains; ▪ Marketing and eco-branding of the sustainability and ecological restorative benefits could also reduce time to market.	▪ Currently unmet demand exists for approximately 100,000 tonnes/year, which could be met immediately by additional production capacity; ▪ In that case, time to market will depend on when the technology is ready for production and how soon the first batch of raw materials can be delivered; ▪ Commercial buyers of unprocessed charcoal are ready to buy, package, and sell to established clients/markets.
Multiplier effect	▪ Given the vast encroacher bush resource and its annual growth rate, it is estimated conservatively that 20 Integrated Feed-Charcoal Production (IFCP) systems can be viable in Namibia. GIZ and N-BiG refer to Bush Biomass Hubs of which >15 could be viable across Namibia, exploring some of the 15 value chains.	▪ As mentioned in the "Animal feed" column, the multiplier effect is viable, keeping in mind that different types of employment can be generated per operation and that most would be unskilled/semi-skilled to skilled.

3.3 FURTHER BUSH VALUE CHAINS TO BE EXPLORED

The Figures below (Figures 3.3a and 3.3b) show analyses of additional value chains that can be viable in Namibia with solid research and development, an excellent blend of skills and expertise, and investment capital.

CRITERIA	SOLID BIOMASS FUEL	SOPHISTICATED INDUSTRIAL APPLICATIONS	SMALL-SCALE USE
Bush selection	▪ Generally, selection need not be species selective since any/all bush material can be used to generate heat energy that is then converted to electrical energy; ▪ For higher and longer burning capacity, the calorific value of the wood can be considered.	▪ Softwood –unlike Acacia species– is usually used as raw material for sophisticated end-products, due to specific fibre properties. Encroacher bush is mainly hardwood and bark for which fibre properties for industrial use are unknown; ▪ Chipboard made from Acacia wood chips has been manufactured successfully in Namibia on an experimental scale. Due to the hardwood chips, more resin/glue is required to ensure chip bonding; ▪ Mopane has proved not to work well as a chipboard component; ▪ R&D and investment are required to deliver a tested, competitive and marketable Acacia wood chipboard that conforms to international standards. There may be niche markets (e.g., IKEA Acacia-specific furniture line) for such eco-branded products.	▪ Species selection would favour hardwoods in the case of flooring and softwoods for shingles (roofing); ▪ For flooring, trees greater than 20 cm in diameter could deliver higher yields at lower processing and production efforts/cost, compared to trees smaller than 20 cm in diameter. Acacia hardwoods could be suitable; ▪ Shingles are used for roofing in European and some northern hemisphere buildings/homes. Softwood with great resistance to environmental conditions is used. Common species in Europe include cedar, larch, fir, spruce and little oak; ▪ Significant R&D and investment are required to assess the viability of the wood but also to explore markets that are willing to try/test products from different tree species.
Market value of end-products	▪ In Namibia, there is a limited yet growing market for solid biomass fuel. Currently only the Ohorongo Cement Plant uses biomass to generate electricity; ▪ Diagonally across from the intended demonstration site is the Cheetah Cement Factory, which uses considerable energy for production. There is an option to discuss the possibility of supplying it with biomass for its production; ▪ There is a well-developed and growing market for biomass as fuel, while in Africa energy pellets can help to extend affordable clean energy to poor households; ▪ Through a partnership approach with the European Biomass Industry Association, an agreement can be explored for future delivery of EU-grade energy pellets and semi-processed biomass.	▪ MDF and compressed wood chipboards (with laminated surfaces) are mainstreamed throughout Namibia and found in all hardware stores; ▪ MDF is used for the base and supporting structures for built-in cupboards while laminated wood chipboards are used as cupboard doors, shelving, bookshelves, kitchen counters and table tops, etc.; ▪ 100% is imported at present, mainly from South Africa, with well-established market value for such end-products; ▪ Requires significant investment cost to establish a production plant; ▪ NamGreenWood is a Namibian-owned wood-plastics composite manufacturer.	▪ There is neither an established market nor market value for flooring and shingles in Namibia; ▪ Laminated chipboard serves a similar purpose as flooring while there may be a small potential market for flooring among the more affluent.

Potential competitiveness of end-products	▪ Namibia's National Integrated Resource Plan (NIRP) –essentially the roadmap for energy security– earmarks 4 biomass power plants at 20MW each by 2024, 2028, 2030, and 2033. Although it is not mentioned in the NIRP, the Namibian power utility is in the process of finalising a techno-financial analysis for the first 20MW biomass power plant which is estimated to use 160,000 metric tonnes of biomass per year; ▪ In addition to NIRP plans, there is an opportunity to replicate the Ohorongo Cement plant model at the Cheetah Cement Plant in Otjiwarongo, which is diagonally across from the site intended for this project's demonstration. Ohorongo uses about 85,000 metric tonnes of biomass per year.	▪ Since all MDF and compressed chipboard are imported, there is potential for import substitution, given it is viable to set up production in Namibia; ▪ As a comparable example, gypsum-based ceiling boards can be manufactured in Namibia at a cost that is only 5% of the average retail price for the same product in the market; ▪ Assuming the raw material is accessible at low cost (of harvesting at N$780/ton), and that experimental production has been done, there is potential to produce a product that competes with imported ones; ▪ A full feasibility study is needed to factor in the investment cost of an MDF plant.	▪ Currently no assessment is possible, since production costs – and consequently pricing – cannot be predicted due to the lack of basic data.
Impact on bush biomass consumption	▪ Based on the current Ohorongo Cement Plant example of using 85,000 metric tonnes of chips/year, equating roughly to 8,500 hectares per year; ▪ Additional 20,000 metric tonnes for the beer brewery furnaces and 160,000 tonnes for a 20MW power plant per year are earmarked and could be augmented in future with Cheetah Cement and the 4 biomass power plants in the NIRP; ▪ Ohorongo, the brewery, and NamPower would use a total of 265,000 metric tonnes, equating roughly to thinning an area of 26,500 ha. If Cheetah establishes a power plant in future at a scale similar to Ohorongo, this could equate to 350,000 tonnes per year, or 35,000 ha; ▪ This would equate to 4.5% of the 5% harvesting rate suggested by MAWF/GIZ to reduce bush encroachment by 67% over 25 years. This was based on an estimated bush extent of 26 million ha.	▪ MDF plants minimum capacities range from 100,000 m3/year to 500,000 m3/year. For Namibia, bush demand for a 100,000 m3/year plant was estimated at 140,000 m3/year of woody biomass; ▪ Non-selectivity based on the experiment by a local farmer could deliver significant impact on minimising/thinning encroacher bush.	▪ The lack of, or limited market for flooring and shingles suggests this is not a viable value chain and would thus not significantly impact minimising/thinning encroacher bush.
Impact on employment	▪ Labour-intensive or semi-mechanised harvesting of encroacher bush also offers the large employment avenue as the chipping, milling, and pelletizing are all mechanised; ▪ The following annual demand forecast for wood chips is broken down as follows: Ohorongo = 90,000 mt/year; Namibian breweries = 7,000 mt/year and NamPower (20MW) = 150,000 mt/year with total biomass demand per year = 242,000 mt; ▪ Employment to deliver this biomass through manual and semi-mechanised harvesting is estimated to be at most 20 persons.	▪ NamGreenWood is a wood-plastics manufacturer in Namibia and employs 20 persons; ▪ Employment for other products is estimated as follows: MDF boards –up to 150 persons working 3-4 shifts per 24 hrs; Wood-Cement Bonded bricks and boards up to 100 persons; ▪ MDF technology is available from a decommissioned kitchen manufacturing company, an opportunity that could help lower investment cost to commence production.	▪ Employment would be mainly in the supply and pre-/processing of raw materials as floor production is mechanised and automated - between 20-30 persons including harvesting and material supply.
Time to market	▪ With Ohorongo Cement as an example, and with increased access to affordable biomass power technology, the time to market is reasonable (6-18 months) given the size and scope of these projects; ▪ For example, Cheetah Cement operates out of Otjiwarongo (opposite Biomass Hub) and could replicate the Ohorongo model to improve production efficiencies and to lower costs; ▪ Cheetah power plant to be of such magnitude that it provides power to new housing developments earmarked for the north-eastern part of Otjiwarongo town.	▪ Based on the condition of the existing technology to manufacture MDF/chip boards, the time to market could be reasonable, i.e., 6-18 months. If the technology is not suitable, the time to market could be 24-36 months, since a project would have to be conceived and financed from scratch; ▪ Wood Plastic Composites (WPCs) are being manufactured and could serve as a learning lesson for additional production plants. Given the growing awareness of WPC's environmental friendliness, the time to market could be 36 months at most.	▪ These products require significant development and the securing of partner commitments ahead of any marketing, particularly in the absence of a domestic market; ▪ Significant time to market (>24 months) unless manufacturing contracts are agreed and supported by an external partner where well-developed markets exist.
Multiplier effect	▪ Namibia's National Integrated Resource Plan (NIRP) earmarks 4 biomass power plants at 20 MW each by 2024, 2028, 2030 and 2033. Not mentioned in the NIRP, the Namibian power utility is in the process of finalising a techno-financial analysis for the first 20MW biomass power plant which is estimated to use 160,000 metric tonnes of biomass per year.	▪ SDG 12, Sustainable Production and Consumption, could aid the multiplication of WPC, for example, as it uses waste biomass material and recycles plastics; ▪ The Global Wood Plastic Composites Market was valued at $2,551 million in 2016, and is expected to reach at $6,584 million by 2023, the global market is dominated by the Asia-Pacific region; ▪ Up to 2 more WPC production plants can exist in Namibia –based on available wood biomass– that could access external markets and provide an eco-labelled product.	▪ Based on the "critical size" requirement of any production and the fact that there is neither a production facility nor a developed market, no multiplier effect is considered.

Figure 3.3a - High-investment, research- and development-intensive bush-based value chains

CRITERIA	WOOD POLES	GUM ARABIC
Bush selection	▪ Selection is not species-sensitive but considers dimensional factors such as straightness and diameter; ▪ Due to selectivity, cost-effective mechanical harvesting is not possible since only part of the tree is harvested at different times; ▪ When poles are the typical end-product, appropriate bushes are selected and manually felled, with remains left on site; ▪ A potential co-product or cooperative (*see below*) approach with charcoal and animal feed can be tested by sorting bush trunks according to the appropriate size and dimensions suitable for poles; ▪ Some species are highly resistant to decay and termites, characteristics that avoid the need for some chemical treatment but increase the need for selectivity.	▪ *Acacia nilotica, A. senegal* and, *Vachellia (Acacia) seyal* are the suitable species; ▪ Gum arabic is a dried exudate obtained primarily from tree trunk of Acacia senegal (L.). Arabic gum is obtained from growing trees by cutting holes in the bark of the tree, while the Acacia Seyal forms natural extrusions in the bark. The gum must be picked into jute sacks, baskets or woven plastic bags dedicated for the gum only to prevent possible contaminations and later quality problems; ▪ Gum production can begin when the trees are 5 years old although gum may be tapped from the trees after 3 years. However, the quality and yield are consistent only after 5 years; ▪ Acacia senegal (Willdenow var. Senegal) and Acacia seyal (Vachelia Seyal) are the two most commercially important sources of gum arabic for Europe. Minor quantities of gum are obtained from A. laeta and other Acacia species; ▪ The main crop is harvested between December and April; ▪ The yield from each tree rarely exceeds 300-400 g per harvest.
Market value of end-products	▪ Formal and informal markets exist for wooden poles used in farming and housing; ▪ The formal market distributes through hardware stores that source locally but mainly import. The informal rural-based market consists of farmers/individuals who produce poles to generate income.	▪ A well-established market value exists for Arabic gum; ▪ End-use products are usually in powder form and priced at US$8.95 for 100 grams (US$0.09/gram).
Potential competitiveness of end-products	▪ Data on product quality in the informal market are not readily available. Product quality varies; ▪ A feasibility study should be done (a) to ascertain the possibility of producing wood poles at a scale to become competitive through intensive investment, or (b) for one entrepreneur to source poles from various suppliers and screen them to sell high quality ones to retailers while selling sub-standard ones to private persons at a discounted price, similar to the current practice in charcoal processing; ▪ The new entrant will also face the problem of transportation cost because the small demand is distributed over significant distances.	▪ A full-scale feasibility study is planned to ascertain (a) the incidence of appropriate species and (b) whether sufficient volumes of gum can be harvested in Namibia per year.
Impact on bush biomass consumption	▪ Wooden poles are mainly imported. Local production would entail selectivity to ensure straightness, length, and suitable diameter. Hence, for a given volume of poles produced, there would be significant unused waste material; ▪ Given the intensity of effort to produce poles and the realistic volume of saleable poles that can be produced per year, this product is not foreseen to deliver significant impact on the reduction/thinning of encroacher bush.	▪ Does not require harvesting Acacia gum-producing trees, hence will have no impact on the reduction of encroacher bush.
Impact on employment	▪ This already generates employment and incomes for rural Namibians, but the current model has limited potential for scaling up; ▪ One potential model could entail individual producers selling to a "market-maker" who buys at an agreed price and off-loads to retailers or consumers. Hence, 20-100 individuals could produce sustainably and sell to 1-5 market-makers who have access to markets.	▪ Based on the example from Sudan and depending on the availability and accessibility of the resource, this could offer vast employment opportunities and incomes to rural women and youth; ▪ The Sudan example: 12,000 people employed, of which 25% are women. Assuming that Namibia has 10% of Sudan's employment, the example suggests 1,200 people could be employed. With >60% households in rural Namibia headed by women, total employment in this activity could comprise 80% women.
Time to market	▪ Given the low equipment and monetary demands, the time to market is short but could improve through a cooperative model as described above, such that the market-makers could ensure supply and could influence production.	▪ Well-established markets exist, and lessons from Sudan could aid in expediting time to market; ▪ It is envisaged that Namibia can enter the market in 36 months from mid-2018, granted project development is dedicated.
Multiplier effect	▪ The multiplier effect can be achieved through a cooperative model described above with market-makers, consumers/retailers.	▪ Since this is a new activity for Namibia, the multiplier potential is unknown currently. Following initial practical piloting, an inference could be drawn on the potential to include more people and increase gum harvesting.

Figure 3.3b - Moderate-investment, medium research and development-intensive bush-based value chains

4

International Development Efforts: Synergies and Coherence

Searching for synergies with sectorial strategy and considered as a complementary tool for implementing national policy for sustainable development, this study considers the research and technical activities conducted so far by the national and international development partners, which are briefly described in this Chapter.

4.1 DEUTSCHE GESELLSCHAFT FÜR INTERNATIONALE ZUSAMMENARBEIT (GIZ)

GIZ has been working in Namibia on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ) and the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) since the country gained its independence in 1990.[13]

The **Programme Competitiveness for Economic Growth** supports the Government of Namibia in implementing the policies described above. It focuses on growth strategies for selected economic sectors, as well as financial systems development and capacity development in the institutions involved. It is complemented by the related GIZ project for the promotion of vocational education and training. Led by the Ministry of Industrialisation, Trade, and SME Development (MITSD), the project analyses selected value chains within the economy that demonstrate high growth potential. Based on the results, and guided by the expected market interest in products, measures are then implemented that tap into that potential. The main targets of this support are small and medium-sized enterprises (SMEs) in all regions of Namibia. To ensure the beneficial impact of the measures, the process involves public and private sector stakeholders, including the Namibia Chamber of Commerce and Industry (NCCI), the Namibia Manufacturers Association, Team Namibia, and the Namibian Employers Federation, as well as the Business and Intellectual Property Authority, the Namibia Statistic Agency, and the Local Economic Development Agency. Project activities include business management training, assistance with product development, and the introduction of new technologies. The Namibia Investment Centre (NIC) receives support in devising strategies to increase foreign direct investments that encourage new enterprises and business growth. At the same time, the project is encouraging a more conducive business environment, for instance through the simplification of processes, incentive schemes, and access to local and regional markets. These measures benefit all businesses and sectors in the country. Public-private dialogue is similarly important, so the project supports NCCI in its communications and advocacy efforts on behalf of the private sector.

Access to finance is a key constraint for businesses, especially SMEs. To improve that access for Namibian enterprises, several reforms and specific measures are foreseen in the Namibia Financial Sector Strategy (NFSS). To support these efforts, the project is cooperating with the Bank of Namibia, the Namibian Financial Institutions Supervisory Authority, the Development Bank of Namibia, and others in adapting regulations (e.g., the Credit Agreements Act and the Banking Institutions Act) and in assessing the viability of new financing instruments, such as venture capital, credit guarantee schemes, and a fund with a first-loss component. Meanwhile, with support from the project, the Financial Literacy Initiative hosted by the Ministry of Finance is communicating important knowledge to enhance access to finance. The initiative includes professional-level training in business and financial management, as well as more general awareness-raising with respect to financial services.

The **Support to De-bushing Project** is a four-year GIZ initiative to address both challenges and opportunities that bush encroachment entails. In order to initiate de-bushing with value addition, Development Consultants for Southern Africa (DECOSA) has been contracted to prepare a Scoping Document on Value Addition and End Use Opportunities for Namibian encroacher bush. It is the main task of the Consultancy to identify products that can be produced using Namibian encroacher bush and to outline their potential for establishing competitive value chains in Namibia. This study identified and assessed potential end-use opportunities under the following broad categories: (a) residential wood fuel, (b) industrial heat and power generation, (c) construction material, (d) products mainly for indoor use (high value and value-added wood surfaces), (e) agricultural implements, (f) pulp and paper, and (g) small-scale uses (e.g., flooring, shingles, toothpicks, crates and boxes, mulch, and traditional medicine).

Programme activities focused on support measures and on efforts to create an enabling environment. Key approaches at the programme level include:

- developing strategies for the profitable use of biomass for electricity generation as well as in agricultural and industrial value chains;
- enhancing know-how and institutional capacities for the successful development of the national de-bushing programme;
- improving the legal and institutional framework for large-scale bush clearance programmes.

The project conducted two studies estimating the net benefits of bush control, compared with a scenario of no action on bush encroachment. Both studies were undertaken by Namibia Nature Foundation (NNF) from February 2016 to February 2017. The studies provided initial economic valuations to guide policy options when acting on bush encroachment. Various ecosystem services on national and regional levels were valued and analysed with a cost-benefit model. The potential net benefits on the national scale were estimated at N$48.0 billion over a 25-year period.

In case of the study on the Otjozondjupa region, the net benefits were estimated at N$4.9 billion. Additional groundwater replenishment accounted for most of the valuation; however, there would also be benefits for livestock production, tourism, biodiversity, biomass-powered electricity generation (and associated carbon offsets), and value addition opportunities such as the production of charcoal, firewood, and animal feed. The findings of the studies clearly show that bush control can make a considerable contribution to Namibia's welfare and economic growth in terms of employment and other social-economic benefits. Moreover, the regional case contributes greatly to the MET Land Degradation Neutrality pilot project in Otjozondjupa and complements the MLR Integrated Land Use Plans, particularly regarding the related strategic environmental assessment (SEA).[14]

A second phase (2018-2021) focuses on encroacher bush management and bush control (BMBC). This includes the application of information and data about bush species and their distribution, resident topography, as well as mineral and nutritional values in order to refine the feasibility assessment of additional value chains. The project also supports adapting the existing policy and legal environments to serve an enabling role instead of posing additional challenges.

4.2 UNITED NATIONS DEVELOPMENT PROGRAMME/MAWF PROJECT

The UNDP/MAWF- and GEF-financed project, NAFOLA,[15] is a five-year project that has been supporting the gazetting of community forests and strengthening management through capacity development and fostering ownership of local forest resources.

The NAFOLA Project targets 11 registered/emerging community forests to improve the management of forest resources. In 7 of the 11 sites, bush encroachment is extensive and a major challenge for indigenous trees and palatable grasses. Output 2.5 of this project directly targets bush encroachment as a threat to indigenous trees, plants, grasses, and even to endemic animal wildlife. By improving the management plans of community forests, the project has been assisting with de-bushing strategies to improve the integrity of the wooded grasslands and forests without unintentionally causing additional damage to forest ecosystems. The project has assisted communities in identifying ways to convert bush material into sustainable products for income generation. Potentially marketable products include charcoal and briquettes, fuel wood, and other wood products. With this aim in view, the project procured a bush-processing machine and piloted it to produce livestock feed. Through the MAWF-GIZ partnership *to strengthen the restoration of productive rangeland in Namibia by identifying value chain opportunities to trigger large-scale de-bushing activities*, the project was able to carry out feeding trials using the bush-based feed in the African Wild Dog community forest. The main outputs of this exercise included:

- A research report providing scientific evidence and elaborating the nutritional value of different bush species, and suggesting the most suitable bush-based feed diet according to the present encroacher bush species and the available supplements;
- A farmer's manual on bush-based animal feed production in a communal setting;
- A business case for commercial production of bush-based animal feed production and storage;
- A research paper for publication in a peer-reviewed scientific journal will also be considered after the research report is completed and the project has ended.

4.3 UNIVERSITY OF NAMIBIA (UNAM)

The Faculty of Agriculture and Natural Resources hosts various departments dealing with animal nutrition and health sciences. This Faculty is involved in research and development pertaining to the use of encroacher bush material for conversion to animal feed. The Faculty technically supported MAWF, local farmers in the Omaheke region, and the NAFOLA Project with trials to test bush-based feed variations. UNAM carries out nutritional and mineral analyses of bush biomass and provides advice on additives and supplements to enable delivery of a well-balanced, palatable livestock feed.

4.4 SEINÄJOKI UNIVERSITY OF APPLIED SCIENCES

Seinäjoki University of Applied Sciences (SeAMK) is a multidisciplinary institution of higher education and an efficient actor in education and research, development and innovation (RDI) in the region of South Ostrobothnia in West Finland. Since 2016, SeAMK has carried out several studies focusing on the feed use of Acacia fractions in Namibia, including a feasibility study that produced promising results. After the first analysis, for instance, the protein concentration of the fine fractions (fines) was on a level of grains. The cooperation with UNIDO on a feasibility study on the compound production of charcoal and animal feed has covered various dimensions of the bush raw material harvesting, identification of technology and human capacities requirements for operationalization of the pilot production plant. Acknowledging the extensive expertise and experience of SeAMK in food chain development and related capacity building activities (including the tailor-made Finnish certified intensive training for food value chain and food safety delivered internationally, food solutions, entrepreneurship and growth and others), the cooperation is considered to be extended for solutions to separate the compound feed and charcoal production chains on the critical control points by using an application of the HACCP –method (Hazard Analysis Critical Control Points), modalities for sustainable transportation and logistics of bush biomass, as well as alternative Acacia processing methods.

[13] https://www.giz.de/en/worldwide/323.html

[14] www.dasnamibia.org

[15] Sustainable Management of Namibia's Forested Lands, financed by the Global Environment Facility.

5

Production System, Technology Appropriateness and Sustainability

5.1 CURRENT STATUS AND TRENDS OF BUSH-FEED PRODUCTION

For the following evaluation and assessment of the proposed production system and technology, an individual approach is elaborated as the baseline production system and technologies in use. The process steps to convert bush to animal feed as end-product are the same for the individual and industrial approaches, with differences in the scale of economic opportunities, professional staff requirements, and specialised equipment suited to the respective production capacities, optimized business processes, and accompanying management challenges.

This section looks specifically at harvesting as a significant cost factor with respect to economic viability. Mechanised harvesting will have to be justified by product competitiveness, while factors such as topography, terrain (mountainous vs. sandy flats), and favoured species distribution can affect the mass balance of harvestable bush areas.

5.1.1 Bush control and harvesting methods

Addressing bush encroachment in Namibia has led to an array of solutions under experimentation that, until recently, were mainly to simply get rid of the bush as fast as possible with as little cost and effort as possible. Over the past decade, more attention has gone into the impacts of bush control/harvesting/thinning, extended to the disposal of the harvested wood biomass, the follow-up measures necessary, and the wider environmental and ecosystem impacts. In the past five years, bush control has been considered from a business point of view, especially when high-tech machinery came into play and some existing value chains started to grow and diversify.

The "Bush Control Manual"[16] published by the MAWF/GIZ in 2017 describes all the current practices and provides useful insights as summarised in the below table.

METHOD	Description	Equipment	Cost Estimate (N$)
Manual	▪ Manual bush control is achieved by hand labour using hand tools only. Highly selective and effort-intensive.	▪ Axes, pangas, and spades.	▪ 1,000 – 3,000/ha.
Semi-mechanised	▪ This form of bush control involves the use of hand-held power tools that are not self-propelled. Still highly selective with faster rate of control at lower man-hours.	▪ Conventional bush cutter, heavy duty bush cutter, and chain saw.	▪ 1,500 – 2,000/ha.
Mechanical	▪ This form of bush control is achieved with the use of self-propelled machines equipped with various appliances. Selectivity varies with the size and sensitivity of control of the harvesting appliance, which can clear vast tracts of land in a short time.	▪ Heavy mechanised cutting machine with clippers, small bulldozer with circular saw, heavy bulldozer, and bush roller.	▪ 750 – 4,000/ha.
Chemical: manual application of arboricides	▪ The most widespread of all methods of control, based on a 2014 survey of commercial farmers. Arboricides are used most frequently and are effective when correctly used. Incorrect use can result in various negative impacts. When treated effectively, encroacher bushes are killed and will not grow back, although the seeds remain unaffected. There is a risk of recolonisation from seeds during years of good rains, resulting in renewed bush encroachment in 2-3 years' time.	▪ Pump sprayers and by hand.	▪ 500 – 2,600/ha.
Planned fire	▪ Frequently unable to control well-established dense bush, it is effective in killing woody seedlings and saplings when they are still fire-tender. Recommended for use during follow-up measures.	▪ Axe, spade, shovels, hoe, picks (manual) and mechanised machinery such as graders and tractors.	▪ About 100/ha.

This project intends to use the mechanical bush control method with technology (see below) that enables high selectivity with limited negative impact and a reasonable harvesting rate.

Figure 5.1 below shows images of mechanical control using a front-loader to push the tree down to the soil such that it uproots.

An observed disadvantage is that there will be more dirt (soil/ash content, including microbes) remaining in the bush material due to be converted either to charcoal or into animal feed. In this case example, the bush is manually trimmed to the appropriate dimensions for chipping, while remaining materials are reused on the site.

[16] Rothauge, A. (2017) Bush Control Manual. Commissioned by the Support to De-bushing Project of the Ministry of Agriculture, Water and Forestry and the GIZ.

Figure 5.1 - A front loader tractor removing the bush and a labourer manually trimming the tree to separate the biomass used for feed

The images below (Figure 5.2) are of another case example using a scissor appliance mounted to a caterpillar with an extendable hydraulic arm that improves reach and selectivity. The farmer intends to have a smaller vehicle (tractor) with a mounted scissor appliance to lower cost and improve operational flexibility.

Figure 5.2 - Tambuti Wilderness Farm: the extendable arm on the caterpillar and the scissor appliance

Figure 5.3 - Example of bush cut manually using an electric saw

In Figure 5.3, one can observe the regrowth emerging from the stump, limiting the recovery of grazing land, according to the farmer on whose land the picture was taken. Another concern at leaving a cut stump in the ground is that it might lead to livestock injuries. Observation indicates that grazing land recovers better where bush has been controlled leaving no stumps behind.

In 2012, the "Bush Roller" (see below Fig 5.4) was introduced when an article appeared in a local newspaper with the headline, "A cheaper solution to invader bush." In the image below, one can picture the heavy-weighted cylindrical roller pushing down trees/vegetation. This is species-indiscriminate bush control with some bushes/trees uprooted and some not. Due to the roller weight, there is breakage and damage to branches that could even jeopardise the quality selection for charcoal, in which bush components of similar appearance and size are preferred for uniformity and a sign of quality. The bush roller is best suited to harvesting material for use as fuel, as burning chips to power industrial furnaces, or even as energy pellets by reducing wood biomass.

Figure 5.4 - Bush roller in action

5.1.2 Bush chipping

Post-harvesting, chipping is a critical point in the value chain as it enables further processing, value addition, and product development. When chipping, size selection is important for feed conversion such that particle size after drying would be suitable for milling and compressing the bush-blended material into pellets. Chippers come in different capacities, and the chipping blades are adjustable. Bush material is fed manually into the chipper, and pre-processed material can make for regular and rapid intake and chipping.

Below are examples of chippers in use in Namibia, noting that there may other different models and types not seen by the project team.

Figure 5.5 - Junkkari HJ 250 GT chipper, imported from Finland and in use at UNAM, Neudamm Campus (20 km east of Windhoek) and wood chips measuring an average 3 cm x 7 cm in size

The chipper at UNAM has not been in use for some time, although there were wood chips that provide insights into the chipping size. The current size selection is not suitable for milling and subsequent pelletizing (see below). Unless the chipping blade can be adjusted, a second chipper would be needed to further reduce the chip size.

In another case example, Langbeen Farm has 3 chippers, one of them currently in use (Tomcat chipper Model 2590 AFP) but unable to chip a size suitable for milling (centre image below with pen for size reference – 5-10 cm chips). A second chipping is required at additional cost and time.

Figure 5.6 - Images showing the chipping machines and chips produced at Langbeen Farm, Dordabis, northeast of Windhoek

The second and third chippers are from SchutteBuffalo. Chips are air-dried and packed in big bags (1 tonne size), which are transported to the storage location where chips air-dry on a flat concrete surface and then undergo a second chipping into the appropriate size for milling (Ø 8 mm). Air-blowing the chips is not effective as there is limited target control such that chips miss the bag opening and land on the ground, mixing with sand and stones.

Figure 5.7 - Images showing the harvested bush material, chipping machine, and chips produced at BosPro Products

A third case example is from BosPro Products, which uses a Bandit 150 Model chipper that appears to have higher production capacity than the above-mentioned equipment at Langbeen Farm. At this operation, no second round of chipping is required following the processing of twigs and branches up to approximately 20 mm Ø ready for milling. A second Bandit 1890 XP chipper with an integrated motor is on stand-by. The farmer has experience with US machinery and equipment.

5.1.3 Drying

Air-drying on a flat clean surface in Namibia is understandable as one measure to harness free resources, namely the warm and dry prevailing climate. The current approach takes up large surface areas where bush material is laid out/scattered to enable enough exposure from air and sun. This approach could be enhanced by:

- Enclosing the area with high-density mesh netting that prevents dust and sand from coming through, but allows airflow;
- Ensuring the surface is slanted to drain water and dust-free when material is laid out/scattered; and
- Compacting and/or expediting the drying process by creating shelves exposed to hot airflow or a rotary grid dryer with forced air circulation (with an intention to divert the gas flow from charcoal production to dry bush material to feed).

5.1.4 Milling

Milling the bush material is essential to achieve a consistency that can be blended with supplements/ingredients/additives to produce animal feed. This has been proven in feeding trials. Like the above current experiences with chipping, the three case examples below provide awareness and understanding of the current milling technology and milling practices used in Namibia. In all three case examples, the "Drotsky" hammermill is used, as described below.

At UNAM's Neudamm Agricultural Campus, there is a hammermill (see pictures below) which needs significant refurbishment. The lesson taken from the UNAM example is the critical importance of screening bush-material before milling to ensure no stones or unwanted materials enter the mill. The Neudamm mill broke due to stones.

Figure 5.8 - Damaged Drotsky Hammermill at Neudamm Agricultural Campus

Langbeen Farm has a hammermill on the premises where feed pellets are produced as seen below. The pelletizer delivers 8 mm pellets that animals consume with ease.

Figure 5.9 - Pelletizing line at Langbeen Farm with a sample of the pellets (the size of the pellets is 8 mm)

BosPro Products has a hammermill fitted with a generator that enables bag-filling as seen below. The particle size after milling is smaller than that at UNAM and Langbeen Farm, which explains the ease of mixing and pelletizing at BosPro.

Figure 5.10 - Hammermill at BosPro Products connected to a bag-filling machine that facilitates production and packaging

5.1.5 Mixing/Blending

Bush material is processed to a degree that enables mixing with additives/supplements/other ingredients to compose a complete or partial feed. The process of mixing/blending is important as it determines the extent to which ingredients are blended to provide a palatable recipe for animal feed. The following section describes current practices to mix/blend bush material for animal feed.

UNAM/Neudamm Campus has no mixing equipment at present. The intention is to have a complete feed production value chain.

Langbeen Farm uses a conventional screw mixer, which is not optimal since it cannot fully mix small volumes of additives with bush material. This mixing leaves a variable blend of feed that is unreliable and would yield varying results. Good results have been achieved using a concrete mixer for a batch-type mixing process. Using a concrete mixer optimises the use of such machinery.

Figure 5.11 - Conventional or standard concrete mixer used in Namibia

BosPro Products uses a semi-industrial mixing process that consists of sheltered storage at ground level for the different components of the final mix and an elevated mixing platform where the supplements and additives are fed into a small open chute that includes a slowly turning agitator. From this chute, a screw conveyor feeds the pelletizer as seen in the pictures below. This setup results in a continuous pelletizing operation that can allow increases in capacity.

5.1.6 Pelletizing

Pelletizing is highly recommended as a means of delivering a product that is known in the market ("look and feel") and of extending product shelf-life. Below is a brief description of the practices currently used in Namibia.

At UNAM's Neudamm Campus – a Johnson pelletizer including a feed silo, the conveyor to the pelletizer, and a conveyor from the pelletizer to the elevated storage and cooling bin. This pelletizing line has not been yet used.

Figure 5.12 - Pelletizing production line at the UNAM-Neudamm Campus

Langbeen Farm blends molasses with the bush material to provide a more cohesive feed material, resulting in a compact pellet. The maximum pelletizing capacity (see Fig. 5.9, a Johnson pelletizer from the RSA) was noted as approximately 2,000 kg/day; this unit is currently used below capacity due to experimental feed production.

BosPro Products uses a tractor-propelled Bandit pelletizer made in the USA. The pelletizer is fed via a conveyor screw that brings material from the mixer. The pellets shown in the bags below were observed to be rather soft, due the recipe ingredients and the moisture of the material.

Figure 5.13 - Pelletizing machine at BosPro Products and, 50-kg size bags filled with freshly made pellets

5.1.7 Recipes and end-products

Several feeding trials have been carried out in Namibia, especially over the past 5 years, with varying ingredients and thus recipes. The section below recaps what is currently being explored and sold commercially.

Langbeen Farm obtained official registration of a bush-based animal feed pellet in the first half of 2018. The feed recipe needed to be revised from 85% bush material to 68% or below since current legislation does not provide for the registration and commercial production of bush-based animal feed. At 85% bush material, the remaining ingredients are molasses, camelthorn pods, and maize.

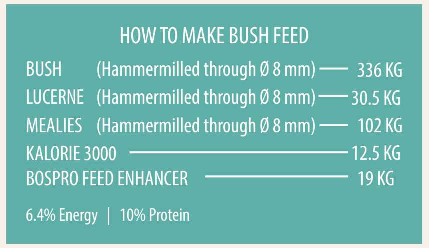


Figure 5.14 - Bush-based animal feed recipe on BosPro Products' website (bush makes up 58% of the feed)

BosPro Products has been in operation for over five years and has a portfolio of marketable products, some of them registered with the Department of Veterinary Services. See picture below of an animal feed recipe and marketing images on BosPro's website (www.bosproproducts.com). The maximum bush content for each of the products is 58%. Like Langbeen Farm, BosPro keeps a small number of cattle to develop and test new products and to further improve and evaluate the results (e.g., weight gain) of bush-based feed.

5.1.8 Summary of current practices and trends

Awareness of assessed benefits: market development and consumer interest can be stimulated by generating wider awareness of the assessed benefits of bush feed, i.e., protein content, daily average weight gains, reducing pressure on underground water resources, and enabling restoration of pastures.

Guarantee quality and consistency of assessed benefits: Product development is required, based on international feed production and quality standards, to ensure acceptable shelf-life and preservation of the nutritional and mineral qualities that deliver the assessed benefits. Two existing producers are aiding this awareness and industry progression, which will facilitate standard-setting. The recent registration of the Langbeen Farm product is evidence of advancement in this regard.

Harvesting and supply of material as key factors: as mentioned above, the cost of harvesting and transporting the raw material is a key consideration in the commercial development of bush-based animal feed. In the case of this project, the feed sets the standard for the species of bush and the size and quality of material to be used. This project modelled a harvesting cost of N$780/tonne, which will be tested in 2019 to ascertain viability.

Optimising/improving current practices and trends: From the above, several inefficiencies and weaknesses can be observed, particularly for UNAM/Neudamm and Langbeen Farm. These are non-commercial operators with no incentive (yet) to optimise and eliminate weaknesses. In the case of BosPro, the process can be improved, and the owner mentioned some actions planned that include up-scaling production. Key observations include:

- Ensuring limited/negligible environmental impact during harvesting and ensuring basic training and provision of protective gear and appropriate tools for harvesters;
- Screening and pre-processing the material before chipping and milling to ensure only bush material is present (no stones);
- Enclosing the drying areas to avoid contamination of the material and/or considering a cylindrical rotational drying method that uses air to reduce drying time;
- Ensuring the material is dry enough before chipping and ensuring the appropriate chipping size to avoid chipping twice to achieve the desired particle size for milling;
- Species and size selection require more attentiveness to ensure quality, palatability, and that only target encroacher bush species are targeted;
- Diesel consumption is reportedly high due to the use of tractor engines to power the chipper, miller, and pelletizer. It is worth considering a renewable energy option, particularly solar;
- The above is influenced by the size and scale of production, whether at individual non-commercial/semi-commercial or at industrial scale.

5.2 CURRENT STATUS AND TRENDS OF CHARCOAL PRODUCTION

5.2.1 Charcoal: origin, uses and characteristics

Charcoal is an important natural resource that has been used throughout history for many purposes, including art, medicine, and chemistry. However, its primary use has been as a source of fuel. Although charcoal can be made from a variety of animal and vegetable products, the most common commercially available charcoal is made from wood.

It is produced by slow pyrolysis, which is heating wood or other substances in the absence of oxygen or with its presence in limited amounts. Pyrolysis, or carbonization, is initiated by heating a pile of wood under controlled conditions in a closed space such as a drum kiln or retort with a very limited supply of air, triggering endothermic and exothermic reactions. As a result of the pyrolysis process, the biomass produces a mixture of gas, liquid, and charcoal.

It is primarily characterized by its density (strength) which can vary between 0.2 and 0.6 t/m3 depending on the density and the carbon content of the wood used as raw material. The density of Acacia is generally above 0.6 t/m3, depending on the species.

Charcoal produced from hardwood is heavy and strong, whereas that produced from softwood is soft and light. The transformation coefficient is about half (example: eucalyptus, with a density of about 0.6 t/m3, yields charcoal with a density of around 0.25 to 0.35 t/m3).

Charcoal has a relatively low moisture content of around 3 to 10%. The heating value of charcoal is linked to the amount of fixed carbon and heavily depends on the carbonization temperature, which can vary from 27 to 35 MJ/kg. Low carbonization temperatures yield more charcoal, but this charcoal is low grade, is corrosive due to its content of acidic tars, and does not burn with a clean smoke-free flame. Good commercial charcoal should have a fixed carbon content of about 75%.

5.2.2 Namibia Charcoal Association (NCA)

The Namibia Charcoal Association (NCA) came into operation following significant concerns and challenges that emerged in a largely unregulated and uncontrolled sector. A 2010 report by the Legal Assistance Centre (LAC[17]), “Namibia’s Black Gold? Charcoal Production, Practices and Implications,” is noted as a catalyst that led to the emergence of the NCA.

There are currently between 6,000 and 10,000 small-scale charcoal producers in Namibia using mainly the rudimentary drum kiln, with some 20% or less considered to be Angolan nationals.

Many are species non-selective, do not use any protective equipment, and do not comply with environmental safety standards.

This informal sector took off due to the low investment cost required to become operational and the easy opportunity to “off-load” unprocessed charcoal to the processing and exporting companies at an agreed price per kg.

Figure 5.15 - Charcoal on display at the NCA Headquarters in Otjiwarongo

Bush material above Ø 20 mm is preferred, but at NCA, charcoal below this size was observed. The NCA advised that the following species be preferred for charcoal: *D. cinerea, Acacia mellifera, Acacia reficiens, Terminalia prunoides, Combretum apiculatum, C. mopane*. For most of these, nutritional and mineral values have been analysed, and they have shown success in feeding trials.

NCA confirmed an annual unmet export demand of 100,000 metric tonnes of charcoal. This demand increases the viability of co-product development, while Jumbo and Makara show interest as bulk buyers of any product.

Of note is the NCA’s intent, together with support from GIZ and N-BiG, to establish a **Namibian Forestry Stewardship Council (FSC) standard**. A draft standard was developed which came into effect in 2018 and provides an incentive to producers and processors to improve environmental and occupational health and safety (EOHS) in the sector.

5.2.3 Jumbo charcoal

The oldest commercial charcoal processor, marketer, and distributor in Namibia, it delivers about 20,000 metric tonnes (mt) of charcoal per year with most exported to the United Kingdom, while other markets are in Poland and Asia.

Jumbo employs about 250 people: 180 in the processing unit and another 70 at the warehouse and packaging facility in Walvis Bay.

Sales at the Walvis Bay facility are N$1,500/tonne for non-FSC charcoal and N$1,700/tonne for FSC charcoal.

Processing includes collecting the raw charcoal from producers, quality assurance, sieving/sifting, and packaging in branded bags. For the UK market, given the prevailing overcast weather, Jumbo produces a “ready-to-burn” product with packaging laced with a flammable agent to enable lighting the entire packaging.

The company purchases from about 18 FSC kiln operators and from about 20 non-FSC kiln operators, each with a labour force of approximately 20 – 40 persons. The company has some small retort kilns that are not in operation.

[17] http://www.lac.org.na/projects/lead/Pdf/charcoal.pdf

Figure 5.16 - Jumbo Charcoal’s operation 4 km west of Okahandja: the sifter uses gravity to drop the charcoal down where it is separated according to size

5.2.4 Makarra bush products

The company delivers about 10,000 tonnes of charcoal/year, employs about 150 people, and acts as a purchaser of drum-kiln-produced charcoal. Processing includes collecting the raw charcoal from producers, sieving/sifting, quality assurance, packaging and preparation for shipment (like Jumbo’s operation).

Due to the considerable volumes of charcoal fines (1-5 mm particles on average) as a waste product from charcoal processing, briquets are also produced. Fines are procured from Jumbo charcoal at a price associated more with ease of access, since it is waste material that is transformed into a high-margin product.

The company uses simple drum kilns and sells drum kilns to its producers at N$2,500.

Figure 5.17 - Charcoal at the Makarra plant in Otjiwarongo

5.2.5 Traditional drum kiln versus retort system

Namibia’s pursuit of a nationalised Namibian Forestry Stewardship Council (FSC) standard and the NCA’s commitment to reforming the industry by ensuring regulation and control are great steps in the right direction. While this project focuses on delivery of an industrial-scale cleaner production mechanism, NCA is supported by other Donors as it seeks to deliver a cleaner and more efficient production technology that can be used by small-scale producers.

The table below details the differences between the currently used drum kilns and this project’s intended retort containerised system.

DRUM KILN	CONTAINERISED RETORT
▪ Highly polluting	▪ Non-polluting
▪ High energy loss	▪ Energy used or saved for future use
▪ Yield 20-30%	▪ Yield 70%, significantly higher bush/energy output
▪ Charcoal is not homogeneous (size and grade)	▪ Homogeneous (size and grade)
▪ Low, varying carbon content 50-70% and unconverted "charred wood"	▪ High fixed carbon content 85-90%
▪ Not suitable for high volume production – effort-intensive and limited volume per batch [up to 6 days to produce 150-250 kg]	▪ Suitable for high volume production – 1 tonne charcoal per 40-hour batch; including by-products of 150 litres tar + 1,000 litres of distillates
▪ Unstable, i.e., not a controllable process	▪ Industrially controllable method
▪ Possibility of bush fires high	▪ No possibility since system is containerised
▪ Short life span	▪ Long life span
▪ Potential to diversify products is low	▪ Potential to diversify products is high
▪ Low potential for improved pricing per unit	▪ High potential for premium pricing due to high quality
▪ High volumes of charcoal fines[18] (35%)	▪ Low volume of fines

5.3 INTEGRATED FEED-CHARCOAL PRODUCTION SYSTEM

As mentioned above, the production system would comprise an Integrated Feed-Charcoal Production (IFCP) System that would aim to have zero waste and reuse of energy. The system would comprise a containerised feed mill and a containerised retort charcoal production system.

5.3.1 Containerised feed mill

This technology (see image below) replicates the totality of steps in animal feed development, including chipping, milling, mixing (blending) and pelletizing. The maximum capacity of this technology is 2 metric tonnes (mt) per hour, capable of continuous production due to matching equipment capacities and quality settings between each of the production steps. The process and technology are calibrated such that every step in the production has 2 mt/hr capacity.

The project has the fortunate position of ordering the equipment almost custom-built for bush-based feed production. Hence, specifications of the conditions and raw material in Namibia have been shared with the specialists to facilitate design and provide a turnkey solution that meets local conditions.

The technology companies are all based in Finland, and all of them, with one exception, visited Namibia to become familiar with local conditions and the target input material. Hence, the technology complies with stringent European quality standards, which may differ from the requirements in Namibia, for example, that it be less automated to allow more employment. Given the sophistication of the technology, the investment is substantive as it translates into higher production capacity, improved quality, robustness and durability of the technology. This scale and quality of technology can be optimised and harnessed to deliver quality products beyond the Namibian border.

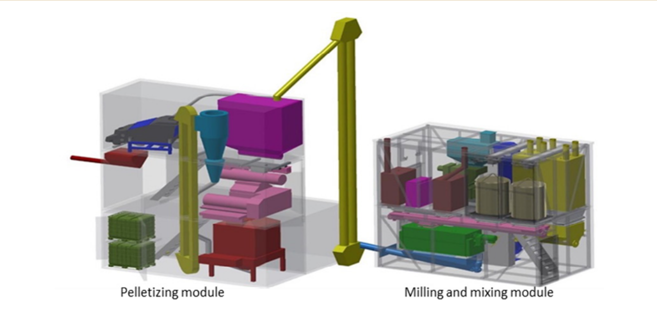


Figure 5.18 - Schematic of the containerised feed production system

18) This may not necessarily be viewed as a negative, since briquettes can be made from charcoal fines/dust, which is a product that fetches a premium price.

As depicted above, the production system is enclosed such that the quality of the feed is ensured by elimination of contamination or interference;

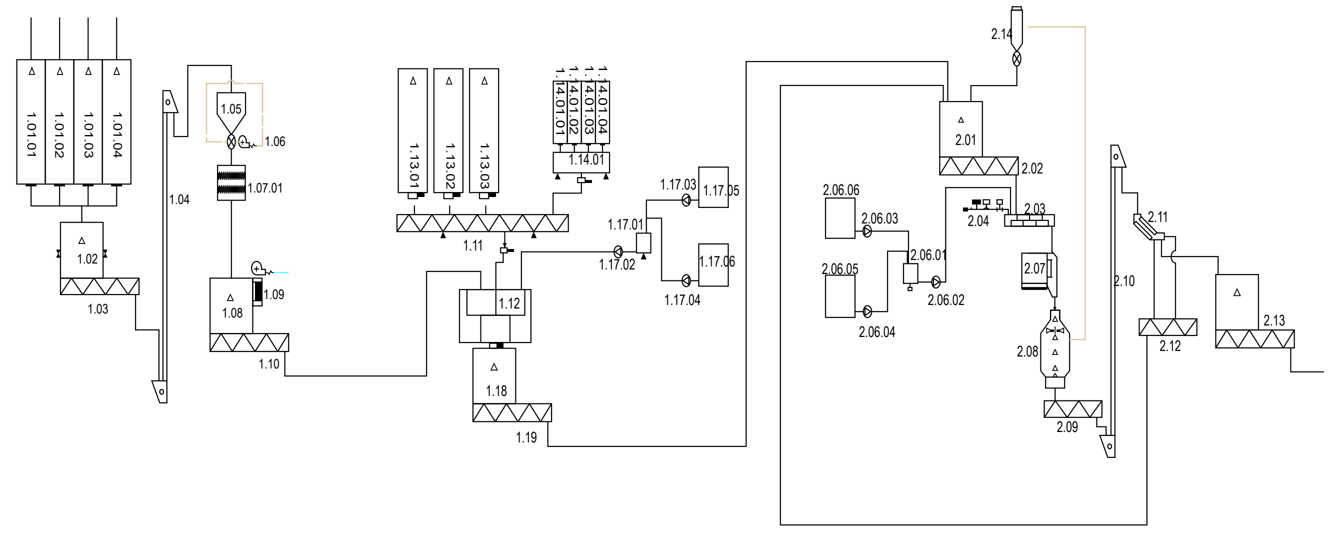
The milling and mixing module is separated from the pelletizing module which handles a variety of input materials after milling and before mixing;

Before pelletizing, the material undergoes a conditioning process with water and steam for hygienic purposes to meet EU quality standards to avoid passing on pathogens from the raw material to the animals. Since this is a standard add-on compared to local productions, it may be an option for downgrading, a decision that would decrease investment and operating costs;

The pelletizing module, as depicted above, comprises three small containers overhead to leverage the use of gravity for internal transportation;

The system does not include a drying mechanism. The project intends to relay the heat/flue gases generated by charcoal production (see heating unit in pictures below) for use to dry bush chips to achieve optimal moisture. The intention is to harvest bush material during the rainy season for which current data on moisture content are not available. The available data are for bush material sampled outside the rainy season, with moisture levels around 10% or higher.

The flowsheet below describes the aforementioned four-stage processes (dosing – milling – mixing – pelletizing) in more detail:



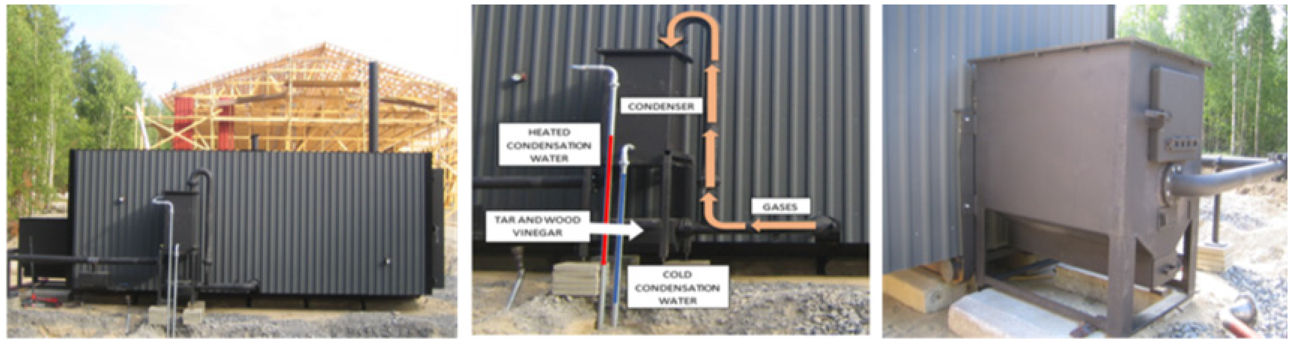
- 1.01.01-04 Dosing silos + dosing slide gates for grinding raw materials
- 1.02 Dosing scale for grinding raw material
- 1.03 Screw conveyor for grinding raw material
- 1.04 Elevator conveyor for grinding
- 1.05 Pre-bin for grinder
- 1.06 Stone and steel cleaning and dosing for grinder
- 1.07.01 Grinder
- 1.08 Bin under grinder
- 1.09 Filter for grinder
- 1.10 Screw conveyor for grinding raw materials for main mixer
- 1.11 Dosing scale for minerals
- 1.12 Main mixer
- 1.13.01-03 Mineral dosing with dosing slide gates from big bag
- 1.14.01.01-04 Silos for micro components (vitamins, etc.) + dosing slide gates
- 1.14.01 Micro dosing scale
- 1.17.01-04 Liquid dosing pumps and scale 2pc
- 1.17.05-06 IPC containers for liquid
- 1.18 Bin under main mixer
- 1.19 Ready feed screw conveyor to pellet line
- 2.01 Pellet mill pre-bin
- 2.02 Dosing screw to pellet mill
- 2.03 Fast mixer/conditioner (mixing max. 2 liquid + steam) heat treatment
- 2.04 Steam dosing system to mixer + also need steam boiler
- 2.06.01-04 Liquid dosing pumps and continuous dosing to mixer 2pc
- 2.06.05-06 IPC containers for liquid
- 2.07 Pellet mill
- 2.08 Cooler (cooling ready pellets)
- 2.09 Screw conveyor for ready pellets
- 2.10 Elevator conveyor
- 2.11 Sifter
- 2.12 Screw conveyor (returns dust from sifter to pellet process)
- 2.13 Ready product silo
- 2.14 Cyclone + fan and rotary valve for air cooler

This suggested solution follows the "black-box" approach in its modules:

- All the above shown and mentioned process equipment allows the mixing of different recipes. Outside of the "black-box," storage areas will be required with some material handling equipment (e.g., fork lift).
- The structural steel supports and operation platforms are necessary to install the plant on a flat surface of approximately 13 m x 8 m.
- The integrated production solution also assumes the availability of the internal means of transportation, conveyors (belt, screw, pneumatic) including supporting equipment such as stone and magnetic separators.
- There must be also plant-internal connection lines, which allow the plant to be connected at one access point with the necessary utilities (electricity, water, pressurized air, …etc.).
  - The electricity supply will depend on the availability of grid power.
  - In case no grid is available, a solution with a generator will be engineered and will represent an option, also at additional cost.
  - Overall electricity consumption for milling, mixing, and pelletizing for a 2 tonnes/hour plant will be approximately 90-120 kwh/hr in full operation; slightly overheated steam demand will be 150 kg/hour; water consumption will be limited to approximately 100 l/hour.
  - When making cost evaluations based on current production, it needs to be considered that operational cost disadvantages of the new plant compared with existing productions may be detected. However, these will not be based chiefly on complete cost accounting of existing productions, since the "critical size and industrial approach" followed within the current Project case has clear cost advantages.
- The erection and installation of the plant and its supplementary equipment may be provided locally. A company supervisor will survey installation and start-up, including commissioning of the plant.

5.3.2 Containerised retort system

The retort is one of the most efficient small-scale industrial units for producing good quality charcoal. In this pyrolysis process, charcoal is produced under highly-controlled, nearly oxygen-free conditions, delivering significantly improved product quality at a higher yield compared to total input material, and in an environmentally safer way. This process – common to the retort process – returns the wood gases from the carbonization chamber back to the external fire-box, burns the volatile components almost completely, and uses the heat for the carbonization process, e.g., by burning the generated methane (CH_4).



View of plant | Process piping | Heating box

Figure 5.19 - Schematic of the containerised charcoal production system

The suggested improved charcoal production system is considered as a modern example of retort technology. Efficiency can be as high as 70%, and noxious emissions can be reduced by 90%. The production cycle is completed within 30 to 40 hours including cooling.

In addition, tar and distillates are by-products of the process. The retort is suitable for industrial charcoal production. The volume of the wood chamber is 10 stacks of m³ (6 m³), and 1,000 kg of charcoal can be produced per batch. Charcoal heating value is 30-35MJ/kg, BET - area is approximately 160 m²/g, and the fixed carbon content is from 85-90% due to the process temperature, which is up to 450° C.

By-products of 1,000 litres of distillates and 150 litres of tar are delivered from each batch of 1,000 kg of wood converted to charcoal.

Both by-products are valuable components for the production of paints. A pragmatic solution could be to enter into a contract with a local paint producer to secure continuous sales for both products. Tar, in minor quantities and in a more refined form, is also used for pharmaceutical purposes, such as paste production. Distillates acids are used in the paint industry as thinner and solvent, as it contains acetic acid. Further applications include the use as an insecticide, for the impregnation of wood and even for the conservation of meat.

Retorts can be assembled in a line (for example, two side-by-side), and then the system can be considered as a continuous industrial process. Theoretically, this could allow production of 30 tonnes of charcoal per month.

In addition to the above-mentioned advantages over a drum kiln, this technology provides a strategic opportunity to diversify into high-end/margin products at no significant increase in marginal cost of production. Such products include biochar, activated charcoal, white charcoal (see below), and generally may become the basis of further product developments in the charcoal application segment.

This technology is designed to comply with European Union quality standards and directives (EN-1860-2). Some of these are met as described below:

83%	CARBON CONTENT MINIMUM
20-80 mm	GRANULE SIZE
4%	ASH MAXIMUM
8%	MOISTURE CONTENT MAXIMUM

5.3.3 High-margin charcoal products

The global market for charcoal includes all kinds and varieties of charcoal as there are multiple uses across the globe, ranging from heating to cultural and religious applications to aesthetic, therapeutic, and nature conservation uses. Below are brief descriptions of high-margin products that leverage charcoal's specific property of a large internal surface area.

Biochar[19]	Chemically-activated charcoal	White charcoal[20]
▪ Produced by pyrolysis process at temperatures above 350 °C; ▪ Porous with the ability to retain nutrients, impurities, and water; ▪ **Main applications:** ‣ Soil enrichment and improvement; ‣ Increasing carbon retention and nutrient recycling, and enabling water filtration; used in compost and sewage treatment; ‣ The broad spectrum of water filtration, sewage and compost treatment; and livestock conditioning and health enhancement.	▪ Wood-based activated charcoal is commercially made using temperatures between 450–900 °C and phosphoric acid; ▪ The "activation" increases the internal surface area on the order of 600 to 1,200 m²/g, depending on the raw materials and process used. At maximum, one gram of activated carbon has a surface area in excess of 3,000 m²; ▪ Wood will be first pyrolised, then the char is saturated with phosphoric acid, followed by controlled reheating to enhance the chemical erosion of carbon atoms, followed by an elaborate washing cycle to remove the acid; ▪ **Main applications:** ‣ Air and water filtration; and ‣ Applications in the chemical, nuclear power, medical and food industries.	▪ It is made by carbonizing wood at moderate to low temperatures, and towards the end, raising temperatures to approx. 1,000 °C to generate a red heat of the wood, which requires an extra oven; ▪ It requires skill to remove the deep red charcoal from the kiln and quickly smooth it with a powder cover to cool it. The powder is a mixture of sand, earth, and ash which gives a whitish colour; ▪ White charcoal ignites slowly but has high thermal conductivity (compared to regular charcoal); ▪ **Main applications:** ‣ Water filtration; ‣ Chemical absorption; ‣ Medical applications; and ‣ Absorption of electromagnetic waves.

5.3.4 Industrial approach: Project implementation

FROM THE INVESTOR PERSPECTIVE

The principle for an industrial approach is to have a centralized animal feed processing unit surrounded by enough closely situated bush to provide up to 5,000 tonnes of appropriate (species related) chips per year. This capacity would comply with the suggested animal feed capacity of 2-2.5 tonnes/hour. The decisive advantage – finally effective regarding cost and margins – is the "economy of scale" which is the pre-condition for high-level professionalization regarding all enterprise processes with more effective equipment, high capacity usage, and strong marketing and management capabilities.

Following the "industrial approach," there are basically two implementation options in place, which may be combined depending on the availability of appropriate management and/or business-related structures:

[19] The use of biochar in cattle farming.
[20] How to make white charcoal.

OPTION 1

A strong landowner or a landowner cooperative controls the full vertical value chain for this industrial approach/business, which includes land ownership, harvesting, producing the chips, processing the chips, and marketing of the final product. Cooperatives can, however, replace the strong landowner function, but still keep control of the entire vertical value chain.

OPTION 2

Following a usual "distribution-of-labour" related approach, as is characteristic for developed industries ("each participant concentrates on what he does best"), this value chain will then be broken down into its independent partial processes, which are:

- Land ownership, e.g., providing a concession to a harvester for harvesting and producing chips;
- The harvesting and chip-production process at the bush site – e.g., bush roller service contracts – to produce and deliver the chips to the chip processor;
- The chip processor and animal feed producer;
- The Marketing and Sales Manager.

In addition to the above processes, a R&D implementation process will have to accompany both options to assure the technological development of the products.

These 2 implementation options determine the range of given business approaches for phase 2 of this project, out of which the most appropriate option – option 1 or 2 or an intermediate solution - will be developed. This requires Namibia-internal discussion and decision, which may also be related to funding considerations. However, if the project is implemented and equipment is to be procured, an addressee for the procured equipment will be required.

FROM THE PLANT SUPPLIER PERSPECTIVE

According to basic market figures and the "multiplier factor" described, the opportunity exists to multiply this application by setting up operations in several locations. This will require plant suppliers to consider a series of effects on design and equipment delivery costs.

The chosen turn-key solution, supported with process guarantees, will provide investors with a guarantee that appropriate equipment will be delivered and a saleable product provided in accordance with the specifications developed. Precise product specifications and design criteria for the plant will be addressed in the second project phase, after approval of this initial phase.

PROJECT IMPLEMENTATION

Before orders for plant equipment are approved, a clear and approved marketing and sales concept with well-defined products aimed at the mutually agreed market segments must be in place within phase 2.

5.4 TECHNOLOGY APPROPRIATENESS AND SUSTAINABILITY

This project assessed the viability of an industrial-scale approach to converting encroacher bush to animal feed and charcoal. This scale of approach is proposed as it would enable delivering the "triple-wins" mentioned before: significant encroacher bush reduction, unlocking potential for rangelands restoration, and generation of employment.

To achieve the above, the technology will be sourced from Finland. Given the specifications of the technology and based on feedback by the Finnish technology companies, it is deemed appropriate. See below for more specific information.

5.4.1 Functional appropriateness

Both the animal feed production mill and the containerised retort system are functionally appropriate as they can deliver the desired product at superior quality and can produce the high volumes associated with industrial scale operations.

To enhance the appropriateness and leverage value-for-money, the project intends to relay the flue gases from the charcoal plant to the feed mill to use the hot air for drying bush chips.

5.4.2 Durability, serviceability and parts replacement

Since the density of Acacia trees exceeds 0.67 t/m³ and Acacias are known globally for their exceptional hardness, the durability of the technology was in question. Following the visits by the companies and after testing bush material taken back with them to Finland, the Finnish companies deemed that the technology is durable in this application.

Through a long-term partnership approach with the Finnish technology companies, the serviceability and maintenance of the technology are not regarded as concerns at present.

5.4.3 Affordability and replacement cost

Based on the financial viability analysis which looks at profitability after all expenses, taxes, and other obligations, the technology is deemed affordable with a return on investment achievable in year 5 of the business.

See the section below that provides additional information on the viability of the business.

5.4.4 Replicability, assembly or local manufacturing

Despite the fact that the suggested technological processes (production of bush-based animal feed and production of retort charcoal) have not yet been introduced or practised in Namibia, in the future opportunities should exist to build significant parts of all three plants in Namibia. Relevant discussions have been held with the Finnish technology providers, who are prepared to provide the necessary know-how as part of a customized technology transfer programme. This may lead within a reasonable time to manufacturing cooperation between Finnish and appropriate Namibian companies, which may have a strong impact on the realization of the earlier mentioned "multiplier effect," since demand for both products will not nearly be met by the suggested new plants. The resulting benefit will be the transfer of technology and know-how together with the creation of employment in the Namibian manufacturing industry.

Bush encroachment is a regional challenge and being able to replicate the technology in Africa for Africa could benefit SADC in tackling bush encroachment on a regional scale.

5.4.5 Impact of this technology

The European Union applies very stringent directives and regulations for the development of technology. Such directives and regulations consider all possible social, economic, and environmental impacts and try to address these during the planning, design, and prototype phases.

Since the technology originates in the EU, and so is subject to those stringent directives and regulations, it is expected to have little to no negative social, economic, or environmental impacts. A detailed monitoring plan will be used during the assembly, commissioning, and full operation of the technology to note important indicators.

5.4.6 Research and Development

This "industrial pilot plant" is intended to address in a resilient and sustainable manner the production opportunities for a type of animal feed that can solve livestock, drought, and other problems. The plant's role as an "industrial pilot plant" also makes it important to have the participation of an R&D institution, e.g., UNAM, to accompany the execution of the project with the analytical and economic research needed to finally achieve an optimal solution for plant use and operation. Consequently, this plant's status as an "industrial pilot plant" requires a more sophisticated plant configuration, so that commercial plants, which will be developed at a later stage, can take advantage of the opportunity presented by the high demand of the market.

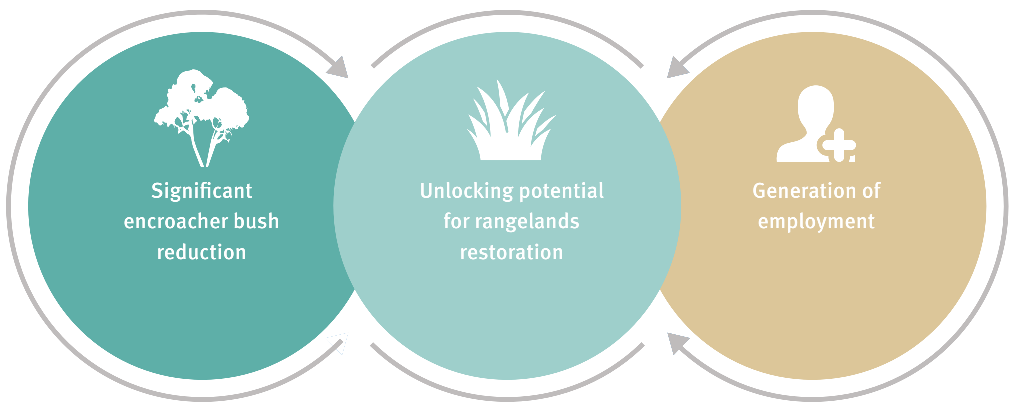


Figure 5.20 - Delivering the "triple-wins" through appropiate and sustanaible technology

6

Institutional and Legislative Overview

6.1 NATIONAL STRATEGY TO UNLOCK ECONOMIC BENEFITS

The 2018 draft "National Strategy for the Optimization of Rangeland Management and Encroacher Bush Utilization" and its implementation plan seek to scale up efforts to control encroacher bush and use biomass to produce value-added or beneficial end-use products. The strategy is a joint effort by MAWF and MITSMED, supported by other line ministries, development partners, the private sector, and civil society. The strategy has a five-year timeframe to achieve the following Strategic Objectives and Outcomes.

STRATEGIC OBJECTIVE	Increase access to the primary resource	Market development	Research and development	Financial incentives to stimulate economic activities (products) for bush harvesting and value addition	Institutional capacity development
STRATEGIC OUTCOME	Security of the biomass (availability)	Local and international markets for encroacher-bush-based products expanded	Innovative ways for growing the encroacher bush-based industry documented and/or commercialized	Effective financial incentives in place	Improved capacity for implementation Improved results of the national strategy

6.2 FORESTRY AND ENVIRONMENTAL AUTHORISATION PROCESS FOR BUSH HARVESTING PROJECTS

This very instructive 33-page booklet provides information and guidance on the background to bush encroachment, the species, the actors, and the policy and legislative environments that allow or pose potential barriers to the harvesting and/or utilisation of encroacher bush. Most of the content is addressed throughout this Strategic Action Programme, but for a more focused review, the reader is advised to obtain a copy. See the sections below on permits and the need for environmental clearance when harvesting more than 5,000 hectares of bush. In closing, the booklet contains some valuable and resourceful contact details to follow up on specific matters or to obtain more information about the emerging bush biomass sub-sector.

6.3 FORESTRY PERMITS

All harvesting of trees and wood in Namibia is governed by the Forest Act of 2001 and its regulations of 2015. This Act is administered by the Directorate of Forestry in the Ministry of Agriculture, Water, and Forestry.

Harvesting Permit

Required for any tree cutting and/or harvesting of wood for commercial purposes.

- Issued by a Licensing Officer, it stipulates conditions for harvesting;
- Inspection of an area to be harvested must be performed before the permit is issued and when an application for renewal is made every 3 months;
- Cost for commercial purposes is N$60; for communal purposes, it is N$20 and is valid for 7 days; and for personal use, it is N$10 and is valid for 3 days.

Transport Permit

Required to convey any wood or wood products (e.g., drops, planks, charcoal, and firewood).

- It is obtainable from any Forestry Office and is valid for 7 days at a cost of N$20 for commercial purposes and 3 days for personal use at a cost of N$10.

Export Permit

Required to send any wood or wood products outside Namibia.

- Obtainable from any Forestry Office, it is valid for 7 days for commercial value-added products costing N$20 per tonne, up to 10 tonnes;
- An additional fee of N$5 per tonne is required beyond 10 tonnes.

Marketing Permit

Required to enable the producer to sell her/his products to any other party.

- The permit is valid for 3 months in commercial areas at a cost of N$60, while in communal areas, the permit is valid for 1 month only.

6.4 INSTITUTIONAL OVERVIEW

The operation of the plant and the distribution of products has to comply to the national legislation and regulations, which are duly considered as part of this document. The following legal acts of Namibia with their relevant conditions are to be considered for the operation of the animal feed and charcoal production.

INSTITUTION	ROLE IN REGULATING ENVIRONMENTAL PROTECTION
Ministry of Environment and Tourism (MET)	MET is the lead government agency charged with Environmental Monitoring, Assessment and Management. The mission of the MET is to maintain and rehabilitate essential ecological processes and life-supported systems, to conserve biological diversity, and to ensure that the utilization of natural resources is sustainable for the benefit of all Namibians, both present and future, as well as the international community, as provided for in the Constitution. MET lays a foundation to implement and promulgate regulations relevant to this project, including the Environmental Act No 7. of 2007, the Park and Wildlife Management Bill, and the Pollution Control and Waste Management Act. The MET plays a role in the approval of Environmental Impact Assessments (EIAs) which are prepared under Environmental Assessment Policy for Sustainable Development and Environmental Conservation (1995). Provisions in other line ministries' legislation strengthen MET's position.
Ministry of Agriculture, Water, and Forestry (MAWF)	The MAWF is the leading agency moving the Agricultural, Water, and Forestry sectors towards the promotion of the efficient and sustainable socio-economic development of Namibia. MAWF is the regulating body of the promulgation of the Water Resource Management Act, 2004 and the Forest Act 12 of 2001, relevant to this project. The Department of Water Affairs is the government agency responsible for monitoring and reporting water quality.
Ministry of Labour and Social Welfare (MOL)	The MOL is aimed at ensuring harmonious labour relations through promoting social justice, occupational health and safety, and enhanced labour market services for the benefit of all Namibians. This ministry insures effective implementation of the Labour Act no. 6 of 1992.
Ministry of Lands, Resettlement and Rehabilitation (MLRR)	The MLRR is responsible for any issues pertaining to land use and land tenure, the rehabilitation of land, and the resettlement of people.
Ministry of Mines and Energy (MME)	The MME issues prospecting and mining licences as well as exploration/prospecting and production licences to ensure that mining activities in Namibia are environmentally sustainable.
Ministry of Works, Transport, and Communication (MWTC)	The Ministry of Works, Transport, and Communication is dedicated to ensuring the availability, quality, and maintenance of transport infrastructure and specialised services. This government body is responsible for implementing the Roads Authority Act 17 of 1999.

LAW	ATTRIBUTES RELEVANT TO THE PROJECT
The Constitution of the Republic of Namibia, 1990	The Constitution is the supreme law in Namibia, providing for the establishment of the main organs of state (the Executive, the Legislature, and the Judiciary) as well as guaranteeing various fundamental rights and freedoms. Provisions relating to the environment are contained in Chapter 11, article 95, which is entitled "Promotion of the Welfare of the People."
The Environmental Management Act (EMA) No. 7 of 2007	As a guiding principle for environmental management, this Act gives effect to Articles 91(c) and 95(l) of the Namibian Constitution by establishing general principles for the management of the environment and natural resources; by promoting the co-ordinated and integrated management of the environment; by giving statutory effect to Namibia's Environmental Assessment Policy; by enabling the Minister of Environment and Tourism to give effect to Namibia's obligations under international conventions. Part VII of the EMA lists different activities that are subject to the EMA. Sections 27 (3) and 35 (1) state that unless a project developer has an environmental clearance certificate granted by the Environmental Officer after assessing the scope, procedures, and methods for conducting the assessment, the developer may not undertake the listed activity.
The Forestry Act 12 of 2001, and Regulations of 2015	According to section 30(1) of this Act, a developer is not allowed to cut down or remove any indigenous tree species from any property without a permit. The Directorate of Forestry listed all the Namibian protected tree species according to the Forest Ordinance of 1952.
Water Resource Management Act of 2004	This is the primary law that governs and oversees the management, development, protection, conservation, and use of water resources. Part VIII of this Act makes provisions for the abstraction and use of water, such that a license is required for such an activity. Further procedures in this process are mentioned in section 33. The protection and control of groundwater are ensured in provisions in part IX, such that a permit is required to engage in drilling, construction, and enlargement or alteration of a borehole. Water pollution control is set out in part XI, whereby discharge of effluents or construction of a treatment facility or disposal site requires a permit. Terms and conditions for such a permit are set out in section 63.
The Atmospheric Pollution Prevention Ordinance 11 of 1976	This regulation sets out principles for the prevention of the pollution of the atmosphere and for matters incidental thereto. Part III of the Act sets out regulations pertaining to atmospheric pollution by smoke. Preventative measures for dust atmospheric pollution are outlined in Part IV and Part V provides provisions for Atmospheric pollution by gases emitted by vehicles.
The Public Health Act 36 of 1919	Section 119 of this Act prohibits the existence of a nuisance on any land owned or occupied by the developer. The term "nuisance" is important for the purpose of this EIA, as it is specified, where relevant in Section 122 as follows: - Any dwelling or premises which is or are of such construction as to be injurious or dangerous to health or which is or are liable to favour the spread of any infectious disease; - Any dung pit, slop tank, ash pit or manure heap so foul or in such a state or so constructed as to be offensive or to be injurious or dangerous to health; - Any area of land kept or permitted to remain in such a state as to be offensive, or liable to cause any infectious, communicable or preventable disease or injury or danger to health; or - Any other condition whatever which is offensive, injurious or dangerous to health.
Soil Conservation Act 76 of 1969	Objectives of the Soil Conservation Act 76, 1969 are to make provision for the combating and prevention of soil erosion, and for the conservation, protection, and improvement of the soil, the vegetation, and the sources and resources of the water supplies.
The Labour Act of 1992	The Labour Act gives effect to the constitutional commitment of Article 95 (11), to promote and maintain the welfare of the people. This Act is aimed at establishing a comprehensive labour law for all employees; to entrench fundamental labour rights and protections; to regulate basic terms and conditions of employment; to ensure the health, safety, and welfare of employees under which provisions are made in chapter 4. Chapter 5 of the Act improvises on the protection of employees from unfair labour practice.
Pollution Control and Waste Management Bill	The purpose of this Bill is to regulate and prevent discharge of pollutants to the air, water, and land in Namibia, and to enable the country to fulfil its international obligations in the regard. The draft Bill forbids any person from discharging or disposing of pollutants into any water or water course without a water pollution licence (aside from the discharge of domestic waste from a private dwelling or the discharge of pollutants or waste to a sewer or sewage treatment works). MET has moved to develop and have promulgated Regulations for Waste Management under the Environmental Management Act of 2007.
Parks and Wildlife Management Bill	This Bill gives effect to Article 95 (l) of the Namibian Constitution by establishing a legal framework to provide for and promote the conservation of wildlife and wildlife habitats, as well as the harmonious and mutually beneficial co-existence of humans with wildlife, within and as part of the natural environment of Namibia, and the sustainable use of wildlife and wildlife habitats. This Act sets regulations for hunting and capturing wildlife and prohibits certain wildlife products.

7

Impacts and Risks

The Directorate of Environmental Affairs (DEA) in the Ministry of Environment and Tourism (MET) is the lead government agency dealing with environmental and social impact assessment, monitoring, and management. As part of their policy and legislative guidance, the DEA encourages Strategic Environmental Assessments (SEA) as a macro-sector level planning tool to guide intended specific development activities – in this case, for bush-processing as an emerging agricultural sub-sector.

In February 2015, the GIZ/MAWF "Support to De-bushing Project" published the "Strategic Environmental Assessment of Large-Scale Bush Thinning and Value-Addition Activities in Namibia"[22] (SEA). This document consolidates past and present information and data on bush encroachment and makes recommendations for addressing the challenge, being cognizant of the existing and emerging institutional and policy environments and the ecological role that woody biomass plays in savannah ecosystems. It proposes systematic bush thinning instead of mass bush clearing due to the inherent ecological and biodiversity benefits of woody biomass when in balance with the ecosystem and resident biodiversity. The SEA reviewed current bush thinning by looking at the specific accessing and harvesting methods to gauge the current and future potential impacts on the environment. It uses this information to frame the recommendations on harvesting methods and, the annual harvesting rate. Importantly, the SEA improved the estimate of the extent of bush encroachment – revising the estimated extent to 45 million ha as compared to the former estimate of 30 million. It also provided the annual growth rate as a percent of total and as an increase in the number of ha/year, and it suggested an approach to estimating bush densities that can be used as a potential indicator to suggest the viability and sustainability of any specific bush-processing value chain. The SEA acknowledges the sustainable development potential that value addition and processing of bush biomass may hold for Namibia but cautions against a "de-bushing boom" based on a limited database to inform planning and decision making. It encourages addressing bush encroachment with multiple benefits in mind, such as:

- the restoration of savannas, thereby improving the carrying capacity of land and benefitting the ecosystem, farmers, and the beef sector;
- sustaining the natural biodiversity and natural aesthetics which support the tourism sector; and
- helping to restore groundwater replenishment to reduce vulnerability to droughts.

The agriculture and tourism sectors are among the top five employers and GDP contributors and are referenced in the 5th National Development Plan (NDP) as avenues to exploring economic growth, employment creation, and food security. This chapter considers the ecological aspects of woody biomass from an ecosystem/food chain perspective while it remarks on the potential impacts, their significance and scope (temporal and spatial) in relation to livestock feed and charcoal production.

7.1 KEY ENVIRONMENTAL CONSIDERATIONS OF BUSH ENCROACHMENT

A savanna ecosystem is complex, with strong inter-dependence among trees, grasses, and soil. Within a defined area, the impacts of bush encroachment would be visible through spatial dominance of encroacher bush, reduction in biodiversity, and possibly habitat rearrangement. When a system is in balance while encroacher species are present, the following processes take place. Trees, including leguminous trees such as Acacias, draw minerals from deep in the soil to the surface while making nitrogen available in the soil. Grasses help to retard rainwater runoff so that water can penetrate the soil. Moisture in the soil facilitates decomposition by soil organisms, thereby enabling the recycling of nutrients from the surface into the root zones of trees and grasses. Large woody plants attract animals, particularly insects and birds that help to fertilise the soil. These ecological processes rely on the synergistic relationship between woody plants (trees), grasses, and soil. Some savanna and rangeland specialists[23] have found that there is higher grass production at low tree density, rather than at zero density.

Bush encroachment has become a challenge due to the spatial dominance by species that are able to out-compete less competitive species (e.g., grasses). Over time, this imbalance results in plant succession such that woody plants dominate the herbaceous layer with an overall drop in local biodiversity, which further encourages encroachment. Consequently, the shade produced by the canopy of encroacher trees begins to selectively allow herbaceous species to thrive or not, depending on their adaptability, thereby altering the grass-dominated ground cover. Shade-adapted shrubs start to colonize this area, creating the ideal habitat for other tree species to establish themselves. This process results in a transition from herbaceous species, i.e., a decline in grass abundance and density, to woody and sometimes invasive species.

This transition in vegetation alters the overall biomass of the savanna from below ground (soil organisms responsible for decomposition and nutrient recycling), in the case of grassland, to above-ground when the savanna is encroached. As a result, the ability of the savanna to support game, livestock (grazing capacity), or even to benefit land-users such as farmers also declines as both species richness and biodiversity change when woody species replace the herbaceous layer.[21]

[21] Nxele, B. J. (2010) Population Genetics of Bush-encroaching Acacia mellifera at Pniel, Northern Cape Province, South Africa. Thesis in partial fulfilment of the requirements for the degree of Master of Science in Conservation Ecology from the University of Stellenbosch.

[22] SAIEA (2015) Strategic Environmental Assessment of Large-Scale Bush Thinning and Value-Addition Activities in Namibia.

[23] Stuart-Hill *et al.* 1987, Teague & Smit 1992, Joubert & Zimmerman 2002.

A study in Omaheke found that in an area harvested for firewood two years previously, grass production was more than double that of the adjacent uncleared area. It was observed that grass production is dependent on the size of the trees rather than the total tree cover in an area. Hence, higher grass production was observed in areas with larger single trees compared to areas with many smaller bushes with higher densities. Grasses that favour shaded areas, such as Panicum maximum, are particularly associated with larger trees. This grass species, which is very palatable for livestock, is high quality and a high-yielding grass with tolerance to droughts. As observed in the Omaheke example and applicable to other areas in Namibia, the larger trees act as 'fertilisers' for the overall habitat.

A recent study[24] that surveyed four commercial farms in the Waterberg Conservancy (near Otjiwarongo) to determine restoration of rangelands over a 13-year period found that soil fertility did not improve. When bush encroachment is addressed by de-bushing, with harvested bush wood sold off the land, then nutrient cycling is disrupted, and soil fertility is likely to decline.

This is due mainly to the removal of important minerals during de-bushing. Hence, the importance of returning of such minerals to the soil is highlighted and the need for introduction of alternative debushing practices to address the mineral loss and reducing soil quality issues.

7.2 ENVIRONMENTAL ISSUES CONCERNING ANIMAL FEED

Bush-based animal feed has been produced in Namibia since 1972 by a private farmer as a supplementary feed during droughts. In the last decade, more farmers – especially commercial ones – have started to harvest, mill, and blend encroacher bush material to supplement livestock feed and to try to restore encroached rangelands. Bush material offers a great substitute for roughage during droughts and may hold potential as a well-balanced complete or supplementary feed. At present, there are one commercial producer of bush-based livestock feed and a few others with experimental, subsistence, and semi-commercial operations that show promise.

Based on available information and data, the following key parameters are known/suggested:

- The rainy season in Namibia is ideal for harvesting bush for feed production. The leaves and twigs are soft and higher in moisture and protein content (up to 16%);
- Harvesting is done selectively to access encroacher species that have proven successful as bush-based feed. Mainly Acacia mellifera is used, while [NAFOLA project] nutritional and mineral content information is available for four additional encroacher species;
- Selective harvesting, instead of mass land clearing, enables the maintenance of ecological function and ecosystem wellbeing, granted that soils are re-mineralised following the removal of encroacher bush;
- Based on scientific observation and literature, massive land clearing has the following impacts:
  - Ecosystem, habitat and wildlife destruction and fragmentation; birds and other tree/shrub-dependent animals and their food chains are destroyed and disrupted, along with the ecological roles and processes they support. While some resilient species may adapt and survive, other animal biodiversity and associated processes with lower resilience and adaptability will not (the activities above could cause the extinction of endemic threatened species);
  - Acceleration of soil salinization;
  - Higher greenhouse gas emissions – through decomposition of material – from clearing land without using the wood biomass. Namibia is a significant GHG sink as recognized by the UNFCCC; hence, mass clearing may impact this status over time.
- According to the SEA (2015), the following trees and shrubs are recognised as the main encroacher species in Namibia:
  - Dichrostachys cinerea;
  - Acacia mellifera;
  - Acacia reficiens;
  - Colophospermum mopane;
  - Terminalia prunoides;
  - Terminalia sericea;
  - Acacia nebrownii;
  - Rhigozum trichotomum;
  - Catophractes alexandri.
- Other species of lesser importance as encroachers include:
  - Combretum collinum (mainly in Zambezi Region);
  - Acacia hebeclada (in areas of eastern Omaheke);
  - Acacia erubescens;
  - Acacia fleckii (in areas of eastern Omaheke);
  - Acacia mearnsii (black wattle – a patch in Otavi area);
  - Acacia nilotica.
- Invasive species include:
  - Prosopis sp.;
  - Leucaena leucocephala;
  - Lantana sp.

[24] Zimmermann I, Nghikembua M, Shipingana D, Aron T, Groves D, Marker L (2017) "The influence of two levels of debushing in Namibia's Thornbush Savanna on overall soil fertility, measured through bioassays." Namibian Journal of Environment 1 A: 52-5.

Following from the above, the key issues identified from available literature and that should be considered and explored as part of a detailed environmental and social impact assessment include:

- The level of knowledge among farmers and workers about tree species, their distribution, and protection status in Namibia;
- Bush selection and harvesting methods;
- The removal of bush and associated minerals and nutrients from the natural environment;
- Negative visual and aesthetic impacts (denuded landscapes) that may affect the tourism sector;
- The loss and fragmentation of biodiversity, especially perennial and pioneer grasses, and birds and insects that play an important role in soil re-fertilization;
- Human health and safety issues from harvesting to the production of a final product. These pertain to the provision of training, personal protective equipment, and preparedness for emergency care in case of accidents that occur far away from medical centres;
- The use of additives and supplements, their origin, and costs. These relate to the economic viability and potential economic impacts, since the price of imported materials would affect the price point of the final product, which would in turn determine the market response and up-take.

7.3 ENVIRONMENTAL ISSUES CONCERNING CHARCOAL

Charcoal has been produced in Namibia since the 1980s by Jumbo Charcoal, 3 km west of Okahandja. Since 2001 to 2010 the sector has seen significant growth, a continuing trend resulting in between 6,000 and 10,000 small-scale charcoal producers (SSCPs) operating in both communal and commercial farming areas. These producers comprise 1-5 persons per operation and sell charcoal per tonne to commercial processors and exporters, such as Jumbo Charcoal. The low cost of making or buying a rudimentary kiln eases entry into production, while the extent of bush encroachment suggests economic viability from a biomass stock availability point of view. The significant growth observed from 2001-2010 was also as a response to addressing bush encroachment through an economically viable approach. Hence, commercial farmers allow SSCPs on their land to produce charcoal in areas where they require thinning of encroacher bush.

The labour-intensive nature of the industry is attractive to impoverished and unskilled persons, and for the rural poor, it has become an affordable and relatively easy way to mobilise means of self-employment and income generation. The cost of the kilns used in Namibia is estimated between N$1,500 to N$3,000, depending on the quality and cost of the material used, and whether it is bought from a formal or informal supplier.

In 2010, the Land, Environment, and Development Project of the Legal Assistance Centre (LAC) in Namibia published a study entitled "Namibia's Black Gold: Charcoal Production, Practices and Implications"[25] This report estimated SSCPs in 2010 at 4,800 and assessed how the existing policy and legal environment serves to facilitate or hinder this informal workforce. It makes recommendations to improve the working environments and conditions of SSCPs. To date, the environmental and social aspects of the charcoal industry are poorly regulated. Charcoal workers (harvesters, burners, and sorters) are regarded as sub-contractors and are not covered by the Labour Act of 2007 (No. 11) and its regulations. The Government of Namibia, supported by labour representative organisations, would like to see charcoal workers afforded permanent employment status with appropriate employment benefits. This requires careful thinking as many SSCPs operate independently on areas of land they are granted access to; while not employed by landowners per se. Negotiations and consultations have been ongoing between the Government, the former Namibia Charcoal Producers Association (now the NCA), and the Namibia Farm Workers' Union, although by 2010, no agreement was concluded on pertinent labour issues.

The Namibia Charcoal Association (NCA) is in the process of formalizing and consolidating the sector by addressing critical and contentious issues, such as labour, knowledge, and skills for sustainable use and production and to establish a regulatory environment. As a start, the NCA will survey all the labourers and register them as SSCPs. Of the current 6,000-10,000 SSCPs, 20-40% are Angolans with unknown residence status in Namibia. It is also unknown whether SSCPs have baseline medical examinations on record that would make it possible to assess the impacts of charcoal production on health and to allow early detection of potential negative legacy issues.

While the report does not go into detail about the environmental impacts, it references common impacts associated with bush thinning activities and negative impacts resulting from charcoal production.

HUMAN HEALTH: The usual pre-employment medical examination costs N$190, while the annual or periodic medical examination costs N$170. Government Gazette No. 4459 of 15 April 2010 reduced these costs to N$15 and N$8, respectively, for self-employed state patients, including people involved in the charcoal industry, as follows: "Occupational medical examination for self-employed state patients, including people involved in the charcoal industry: This service includes consultation, treatment and special investigations between 07h30 and 16h30 on a week day, excluding a public holiday: Class A: N.A. [Not applicable]. Class B1: N$15, Class B2: N$8". This reduction would obviously not be valid where an employee-employer relationship is entered as described by the Labour Act, since charcoal workers would no longer be regarded as self-employed.

[25] LAC (2010) Namibia's Black Gold: Charcoal Production, Practices and Implications. Land, Environment and Development Project, Legal Assistance Centre, Windhoek, Namibia.

7.4 KEY SOCIAL CONSEQUENCES OF BUSH ENCROACHMENT

Bush encroachment is recognised as a formidable sustainable development challenge, socially, economically and environmentally. In order to explore the potential viable opportunities to address these challenges and propose solutions for bush control and utilisation of bush biomass that could catalyse enhanced agricultural productivity, these challenges are to be identified, as enlisted below.

- Drastic reduction in livestock carrying capacity that results in meat production losses of as much as 300% with a resulting economic loss (at 2009 beef prices) of more than N$1.2 billion.
- Reduced farming capacity results in reduced labour opportunities on farms, the beef industry downstream, reduced beef exports, and reduced tax revenue to the Government (CCA 2010). Approximately 6,283 commercial farmers employ 35,000 workers with a total number of dependents on these farms projected at approximately 140,000 people (average household size of 4.03), who are or would be affected by the bush encroachment problem.
- Lower farming capacity results in reduced ability to secure food and thus lowers the resilience of farmers who already face a myriad of external factors such as price fluctuations, climate variability and diseases.

7.5 FOLLOW-UP MEASURES

Two objectives of follow-up measures include:

- Rehabilitating and ensuring rangeland productivity, and
- Preventing re-encroachment.

There are limited follow-up measures that include biological, manual, and chemical methods. These methods are briefly discussed in this chapter.

7.5.1 Follow-up measures methods

Follow-up measures entail, in all cases, the systematic removal of small, immature woody plants (mainly low coppice growth and saplings) to achieve a specific objective, e.g. to restore rangelands or to enable growth of some woody plants for use in other value chains. In the interest of the environment, it is advised to practice selective follow-up measures with non-chemical methods. Follow-up measures can range from highly selective methods with specific objectives to non-selective methods with no clear objective for post-thinning land use.

BIOLOGICAL FOLLOW-UP MEASURES

Browsers provide the most profitable way to control sprouting and emerging bush. Goats and other browsing animals are well-adapted to harvest young and small woody plants and are specially equipped to deal with physical and chemical plant defences (e.g., thorns and tannins, respectively). Their saliva and livers contain tannin-neutralising substances to prevent the induction of a protein deficiency related to tannins. Depending on the bush thinning objective and the area context, herding and herd management would be appropriate measures.

Controlled fires of bush-encroached rangeland to kill off immature small woody plants and soft-coated seeds in the soil seed bank is a natural/biological method that should be used more often. The planned fire does not need to burn as fiercely as fire required to contain mature bush. Compared to goat browsing, the advantage of a planned fire is that woody seed and small bush are eliminated completely, but that result is more difficult to achieve.

MANUAL FOLLOW-UP MEASURES

Small bush and saplings are easily removed by chopping them off about 10 cm below ground level, thus removing the whole plant. One person can cover several hectares per day, depending on density and terrain. This follow-up measure method is quick and easy, even on hard ground, because the targeted woody plants are small. The biggest drawback of manual control is that some saplings may be overlooked.

CHEMICAL FOLLOW-UP MEASURES

Includes foliar spraying of coppicing bush, seedlings, and saplings along with the chemical treatment of cut stumps. This method should be applied with great care to avoid a worsened case of bush re-growth.

7.5.2 What comes after follow-up measures?

Bush encroachment is promoted by inappropriate land uses, non-adaptive grazing, and unsustainable rangeland management. Hence, to adequately address its cause and prevent the recurrence of bush encroachment, land use and management approaches should shift toward sustainable practices.

7.5.3 Rangeland Management Policy and Strategy

Namibia's National Rangeland Management Policy and Strategy (2012) is a farmer-driven policy that promotes the voluntary adoption of "principles of sound rangeland management" instead of prescriptive rules and regulations. These principles recognise that ecosystem health is at the core of rangeland management.

The policy advocates sustainable rangeland utilisation, which includes the avoidance and mitigation of man-made impacts such as bush encroachment. While bush encroachment will continue due to natural drivers, it will be much less pervasive and probably more manageable. The eight principles of sustainable rangeland management are listed below.

1	KNOW THE RESOURCE BASE: Know the dominating perennial species of grass and ensure optimal growing conditions. Know the soil, nutrient hotspots, and general rangeland ecology; know recurring bush, its density, and impact; and use indicator species to monitor and evaluate encroachment.
2	MANAGE GRASSES FOR EFFECTIVE RECOVERY AND REST: Perennial and preferred species of grass are usually grazed first and most intensively. They need to recover completely from previous grazing until they have set seed before being grazed again.
3	MANAGE FOR EFFECTIVE UTILISATION OF GRASSES AND SHRUBS: Grazing should stimulate grass production and not inhibit it. Grazing domestic livestock such as cattle and some sheep breeds do not browse much. The browse component of a savanna rangeland is under-utilised, while the herbaceous (grassy) component usually is over-utilised. Browser-based livestock enterprises are encouraged.
4	ENHANCE SOIL CONDITION: For grasses to flourish, the top layer of soil must be in good condition, allowing rainwater to infiltrate easily (proper water cycle) and binding plant nutrients so they do not leach out (proper mineral cycle). This condition is achieved mainly by keeping the soil well covered with living plants or mulched with dead plant litter to prevent soil erosion by wind or water.
5	CONTROL BUSH ENCROACHMENT: As per the MAWF/GIZ Bush Harvesting Manual.
6	PLAN FOR DROUGHTS: By timely reduction of the livestock stocking rate in synchrony with the advancing fodder deficit. Grow more fodder to compile a fodder bank to be used during a drought.
7	MONITOR THE RESOURCE BASE: By keeping a variety of records of the veld that inform rangeland management. The establishment of woody seedlings is an important indicator of the transition to a bushy state, requiring management intervention.
8	PLAN LAND USE INFRASTRUCTURE: To make sustainable rangeland management easier, e.g., by providing enough camps per herd of livestock to facilitate effective rotational grazing management that allows perennial indicator grasses to recover from grazing.

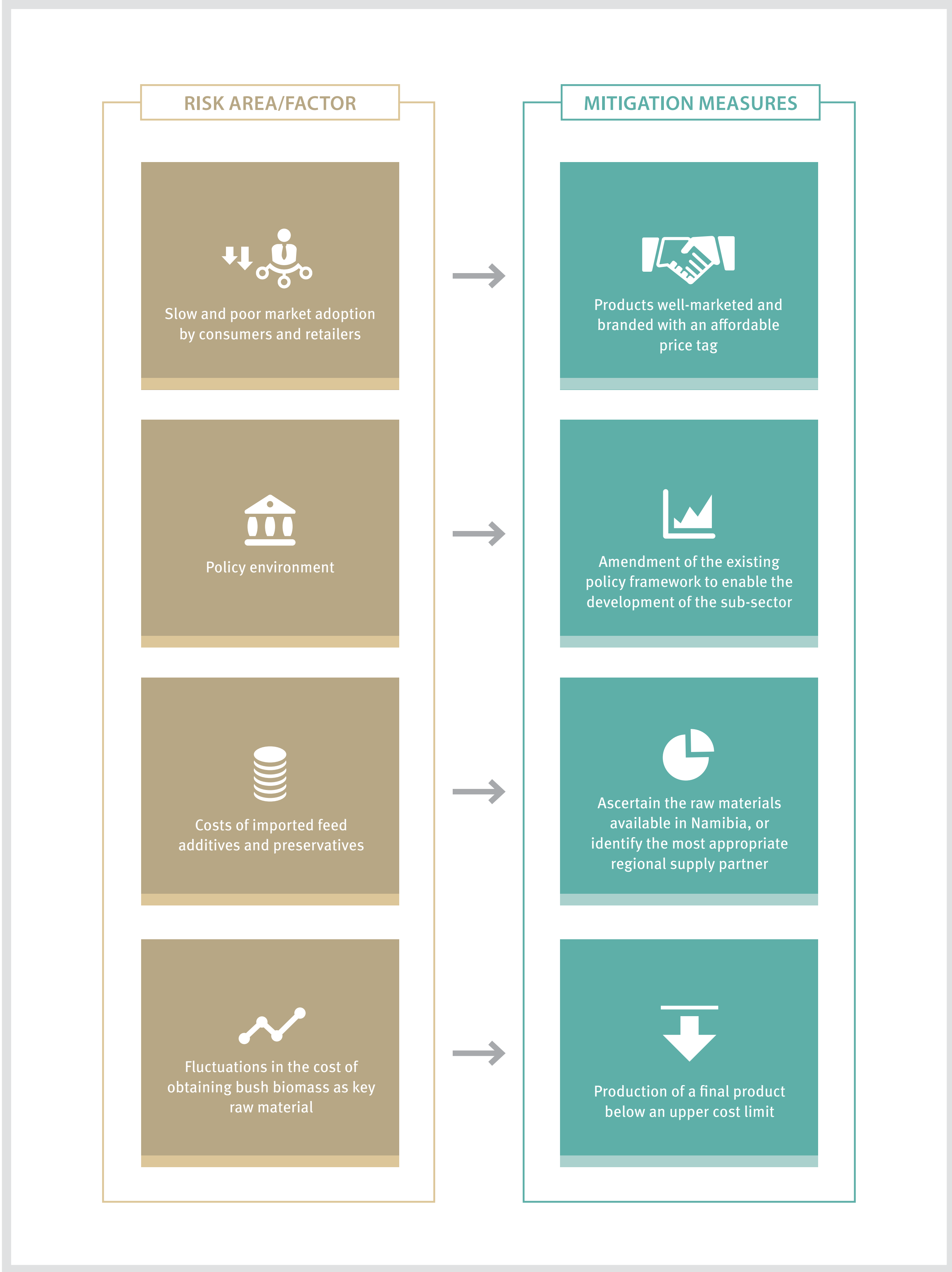
7.6 RISK ANALYSIS AND MANAGEMENT

The following risk areas and/or factors have been identified for pilot integrated production plant:

- Slow and poor market adoption by consumers and retailers may not make it possible to reach optimal sales targets and revenues.
- The policy environment is not ready for the approval and registration of animal feeds with more than 50% concentration of bush material.
- The costs of imported feed additives and preservatives play a major role in driving production costs and thus retail pricing.
- Fluctuations in the cost of obtaining bush biomass as key raw material may negatively impact the total cost of production and thus the retail price.

Considering these risk factors, the following mitigation measures will be put in place not only to safeguard the provided investment, but also the business itself:

- There is evidence that Namibian farmers have been using encroacher bush as a feed supplement and as feed since 1972. The feeding trials that were conducted from 2015-2017 show great potential and suggest market adoption when the product is well-marketed and branded with an affordable price tag. The first 12 months will enable testing the market by conducting trial sales of the feed at consumer and wholesale levels.
- The emergence of bush biomass as an agricultural sub-sector that holds massive potential for Namibia has prompted the Directorate of Forestry, the MAWF, and line ministries to consider amending the existing policy framework to enable the development of the sub-sector.
- Feed additives such as lucerne, wheat bran, and molasses are mainly imported, even though lucerne and wheat are cultivated in Namibia. A survey is currently underway to ascertain the type and volumes of such raw materials in Namibia, and if not found domestically, to identify the most secure and sustainable regional supply partner.
- The Namibia Biomass Industry Group (N-BiG) can harvest and deliver bush biomass to the operation. N-BiG can provide bush material at an agreed price per year. The pilot plant will ensure that the price negotiated with N-BiG enables the operation to produce a final product below the upper cost limit of N$2,568 per tonne.



8

Investment Case

8.1 SUMMARY OF KEY METRICS

The below table demonstrates the required **investment cost** for the demonstration and development phases of an integrated feed/charcoal production facility.

CHARCOAL PRODUCTION

Applying a retort system:

- Produces 30-40% higher yield than conventional system;
- Uses containerized system with lower emissions and improved environmental and human health and safety;
- Produces tar and distillates as by-products.

Cost per metric tonne (N$) – incl. harvesting	4,137
Target selling price per tonne (N$)	7,000
Margin - selling price less cost of production (N$)	2,863

ANIMAL FEED PRODUCTION

Applying a modular feed mill system:

- Uses containerized system that would harness heat from the charcoal plant to dry the wood chips;
- Able to produce 2.5 tonnes of feed per hour.

Cost per tonne of bush feed (N$)	1,768.25
Suggested profit margin against retail price of N$4,000/t	56 %
Cost per tonne of commercial feed (N$)	4,291.65
Suggested profit margin	14 %

8.2 FINANCIAL OVERVIEW AND HEADLINE PROJECTIONS

The below table demonstrates the required **investment cost** for the demonstration and development phases of an integrated feed-charcoal production facility.

Cost Item	EURO	NAD
Bush-to-feed modular technology	930,000	11,864,000
Containerised charcoal production systems (x2)	130,000	1,927,900
Cost for delivery of above on-site	20,000	296,600
Site preparations and installation cost	20,000	296,600
Training and capacity development	50,000	741,500
Ongoing R&D/Surveys	20,000	296,600
Ongoing environmental monitoring	20,000	296,600
Raw materials	50,000	741,500
Maintenance and servicing of technology	10,000	148,300
TOTAL	**1,250,000**	**16,609,600**
More realistic + 35% (inclusive)		**22,422,960**
Annual repayment of 10-year financing (excluding interest rate, legal fees)		**2,242,296**

The below table demonstrates the **estimated economic benefits** that can be derived during one year of commercial operation. This does not account for all compliance obligations and contingency matters, hence the significant discount rate.

CHARCOAL PRODUCTION / Item	Euro/mt ('000)	NAD/mt ('000)
Annual target (metric tonnes, mt) (10-month production)	90	90
Total projected annual revenue	42,481	630,000
Cost of production (at 59% of revenue)	25,109	372,365
Before tax profit margin (at 41% of revenue)	17,373	257,635
Discounted profit (50%)	**8,686**	**128,817**

BUSH FEED PRODUCTION / Item	Euro/mt ('000)	NAD/mt ('000)
Annual target (metric tonnes, mt) (4-month production)	4	4
Total projected annual revenue	1,079	16,000
Cost of production (at 41% of revenue)	477	7,073
Before tax profit margin (at 56% of revenue)	602	8,927
Discounted profit (50%)	**301**	**4,464**

Summary of estimated economic benefits:

SUMMARY	Euro/mt ('000)	NAD/mt ('000)
Total annual revenue	43,560	4 646,000
Total annual production cost	25,586	379,438
Total gross profit	17,974	266,562
Total discounted profits (50%)	8,987	133,281

The below table shows the estimated **annual operating costs** for the production facility. These are at the lower end of the market and would serve to ensure capacity during demonstration and would be adjusted during commercial up-scaling.

SUMMARY	MONTHLY SALARY	MONTHLY SALARY	Median
General Manager	25,000	300,000	313,732
Technician: Feed mill	15,000	180,000	258,000
Technician: Charcoal plant	15,000	180,000	258,000
Administrative Assistant	7,500	90,000	95,000
Goods Receiving (GR, Biomass)	8,000	96,000	102,500
Stock controller (SC, Finished product)	8,000	96,000	102,500
General **Labourer** (GR)	5,500	66,000	88,722
General **Labourer** (SC)/ **Storeman**	5,500	66,000	88,722
Total wages per year (N$)	**89,500**	**1,074,000**	**1,307,176**

8.3 MARKET OVERVIEW OF THE ANIMAL FEED PRODUCTION

8.3.1 Global market overview

In 2016 and 2017, global feed production was more than 1 billion tonnes. In 2016 this production milestone was recorded for the first time. Alltech is an American company founded in the 1970s with operations in animal feed, meat, brewing, and distilling. Since Alltech started the Global Feed Survey seven years ago, the feed industry has seen increases in production of 161 million tonnes per year (or 2.95% per year), a growth of 19% over the seven-year period. The USA and China deliver 35% of total feed production, while globally there is a growing trend of reducing the number of feed mills by consolidating facilities to reduce production costs and increase efficiency. This trend is evidenced by a 7% reduction in the number of feed mills, while production increased by 3.7%.

Global feed prices in 2016 and 2017 were down when compared to 2015 figures. As a result, so is the cost of raising production animals. From a global perspective, the feed industry can be roughly valued at around $460 billion dollars, although feed prices in general were 5–7% lower than in 2016. This estimated total industry value represents a small increase over 2015, reflecting higher values attributed to the pet, equine, and other businesses. The pie-chart below depicts the estimates of animal feed types as percentages of total global feed production.

Feed production is closely related to the production of inputs such as maize, wheat, and soybeans. Global production for these major inputs has increased significantly over the past few years, largely driven by increasing demand from both food and animal feed industries.

The International Grains Council (IGC) forecasted 2017/18 global maize usage in the animal feed industry at 613 million tonnes, up by 2% from the previous season and the highest level in more than a decade.

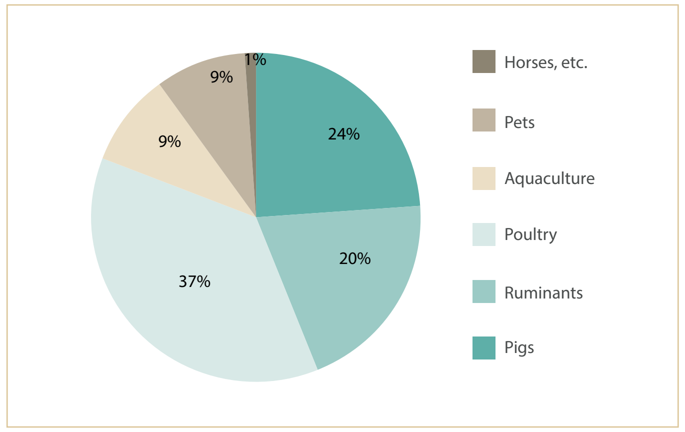


Figure 8.1 - Feed by type of animal as a percent of total global feed production

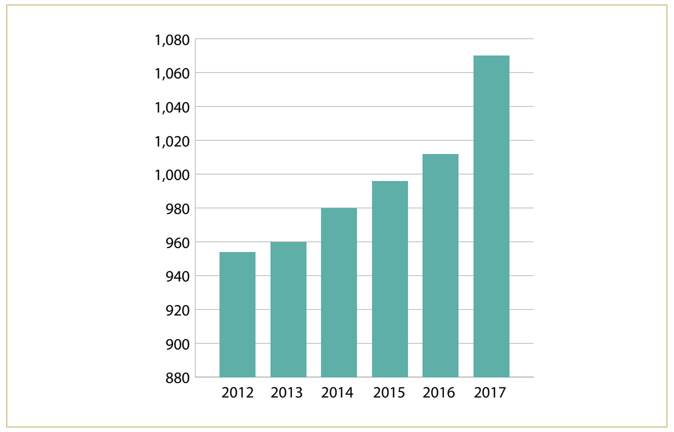


Figure 8.2 - Trend in global feed production

Given the growing demand for food for the human population, competition between the food and animal industries for these inputs is increasing. This competition will intensify as the world population is projected to reach 9-10 billion by 2050. Growth in human population drives an increasing trend in animal protein consumption (especially beef). Hence, the demand for animal feed is expected to maintain the steadily increasing trend observed from 2012 to 2016. One solution is to find suitable, affordable, sustainable, and palatable substitutes for maize, wheat, and soybeans such that these can be comfortably made available for human nutrition.

8.3.2 Regional market overview

Africa is the fastest growing region, with a regional average growth rate of over 30% over the past five years. Half of the countries grew strongly, and only a handful had lower production. Top producers in the region include Algeria, Kenya, Nigeria, Tunisia and Zambia, all of which saw growth of at least 30%. Nigeria is leading the continent due to its population growth; it is projected to have the fourth largest population on the globe by 2050. This is coupled with related economic possibilities as many countries in the region continue to demonstrate economic prosperity. According to the Alltech 2018 Global Feed Survey,[26] Africa presents the greatest growth opportunity for the feed industry.

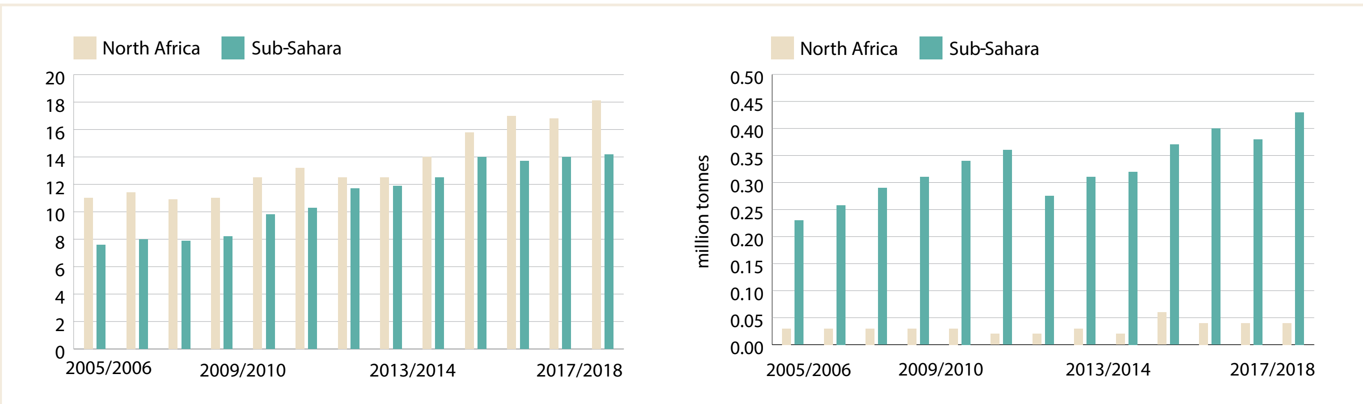


Figure 8.3 - Trends in African feed production based on maize and soybeans

[26] 2018 Alltech Global Feed Survey.

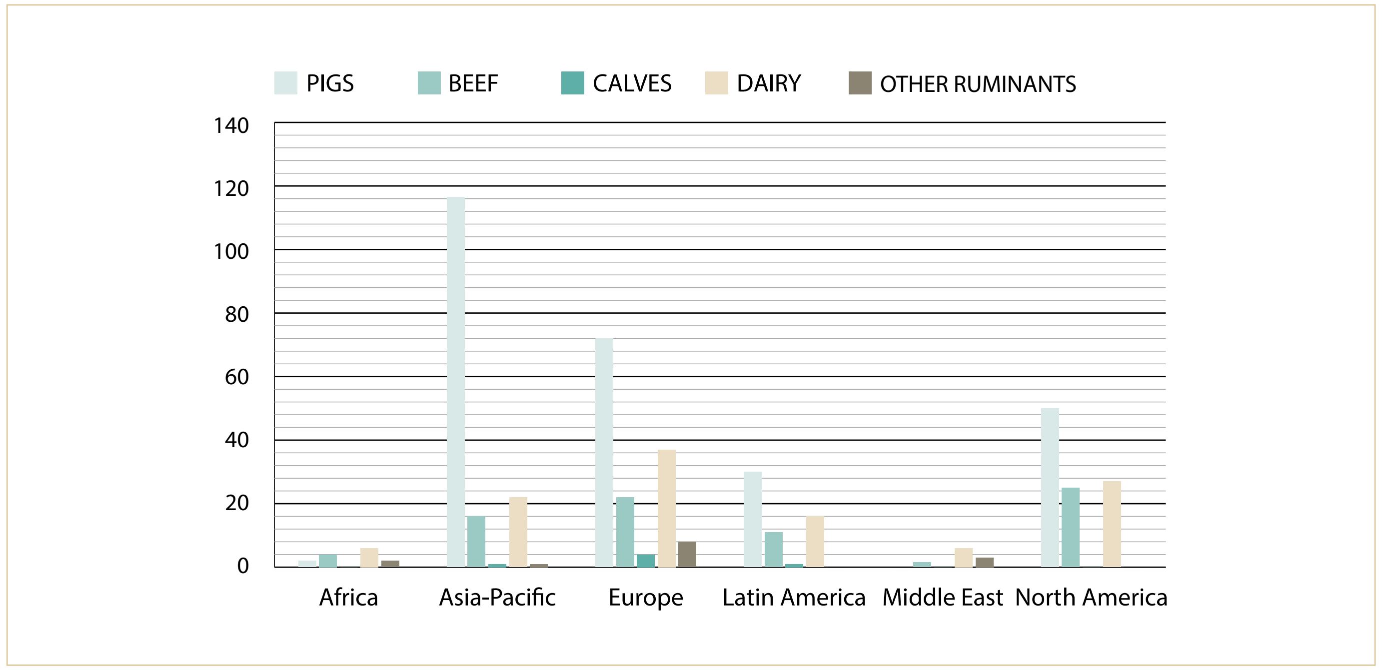


Figure 8.4 - African Animal Feed Production for 2017/18 compared to other regions

The growth in feed production in Africa is parallel to growth in the production of primary inputs, such as maize, wheat, and soybeans. For the 2017/18 financial year, maize usage in animal feed industries was estimated at an all-time high of 32 million tonnes,[27] up by 6% from the previous season. This is widespread across the region, with an increase of maize usage in animal feed up by 6% in North Africa from the previous season (estimated 18 million tonnes) while in Sub-Saharan Africa, maize usage in animal feed production increased by 2% (estimated 14 million tonnes) compared to the previous season.

8.4 COMPETITOR ANALYSIS AND ECONOMIC IMPACT

8.4.1 Namib Mills Investment Group

The Namib Mills Investment Group (Pty) Ltd established Feedmaster in 1983, which has become the leading animal feed manufacturer in Namibia, delivering annual volumes in excess of 115,000 tonnes. Initially the purpose was to convert milling by-products (initially only maize chop) into animal feed, and today, it provides a range of scientifically formulated animal feed products developed especially for domestic conditions. The feed plant has been compliant with ISO 9000 and ISO 22000 since 2007. It markets approximately 25% of its ruminant feeds to farmers in communal areas with the balance of its products sold to the commercial farming and animal wildlife sectors. The following list presents a few milestones in the history of Feedmaster:

- In 1986 Namib Mills invested in a wheat mill to enable it to use its by-products to diversify livestock feeds;
- In 2011/12, the Feedmaster plant was upgraded at a cost of N$75 million to become a specialized ruminant feed plant;
- In 2017, Feedmaster commissioned a N$31 million plant to augment its production capacity due to consistent growth and demand in the ruminant feeds market of Namibia;
- The ruminant sector served by Feedmaster includes dairy, beef, small stock (sheep and goat), and animal wildlife (game). The company also manufactures feed for chicken broilers, commercial layers, and pigs;
- Feedmaster delivers 500 tonnes of feed per day; and from 2017 onward aimed at producing 160,000 tonnes per year with concomitant estimated revenue of N$800 million;
- Regarding cattle feed, additives, and supplements, Feedmaster offers 6 categories (for cows and calves) with the "Dry season" category offering 8 different products, mostly licks, concentrates, and supplements. The numbers of products in other categories range between 3 and 6, with the total number of products for cattle at 31, again mainly supplements, licks, and concentrates.

Feedmaster is the only animal feed producer in Namibia that would serve as competitor to the proposed pilot integrated production plant. Some 5-7 wholesalers and retailers sell the Feedmaster brand along with imported products from South Africa and elsewhere.

[27] Sihlobo, W. (2017) Brief overview of the animal feed market. Agricultural Business Chamber, South Africa.

8.4.2 Other Bush-to-Feed production in Namibia

Since 1972, farmers in Namibia have been converting bush biomass to animal fodder, particularly to supplement feed during droughts and the winter season. There is currently one commercial producer of animal feed, BosProProducts (Pty) Ltd, which delivers a feed that comprises 67% encroacher bush material while other ingredients include lucerne (6%), mealies (20%), a commercial feed additive to enhance taste (3%), and a growth enhancer (4%). Based in the Outjo farming area, BosProProducts serves mainly northern farmers. The owner of the operation is also aware of the demand in central and southern Namibia, based on weekly calls by clients who wish to buy the feed. Based on feeding trials, BosPro products can produce a daily weight gain of 1.33kg, (see figure below).

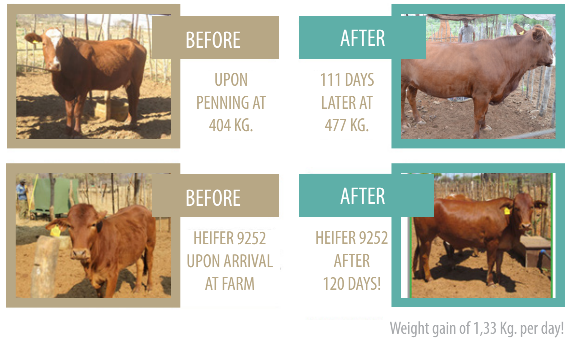


Figure 8.5 - Promotional image on the BosPro Products website, www.bosproproducts.com

A second entrepreneur based out of the Dordabis farming community has been experimenting with bush-to-feed for nearly 5 years and has produced a feed comprising up to 85% encroacher bush. This farmer has conducted feeding trials with his own cattle and observed a daily weight gain of up to 2.1 kg, with the lowest daily gains at 1.2 kg and an average of around 1.5 kg.

UNAM, in partnership with the NAFOLA/UNDP project, supported communal farmers in Okondjatu in the Omaheke region to test the development of a bush-based feed as an affordable option to raise cattle to market size. UNAM conducted feeding trials to test the feed with the participation of local farmers. Similarly to the Dordabis observation, UNAM recorded weight gains of more than 1kg per day and found the nutritional and mineral values of the bush-based feed to be of superior quality compared to some commercial feeds. The University analysed the nutritional and mineral values of several encroacher bush species in an attempt to convince farmers and officials that encroacher bush can be intensively targeted for the conversion to bush-based feed.

In general, cattle gain between 500-700 grams of weight per day on average on natural fodder and from commercial feeds in the market. Hence, gains of more than 1 kg per day are impressive and may suggest that bush-based feed could be positioned in the domestic, regional, and global feed markets as an affordable premium feed.

To eliminate challenges posed by tannins and lignin (indigestible and unpalatable components of bush material), UNAM and Seinäjoki University of Finland recommended using only bush biomass less than 20mm in diameter and harvesting encroacher bush during the rainy season to capitalise on the thinner twigs and leaves that are highest in nutritional value.

8.4.3 Feed prices in Namibia

Feed prices for livestock range between N$220 to 250 per 50 kg and N$4,400 to 5,000 per tonne.

Bush-based animal feed can be competitive in the market since it costs N$1,768.25 to produce a tonne of feed. The key drivers of this production cost are the costs of harvesting and transporting raw material. Hence, with the most expensive harvesting method, the production cost increases to N$2,568 per tonne, which would still make it possible to set a competitive and market-relevant price per 50 kg and per tonne.

Assuming the upper cost of production, the feed could come into the market as the most affordable at a price below N$220 per 50 kg or below N$4,400 per tonne, fetching a margin above 30%.

8.4.4 Shifting Namibia's trade balance

Based on the NSA's 2017 Trade Reports, Namibia still suffers a negative trade balance of some N$29 billion. Of this amount, N$6-8 billion is for the importation of fodder and feeds, including prepared animal feeds, which are the type of feeds sold by Feedmaster.

The trade statistics are not disaggregated and do not allow insight into the allocation of the N$6-8 billion to different feed subsectors.

However, beef production comprises over 70% of total agricultural output per year, so assuming that most of the imported feeds are diverted for meat production, one could assume that at least N$3 to 4 billion worth of complete cattle feed, feed supplements (e.g., mineral licks), and feed concentrates are imported per year.

Well-designed and tested bush-based feeds and feed supplements could contribute toward reducing the negative trade balance associated with the pilot integrated production plant of feeds. At a cost of N$3.5 billion per year, Namibia imports some 700,000 metric tonnes of feed (assuming a cost per tonne N$5,000).

The pilot integrated production plant intends to deliver at least 4,800 metric tonnes of feed during the 12-month trial phase. Afterwards, production would be scaled up year-on-year to grow market share and to start contributing significantly to the reduction of the negative trade balance.

8.5 GLOBAL AND REGIONAL MARKET OVERVIEW: CHARCOAL

8.5.1 Top charcoal exporting and importing countries

Production of charcoal has been increasing worldwide from 18 million tonnes in 1965 to 47 million tonnes in 2009, by which time Africa produced 63% of the charcoal in the world. The largest contributors to global export in charcoal, Paraguay (12%), India (11%), Indonesia (11%), Argentina (11%), and Somalia (5%), account for half of the charcoal exports. Since the introduction of biochar, demand and production are growing. India exported 18% of the wood charcoal it produced in 2014, the USA being its major importer.

Countries that have the highest share in global charcoal imports are Germany (9%), China (8%), Malaysia (8%), Japan (7%) and the Republic of Korea (6%). Germany imports charcoal worth 111 million US dollars, coming mainly from Poland (40%), Paraguay (12%), Nigeria (6.7%), France (6.3%), Bosnia and Herzegovina (5.3%), Ukraine (5.3%) and Indonesia (4.5%). The charcoal is mainly used in the leisure industry for barbecues and restaurants, as well as industrial purposes such as smelting. China imports 75 million USD of charcoal mainly from India, Myanmar, Colombia, Indonesia, Thailand and Ivory Coast. China's growing demand for charcoal is driven by its silicon production, which accounts for 50 % of the world production.

8.5.2 Charcoal production in Namibia

Namibian charcoal is well established on the market and offers accordingly significant expansion potential, since general demand is still growing. For example, over 40% of charcoal sold in the UK comes from Namibia.

According to NCA (Namibian Charcoal Association) invasive bush encroachment affects around 26 million hectares of Namibia's farmland (there are different figures depending on publishing authorities in place, between 26 and 45 million hectares). As a way of managing this problem, farm owners have turned to charcoal production, using cleared bush to create charcoal. The Namibian charcoal industry is informal and fragmented, mixed with exploitation of workers and preventable environmental degradation and is based on low technology and mainly unskilled labour. Namibia has high levels of unemployment, charcoal workers are often migrants from Angola and Namibia's lower income region, Kavango.

8.5.3 Current and potential capacities as incentive for improvement

The Namibian charcoal market demonstrates the comparative advantages that are to be further explored to facilitate better market access. Below are some of the key features of this market that could be further explored for sustainable development and increased contribution to the country's economy.

- Namibia is the world's sixth largest charcoal exporter. 90 % of the total production is exported, the main single market being South Africa. 30 % of the exports to South Africa consists of bulk.
- The second biggest importer is the UK which received 22% of Namibia's charcoal exports in 2015. In 2017, the total production of Namibia was approximately 180,000 tonnes, evenly split between South Africa and other markets. Namibian charcoal enters the consumer market under more than 15 different brand names, of which only a few are registered in Namibia, e.g. Jumbo, Etosha and Savannah. The rest enters the market through South African trademarks. Agents and distributors play an important role in marketing of Namibian charcoal.
- According to NCA reviews and further international business contacts and investigations, another 100,000 tonnes are considered possible to be exported. According to NCA, this includes also the opportunity to address an additional market segment that consists of the application of the produced retort charcoal as "restaurant charcoal" because of its superior quality.

Based on above-mentioned features of the market, with the support of UNIDO and in partnership with the national counterparts, the intention is to facilitate improvement of the product, contribute to its value addition and competitiveness, thereby improving market access, and ensure that environmental impact of the productive activities (as well as the health and working conditions of the staff required production units) is compliant to the respective national regulations and reduced to the extent possible.

The potential of charcoal production in Namibia can be seen from the perspective of expected export volumes of about 180,000 tonnes at average prices between N$ 1,500 and 1,700 per tonne (FOB Walvis Bay), depending on quality Forest Stewardship Council Certificate (FSC)[30] and non-FSC charcoal and with a significant up potential in case of specialties (e.g. waxed charcoal) and more sophisticated pyrolysis productions (retort charcoal, bio-charcoal). At the same time, the charcoal production in Namibia has a strong potential as a major employment generator, as the production is labour intensive, thereby employing about 5,000-6,000 people under hard conditions, plus more skilled workers in the approximately 18 processor operations.

8.5.4 Structure of charcoal business in Namibia

The simplified and widely applied structure of this business shows three important participants of the charcoal value chain, which are as follows:

1. The "**contractors**" working for the different farms to cut the required bush and "burn" the wood to charcoal. They act as a service function to the producers, the farmers and employ about 5000-6000 workers, 2,000 of them Angolan currently, with mostly informal labour contracts.
2. The "**producers**", who purchase the service of the contractors and sell as landowners/farmers the charcoal to the processors. They are mostly the owners of the drum kilns, which are often purchased from the processors, who are able to manufacture them at a price of approximately N$500.

Figure 8.6 - Drum kilns built in Otjiwarongo and working for Otjiwarongo (Makarra bush products)

3. And finally, the "**processors**", who purchase the charcoal, process it further to sellable products and execute the required marketing, sales and exports. According to NCA, there are about 18 processors, from which 13 are doing exports.[28] They are mainly responsible for the market success. They do the necessary product acquisitions in export countries with the support of agents, develop an appropriate product portfolio including specialties and apply significant quality pressure to the contractors and producers to be competitive – including compliance to foreign standards.

The infographic on the next page shows in more detail the main structure of Namibia's charcoal business. This structure also sets the foundation for how the project, with its production improvement suggestion, has to be integrated into the current business process, to take advantage of existing market contacts, in addition to the development of own and additional customer segments. Accordingly cooperation opportunities with processors will be addressed.

For that purpose, two processors have been visited to understand current business models and to develop mutually an appropriate improvement suggestion, which is based on higher yields and carbon content and fewer fines of the suggested retort process, and is appropriate also for higher priced end products.

8.5.5 Current drum kiln operations as reason for suggested improvement

There are sometimes also other arrangements in place, but the processor mostly acts as purchaser of the produced charcoal, picked up at the farm's roadside. This represents a significant problem for tourism, since "the clean nature" requested from tourism is heavily charged from operating and smoking drum kilns on, and besides touristic routes due to widely visible smoke generation. Moreover, workers are of course harmed to a significant higher extent from smoke and gas emissions (CO_2, CH_4, other volatiles and non-condensable gases) directly at production sites.

The above mentioned problem will be significantly improved by introducing the suggested retort technology and will comply with current workers' health protection developments and overall environmental regulations.

At production site

View on drum kiln-emission

[28] Forest Stewardship Council Certificate established to promote the responsible management of the world's forests

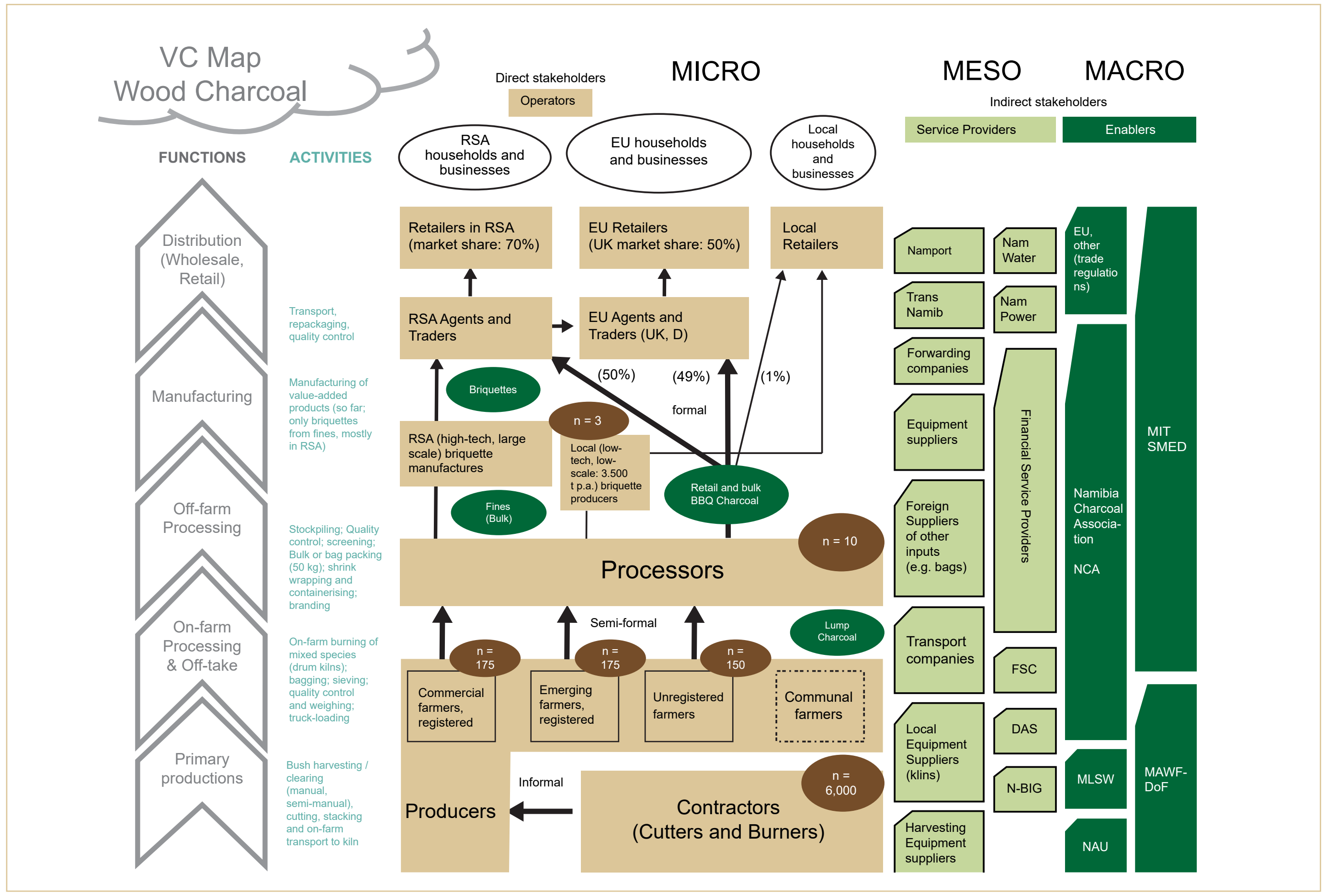


Figure 8.7 - Main structure of Namibia's charcoal business in detail

8.5.6 Investigations and opportunities

Aiming to ensure the detailed understanding of the available opportunities for development of charcoal production in Namibia, the following major investigations were accomplished and respective action proposed:

- The largest processor, Jumbo charcoal in Okahandija, has exports of app. 20,000 tonnes at a labour force of app. 250, is concentrated currently on the UK, but does also exports to France, Greece and Portugal. As evidence that they also see opportunities in retort charcoal they dispose some retort charcoal pilot plants, which are not operative, but which can be understood as potential steps into the higher priced market segment of retort charcoal.
- Makarra Bush Products in Otjiwarongo delivers about 10,000 tonnes of charcoal per year, employs about 150 people and acts as purchaser of drum kiln produced charcoal. Processing includes collecting the raw charcoal from producers, sieving/sifting, quality supervision, packaging and preparation for dispatch (similar to Jumbo). There are also some interests to market higher value charcoal products, which is already done with the production of briquettes, taking advantage of the low raw material costs of charcoal fines (1-5 mm particles on average). Makarra's business model includes also the production of drum kilns and their sales and rental to contractors or producers.
- Discussions showed that Makarra is currently undertaking strong efforts to cooperate with German retailers, which demonstrates some price problems since they are confronted with low priced charcoal originating from East Europe. According to some investigations, these producers may base their low prices on imported low quality West African coal being used to dilute genuine charcoal. This mixture misses of course some quality criteria of properly produced charcoal. This can be tackled with the introduction of some certification process demonstrating a standard is not met by the offered low quality/priced charcoal.
- Based on some contacts of the Finnish plant supplier a request from a Finnish company was received to offtake the whole production of both retorts at a profitable price, after providing the necessary quality evidence relevant to "bio-charcoal". Following that, the plants will be equipped with the relevant minor adaptations. This opportunity will be further pursued.
- Moreover, there is a request from a large South African distributor in place concerning the offtake of significant charcoal volumes.

The above listed major findings demonstrate that overall charcoal production in Namibia has strong potential as a further competitive niche market and would be capable of supplying sufficient volumes of the products.

9

CONCLUSION: UNIDO PROJECT IMPLEMENTATION AND OUTLOOK

CONTENTS

Namibia is a land of extraordinary beauty with an abundance of natural resources. One of these resources is the country's wealth of biomass in the form of various species of bush. The country has already determined legislation to care for the protection of this resource.

UNIDO, jointly with the national partners and with the financial support of the Government of Finland and Baobab Capital Ltd, is supporting the Government of Namibia in advancing the sustainable industrial development of Namibia by utilizing this abundance of biomass of invasive bush species for production of higher value-added final products –animal feed and charcoal as pilot products– as described in this report. Direct outcomes of the UNIDO technical assistance implemented as part of the project entitled "Promoting Sustainable Bush-Processing Value Chains in Namibia" encompasses the identification, testing and adaptation of appropriate technology solutions for manufacturing these identified final products based on locally collected bush biomass. The identified technologies are to be transferred to Namibia and installed for further operationalization at a pilot processing plant to be designed and established for manufacturing of high-value livestock feed, charcoal (potentially also retort charcoal and/or "biochar"), and other selected products utilizing Acacia and other raw materials. Hence, the sustainable utilization of invasive bushes like Acacia helps to mitigate bush encroachment as a form of land degradation. Through these measures, higher levels of agricultural productivity can be achieved, resulting in a better supply of food, increased resilience of farmers to droughts and reduced poverty, especially in rural communities. The improved provision of arable land for agricultural activities would result in enhanced capacities for local job creation and income and exports generation. In addition, through controlling the spread of invasive species and sustainable use of available bushes, the tourism sector would also benefit through renewed access to underground water resources, the restoration of original rich scenery with native plants and wildlife.

More than half of the surface area of Namibia is bush-encroached, an estimated 45 million hectares offering some 450 million metric tonnes of wood biomass, growing at 3.18% (or 1.5 million ha) per year.

Bush control and biomass utilisation have the potential to generate substantial net benefits of around N$48 billion over 25 years and thus to contribute to Namibia's social, environmental, and economic welfare.[29]

At an estimated biomass of 450 million metric tonnes, Namibia can address poverty, unemployment, and food insecurity by exploring the 15 viable value chains. A production plant for animal feed and charcoal can engage in viability analysis for value chains that can leverage the existing infrastructure and machinery. For example, wood chips produced as the input material for animal feed are also input material for compressed firewood and energy pellets (for use in industrial biomass-to-energy plants), medium-density boards (commonly used for built-in cupboards in homes), and wood-plastic composites (WPC).

Properly done, bush thinning can enable the restoration of rangelands for livestock and improve water security. Rangelands restoration will increase the effective national carrying capacity, suggesting higher capacity for livestock farming while more surface water will filter through to replenish aquifers.

The tourism sector would also benefit through renewed access to underground water resources, the restoration of original rich scenery with native plants and wildlife.

As such, this report represents a convergence of feasibility study and market intelligence to provide a market oriented sustainable business model to benefit from bush biomass for production of competitive higher value-added products and facilitating job creation. This pilot production plant is to be equipped with modern innovative machinery, including biochar production equipment for production of charcoal, tar and distillates, bush cutting and chipping equipment, containerized feed mill and pellet line. This plant is to be established at the land plot to be allocated by the national counterparts, in particular, the Ministry of Industrialization, Trade and SME Development (MITSMED) of Namibia and the Namibian Development Corporation (NDC).[30]

To enable the establishment of the pilot production plant, UNIDO will facilitate transfer of the identified technologies through procurement and installation of the machinery appropriate for the production of animal feed, charcoal and other by-products and suitable to Namibian conditions.

In particular, the technologies to be transferred include:

- animal feed production plant with a capacity of approximately 4,400 tonnes/year;
- two charcoal production plants with a capacity of approximately 500 tonnes/year, whereby for both plants (animal feed and charcoal) their capacities are essentially dependent on personnel deployment, shift schedules and further optimization and are thus flexible;
- harvesting equipment required bush raw material.

In accordance with the strategic actions as defined in this report, the task is thus threefold:

- transfer of technologies and know-how to Namibia and respective procurement of equipment;
- the operationalization of the production plant, including ensuring the necessary pre-conditions for its sustainable production processes;

[29] MAWF/GIZ (2016) Assessment of the economics of land degradation related to bush encroachment in Namibia report. Prepared by the Namibia Nature Foundation.
[30] Namibian Development Corporation (NDC) was being transformed into Namibia Industrial Development Agency (NIDA) as of November 2018.

- ensuring the entrepreneurial conditions to make the investment an economic success.

The operationalization of the pilot production plant will include the testing and adaptation of the production processes in cooperation with the original equipment producers and Finnish expertise/academia including from the Seinäjoki University of Applied Science, training of the national experts on the operation of the equipment and technologies transferred as part of this project. Furthermore, in collaboration with the Finnish academia and University of Namibia, the local experts will be trained to provide capacity building for harvesting and production of bush-based animal feed and charcoal in a sustainable manner.

One of the key aspects described in this report is the targeted business model and respective actions to ensure the economic success and sustainability of the pilot production plant. This aspect is of particular importance as both the available raw materials (bush biomass) and the targeted sales market allow to estimate the potential for replication of similar plants across the country, thereby demonstrating the potential of a significant contribution to Namibia's economic development as a whole. As such, the business model considers the economic characteristics and design of the pilot production plant during the follow-up work on this project, since only a profitable operation and plant will be considered for further replication. In order to meet this economic challenge, the necessary entrepreneurial and business management technical support and respective capacity building activities to constitute the important part of the project need to be in place. Specifically, this means, among others, technical assistance in solving concrete entrepreneurial tasks, such as:

- technical support in any operation and business operational issues relevant for the operationalization of the plant to meet the economic and profitability pre-conditions;
- support for the development and maintenance of the successful business model for the production processes and operation of the plant, starting from the raw material requirements, the different prescription-dependent supplements up to the production capacity, which also defines the needs for equipment and personnel in the different modes of operation (including various mass balances and their influence on additional grazing areas);
- guidance to the national counterparts to ensure the sustainable business partnerships and operational contracts, such as secure supply of raw material, sales, future involvement of Namibian companies and institutes (including know-how transfer and product development);
- assistance in preparation of job descriptions and identification of personnel for the operating production plant to ensure management know-how in the final business planning stage, the construction and the operation phase;
- support for the overall business management of the plant through appropriate application of the business model to achieve the economic objective of the project.

In addition to the transferred animal feed and charcoal production technologies, sustainable process adaptation and development perspectives are being considered as a milestone action for this project, as the pilot production plant aims to support the generation of significant proprietary local know-how that would allow for stimulating a strong competitive positioning of the Namibian produce. This will take into account both the bush biomass characteristics and adaptation of the final goods to the needs of the local and external markets. The adaptation of the locally developed final product is to be specifically critical for appropriate positioning at the new market segment that is characterized by:

- development of suitable and competitive animal feed recipes that are affordable for the Namibian market;
- development of higher quality charcoal ("biochar") potentially competitive at the national and international markets;
- outlook for potential introduction of a new product "Arabic Gum" at the local and export markets.

These factors are part of the business model introduced for the pilot production plant that would serve as the basis for its testing and adaptation to ensure the sustainable and profitable operation of the pilot production plant. The business model further incorporates all parameters influencing revenues and costs determined so far, thereby providing the opportunity to model the economic result of the operation under changing and also hypothetical parameters, thereby allowing prediction of the effects of each parameter influence on the pilot production plant's profitability. At the same time, the business model includes a tailor made marketing and branding strategy for promotion and improved market access of the final products at the competitive local and export markets, including creation of unique brand and registration of the logo for the production entity and its produce.

As such, according to the estimates, the piloting of the production plant is expected to generate new jobs, stimulate development in Namibia with a multiplier of 30-50, and 100 for similar plants to be established in the region. This market-oriented sustainable business model provides the basis for establishment of a pilot production plant and formulation of tailor made business plans for its operationalization for the upcoming 10 years with estimated revenues ranging between 14-26%.

The "Promoting sustainable bush-processing value chains in Namibia" project addresses many of the regional challenges posed by bush encroachment, and contributes to Namibia's national sustainable development objectives as well as the SDGs. By utilising invasive bush species to produce value-added products, this project will help Namibia generate jobs, including for women and marginalised individuals, increase food security and improve livelihoods, while restoring the environment and supporting climate sustainability.

Table of Figures

Inclusive and Sustainable Industrial Development

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