

Support to
De-bushing
Project

Value Added End-Use Opportunities for Namibian Encroacher Bush



Implemented by

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für Internationale
Zusammenarbeit (GIZ) GmbH

Value Added End-Use Opportunities for Namibian Encroacher Bush

Imprint

Commissioned by

Support to De-bushing Project
Ministry of Agriculture, Water and Forestry/Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH
Windhoek, Namibia

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Design & layout

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Printed by

John Meinert Printing

Published

May 2015

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ABBREVIATIONS

BMBF	German Federal Ministry of Education and Research
CBEND	Combating Bush Encroachment for Namibia's Development
CBRLM	Community Based Rangeland and Livestock Management
CCF	Cheetah Conservation Fund
CHP	Combined Heat and Power
cm	centimetre
CSIR	Council for Scientific and Industrial Research (South Africa)
DAS	De-bushing Advisory Service
DECOSA	Development Consultants for Southern Africa cc
DoF	Directorate of Forestry
DRFN	Desert Research Foundation of Namibia
EADI	European Association of Development Research & Training Institutes
EEF	Energy for Future
e.g.	for example
EPZ	Export Processing Zone
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
FSC	Forest Stewardship Council
GIZ	Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GJ	Giga Joule
GRN	Government of the Republic of Namibia
GWh	Giga Watt Hour
ha	hectare
hr	hour
INM	Leibnitz Institute for New Materials
IPP	Independent Power Producer
IPTT	Indigenous Products Task Team
kcal	kilocalorie
KfW	Kreditanstalt für Wiederaufbau / German Development Bank
kg	Kilogram
km	Kilometre
kWh	Kilo Watt Hour
l	litre
m³	cubic meter
MAWF	Ministry of Agriculture, Water & Forestry
MDF	Medium Density Fibre Boards
MET	Ministry of Environment & Tourism
mj	mega joule
MLR	Ministry of Lands and Resettlement
mm	millimetre
MOF	Ministry of Finance
MRLGHRD	Ministry of Local Government, Housing and Rural Development
MTI	Ministry of Trade and Industry
MW	Mega Watt
NaMiBIND	Natural and Mineral-based Binders for Ecological Building Materials Industries
NAU	Namibia Agricultural Union
NBIG	Namibia Biomass Industry Group
N\$	Namibia Dollar
NCCI	Namibia Chamber of Commerce and Industry



NCPA	Namibian Charcoal Producers Association
NDP	National Development Plan
NDP4	National Development Plan 4
NNFU	Namibia National Farmers Union
NPC	National Planning Commission
NPCS	National Planning Commission Secretariat
NREL	United States National Renewable Energy Laboratory
NRF	Namibian Rangeland Forum
NSA	Namibia Statistics Agency
n.y.	no year
OES	Organic Energy Solutions
OSB	Oriented Strand Boards
p.a.	per annum
PRC	Peoples Republic of China
RSA	Republic of South Africa
SADC	Southern African Development Community
SME	Small and Medium Enterprise
t	metric tons
TA	Traditional Authorities
t/hr	tons per hour
ToR	Terms of Reference
UF	Urea formaldehyde
UK	United Kingdom
UNAM	University of Namibia
UNDP	United Nations Development Programme
USA	United States of America
WCT	Wood-Plastic Composites
WPI	Worcester Polytechnic Institute



EXECUTIVE SUMMARY

1. BACKGROUND AND OBJECTIVES

- 1.1 Bush encroachment, i.e. an increase of bush density and significant decrease of grasses, is a national challenge in Namibia. It is estimated that 26-30 million ha of farm land are affected by bush encroachment, resulting in extremely reduced livestock carrying capacity, erosion, loss of groundwater potential, etc. The annual losses in meat production alone are estimated to be N\$ 1.4-1.6 billion.
- 1.2 Although the problems are known and discussed since decades, only limited measures are implemented to combat bush encroachment due to the costs involved. Thus de-bushing can only be successful if the woody biomass is recognised as a valuable resource for existing and new value chains.
- 1.3 The current economic utilisation of encroacher bush focuses mainly on firewood for local communities, charcoal for exports, and small production of compressed firewood. Other initiatives have been identified in the field of agriculture and energy. However, with the exemption of the currently limited bush utilisation for energy, these projects are not yet at a stage to be implemented and/or are not economically viable.
- 1.4 It is against this background that the Governments of Namibia and Germany agreed on a 4-year Support to De-bushing Project to address both challenges and opportunities that bush encroachment entails.
- 1.5 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 outline their potential for the establishment of competitive value chains in Namibia.
- 1.6 The overall aim of the consultancy is to create a comprehensive overview and initial assessment of products that can be produced on the basis of Namibian encroacher bush.

2. ENCROACHER BUSH RESOURCES AND THE FRAMEWORK FOR UTILISATION

- 2.1 Encroacher bush is classified by the bush density (with enormous variations from 2 000 to 10 000 bushes per hectare) and dominant species in different areas. Although species may be dominant in some areas, most of the encroacher bush consists of a diversity of species of different sizes and age groups.
- 2.2 Encroacher species are not clearly defined and separated from protected species. This creates insecurity for investors.
- 2.3 A major challenge for the processing of encroacher species is the lack of knowledge about properties of individual species, which are important for end-use opportunities, such as strength, grain, resin and other contents. Specific characteristics, distinguishing encroacher bush from other industrial wood resources, include
 - the mixture of hardwoods from species with different mechanical and chemical properties;
 - the dimensions of the woody biomass, which are fairly small (branches and small dimension-al stems are dominating);
 - the species are often very heavy hardwoods;
 - the bark content is relatively high.
- 2.4 Based on assumed 26-30 million hectare and a harvest of 10 t/ha on average, the encroacher bush theoretically offers 260-300 million tons of biomass. This opens an enormous potential for value added production. However, information about the quantities of encroacher species

in different areas and their growth rates are rare. Therefore, the Support to De-bushing Project initiated two research projects, a national GIS mapping on bush encroachment complemented by a detailed assessment of local biomass resources in a selected area.

- 2.5 The existing legislative framework is in principle a promising basis for combating bush encroachment and for developing end-use opportunities with value addition. The development of harvesting rules and guidelines would further enable serious investments in the utilisation and processing of encroacher bush. Currently, changing regulations and the short validity of harvesting permits, have a negative impact on the development of industries, creating a level of insecurity and hampering investments.
- 2.6 The huge number of institutions directly or indirectly involved in de-bushing without a real co-operation and coordination is another matter of concern. However, the recent establishment of a coordination unit responsible for the implementation of the National Rangeland Strategy and thus for de-bushing will hopefully strengthen future actions to combat bush encroachment.

3. ASSESSMENT OF POTENTIAL END-USE OPPORTUNITIES

- 3.1 Numerous end-use opportunities have been identified requiring larger quantities of resources, and in addition products, which can be produced in small quantities, but may still lead to considerable value addition as well as the creation of SMEs and employment.

The commercial experience with most opportunities based on encroacher bush is limited in Namibia (mainly firewood, charcoal, chips for energy generation). It is a challenge that also internationally many of the identified opportunities are based on specific biomass species (in particular softwood or agricultural plants) but hardly ever on mixed, heavy hardwoods which are common in Namibian encroacher bush.

The opportunities can be grouped into three categories.

- 3.2 The following opportunities - though mainly small scale - are already implemented in Namibia or have a realistic chance of being implemented by local entrepreneurs with limited intervention.

Opportunity	Remarks
Furniture	<ul style="list-style-type: none"> ○ Only based on prosopis ○ Small diameters of other invader species not suitable/financially viable
Wooden Frames & Kitchen Boards	<ul style="list-style-type: none"> ○ Import substitution targeted ○ Entrepreneur to be identified to test feasibility
Carving	<ul style="list-style-type: none"> ○ Widespread local experience ○ Promotion of wood from encroacher bush recommended
Sticks & Handles for Tools	<ul style="list-style-type: none"> ○ Import substitution & export targeted ○ Low investment for mechanised production ○ One entrepreneur to be identified to test feasibility
Wood Glue	<ul style="list-style-type: none"> ○ Experience in other countries available ○ Foreign partners to be mobilised to investigate feasibility
Compost	<ul style="list-style-type: none"> ○ Mainly for own use by farmers ○ Small current commercial production in Namibia exceeds demand
Mulch for Gardening	<ul style="list-style-type: none"> ○ Mainly for own use by farmers ○ Small current commercial production in Namibia exceeds demand
Smoking Material	<ul style="list-style-type: none"> ○ By-product of wood processing ○ Import substitution targeted

Opportunity	Remarks
	<ul style="list-style-type: none"> Local entrepreneur to be identified

- 3.3 14 opportunities have prospects for development (also on larger scale) on the basis of Namibian encroacher bush, but they require further action/investigation in order to contribute to de-bushing. This category includes also important already on-going opportunities, which require different measures to improve the value chain (e.g. charcoal, wood chips, animal feed).

Opportunity	Prospects
Charcoal	<ul style="list-style-type: none"> Already most important value chain for wood from de-bushing Positive image of Namibian barbeque charcoal on undersupplied world market (6th largest exporter) Potential to fourfold exports in 10 years Need to improve harvesting, production sector and regulatory framework
Wood Chips	<ul style="list-style-type: none"> Huge, increasing world market (35.1 million tons imports p.a.) Short-term domestic demand by industry and power generation exceeds production capacities Engineering solution to chipper technology customised to harsh Namibia conditions required Tailored logistic chain solutions to access international markets to be developed
Compressed Firewood	<ul style="list-style-type: none"> Existing market demand in Namibia/RSA exceeds current production capacities Additional markets both locally and internationally may provide huge growth potential Engineering solution to minimize sand content in resource required Tailored logistic chain solutions to access international markets to be developed
Firewood	<ul style="list-style-type: none"> Huge, stable domestic demand (about 550 000t p.a.) Use of invader species to be promoted in order to contribute to environmental protection
Animal Feed	<ul style="list-style-type: none"> Considerable domestic demand for complementary and emergency animal feed both in communal and commercial areas Considerable number of production tests under way in Namibia Digestion of wood controversial point of discussion Suitability of species, optimal production processes and feed composition to be clarified
Wood Pellets	<ul style="list-style-type: none"> Huge, increasing international demand (12.2 million tons imports p.a.) Higher energy efficiency and bulk density as compared to wood chips Engineering solutions to customized chipper technology and high sand content of resource required Tailored logistic chain solutions to access international markets to be developed
Poles	<ul style="list-style-type: none"> Continuous domestic demand on high level Potential for increased local production for import substitution Quality improvements required
Wood-cement Bonded Boards & Bricks	<ul style="list-style-type: none"> Increasing demand in industrialised countries due to excellent properties Improvement of the construction industry and import substitution of panels possible Material specifications of Namibia bush and related suitability to be clarified



Opportunity	Prospects
Medium Density Fibre Boards (MDF)	<ul style="list-style-type: none"> ○ Possibly demand for indoor construction in Namibia and other African countries, i.e. import substitution and export promotion possible ○ Overseas export hampered by quality requirements ○ No experience with Namibian hardwood species; tests required
Wood-sand Boards	<ul style="list-style-type: none"> ○ Research in Namibia ongoing; results only expected in years ○ Financial viability doubtful, therefore not commercially applied in other countries
Wood-plastic Composites (WPC)	<ul style="list-style-type: none"> ○ Niche markets of indoor construction, furniture production, agriculture (e.g. droppers) ○ Huge variety of products ○ Test results with mixed encroacher species promising ○ Market demand/opportunities in Southern Africa to be verified
Parquet	<ul style="list-style-type: none"> ○ Small (high end) local market ○ Wood of high density required; possibly available from several invader species ○ Only larger woody parts of bushes suitable ○ Sufficient quantities of attractive wood required
Shingles	<ul style="list-style-type: none"> ○ Very special traditional niche market in a few European countries ○ Invader species with relevant properties should be available ○ High prices in Europe due to manual production
Traditional Medicine	<ul style="list-style-type: none"> ○ Increasing import demand in Europe and North America ○ Highest value addition ○ Longer term research required (e.g. quantities, applications, acceptance)

- 3.4 The other opportunities are currently not recommended to be considered as value chains to be supported by government. They either show no concrete potential or are seen as long-term opportunities only (see Chap. 4.1).

4. COMPARATIVE EVALUATION AND RANKING OF END-USE OPPORTUNITIES

- 4.1 The 14 aforementioned opportunities (see 3.3) were evaluated using the method of a qualitative matrix evaluation. The evaluation provides some indications for project developers, investors, farmers, etc. to decide, which opportunities they intend to follow-up primarily. The opportunities can only be compared within the following categories.
- 4.2 Opportunities, which require limited technology, skills and investment and can be based on the mixed encroacher bush without selection of species with specific properties, bear the lowest risk, but their stage of processing is limited. The most promising opportunities within this group are
- charcoal,
 - wood chips, and
 - firewood.

- 4.3 Real manufacturing industries require investments in technologies, skilled personnel and in most cases selection of suitable species. Priority opportunities within this group are
- compressed firewood, and
 - animal feed
- 4.4 Promising opportunities with limited effect on de-bushing but possibly high value addition are
- parquet
 - shingles, and
 - traditional medicine
- 4.5 The ranking does not mean that products ranked lower are not recommended. All businesses are selected from a wider range of opportunities and can contribute to use invader bush with value addition. A final decision is only possible after further investigation.

5. RECOMMENDATIONS FOR IMPLEMENTATION OF PROMISING END-USE OPPORTUNITIES

- 5.1 A final decision of the optimal locations to establish the recommended opportunities depends on the different requirements, which have been identified and evaluated. Due to the current lack of reliable information, in particular with regard to the resources, only preliminary recommendations are included in Chap. 5.1.
- 5.2 The utilisation of encroacher bush with value addition will only be successful if the basic conditions are improved. Important measures to support de-bushing have been initiated, namely creation of a coordination unit, assessment of optimal harvesting technologies and costs as well as evaluation of the biomass resources. Also an enabling regulatory framework must be provided (in particular harvesting guidelines) as security for investors, and in addition to already existing incentives direct financial incentives of the Government should be considered as for example foreseen in NDP4 and in the Soil Conservation Act.
- 5.3 The general support measures must be complemented by specific support of the different value chains including
- awareness creation amongst the local business community about existing (mainly small scale) opportunities;
 - determination of the wood properties, which are essential for several end-use opportunities;
 - development of production technologies (e.g. chippers, extruders, pelleting machines) adapted to the special requirements of the Namibian encroacher bush;
 - mobilisation of investors and know-how partners;
 - education, e.g. with the aim to promote the use of encroacher bush instead of using other endangered forest resources;
 - capacity building for instance in areas such as business operation of SMEs, production of improved animal feed, poles and charcoal; and
 - preparation of strategic documents required for the final evaluation and promotion of several value added opportunities, e.g. detailed assessment of transport options, special market surveys and feasibility studies.

5.4 The costs for the recommended actions are roughly estimated in Tab. 13 and summarised in the following for the different opportunities.

Action	Costs in N\$
Charcoal	1 050 000
Wood Chips	375 000
Compressed Firewood	805 000
Animal Feed	1 840 000
Firewood	130 000
Wood Pellet	255 000
Wood-cement Bonded Bricks & Boards	1 150 000
Medium Density Fibre Boards	1 800 000
Wood-plastic Composites	880 000
Parquet	560 000
Shingles	630 000
Traditional Medicine	3 030 000
Wood glue	100 000

In addition, for general capacity building in species identification and harvesting as well as operational management of SMEs N\$ 380 000 is estimated.

- 5.5 The development costs are marginal in light of the benefits such as increased livestock carrying capacity, reduced support of livestock farmers in years of drought, substitution of imports, promotion of exports, fiscal benefits as well as employment creation and income generation, in particular in rural areas for economically disadvantaged segments of the population.
- 5.6 In order to facilitate the implementation of value added opportunities based on encroacher bush action and time plans are provided in Chap. 5.3.1 and 5.3.2 including possible partners to be involved.

1. INTRODUCTION

1.1 Background, Objectives and Tasks of the Consultancy

Bush encroachment, i.e. an increase of bush density and significant decrease of grasses is a national challenge in Namibia. It is estimated that 26-30 million ha of farm land are affected by bush encroachment including the following negative effects:

- Economic losses for farmers, farm labourers and their families as well as downstream industries, commerce and exports that rely on livestock production. Annual losses of N\$1.4 to 1.6 billion are estimated. This is underlined by the fact that cattle numbers in communal farming areas currently equal only 36% of their number in 1959; this can be attributed mainly to the problem of bush encroachment.
- Implications on water resources are yet not fully known. However, research has begun to quantify the groundwater potential lost due to dense bush. A study carried out by Colin Christian 2010 estimates that encroacher bush has affected 89% of the Namibia's high groundwater potential.
- Reduced protection of the soil and thus erosion often combined with reduction of the biodiversity.

Although these problems are known and discussed since decades in Namibia, only limited measures are implemented to combat bush encroachment and to use the opportunities for the national economy if the woody biomass is recognised as a valuable resource for existing and new value chains in the country. The current economic utilisation of encroacher bush focuses mainly on firewood for local communities, charcoal for exports, and production of compressed firewood as value-added fuel for local markets and exports. However, such activities are limited, have not attracted significant investments and thus the potential to combat bush encroachment is by far not leveraged.

Other initiatives have been identified in the field of agriculture (animal feed and organic fertiliser) and energy (industrial energy applications and power generation). However, with the exemption of the bush utilisation for energy at the Ohorongo Cement factory near Otavi, these projects are not yet in a stage to be implemented and / or are not economically viable.

It is against this background that the Governments of Namibia and Germany agreed on a 4-year Support to De-bushing Project to address both challenges and opportunities that bush encroachment entails. The project's overall objective is to trigger large-scale de-bushing activities. To this end a demand-driven approach is pursued, focusing on the identification of potential bush based biomass value chains. Therefore, a Scoping Document on Value Addition and End-use Opportunities for Namibian encroacher bush should be prepared. It is the main task of this Consultancy to identify products that can be produced using Namibian encroacher bush and outline their potential for the establishment of competitive value chains in Namibia.

The overall aim of the Consultancy is to create a comprehensive overview and initial assessment of products that can be produced on the basis of Namibian encroacher bush. The assignment is to be understood as the first of two phases of value chain research. It shall cover various aspects of full value chain analysis, but be limited in depth and scope. The resulting study shall inform decision makers on general opportunities for value chain development and propose priorities, which will lead to in-depth research on selected products/value chains.



1.2 Execution of the Consultancy

The Consultancy was executed by the following team from DECOSA:

Name	Main Tasks/Responsibilities
Prof. Dr R. Trede	Project management, evaluation of resources, identification of opportunities, analysis of current operations, assessment of the applicability, determination industry entry requirements (resources), estimation of demand, determination of support services, final evaluation & recommendations.
Prof. Dr R. Patt	Identification & pre-selection of opportunities, assessment of economics of scale, selection of opportunities, determination of capacities & investments.

Based on the Consultancy Agreement and the terms of reference (ToR), the Consultancy was executed in the following steps:

(i) *Identification of Opportunities*

DECOSA aimed to compile a near conclusive list of possible bush-based products / opportunities, which was not available in Namibia.

The compilation of such opportunities is based on the following sources:

- Documents available in Namibia, at GIZ and other stakeholders and at DECOSA's library (see Annex 1).
- Internet research (see Annex 1).
- Namibian and foreign experts from institutions and the business sector (see Annex 2).

The identification of international best practices that are new to the Namibian context was research priority. However, also products which are obviously not suitable for Namibian encroacher species were considered. By including such products, it shall be avoided that they may be discussed or investigated in future as it happened in the past in Namibia.

(ii) *Definition of Value Chain Requirements for End-use Opportunities*

As basis for the assessment of potential opportunities, the applicability and requirements had to be defined. In this context the resources of the invader bush are of overriding importance. Therefore, the regulatory and institutional framework as well as the characteristics of the encroacher bush and its species, were briefly evaluated.

(iii) *Assessment of Potential End-use Opportunities¹*

Based on the defined requirements, each opportunity was assessed as main part of the Consultancy. This assessment considered in particular international best practices, experience in Namibia (if any) and national as well as international experts' opinion.

In deviation from the ToR, not only pre-selected but all identified opportunities were assessed in Chap. 3 in agreement with GIZ. However, opportunities which demonstrated already at an early stage of the investigation that they are not feasible are only evaluated briefly. The as-

¹ Estimated investments include only processing equipment, not land, buildings and vehicles.



assessment of all opportunities in one chapter is deemed advantageous because thus a complete document about all opportunities is available which can be used by officials and potential investors separately from the whole project report.

(iv) *Comparative Evaluation and Ranking of End-use Opportunities*

The assessment resulted in grouping the opportunities into three categories:

- Opportunities without a realistic chance to be implemented or only on a long-term.
- Opportunities which are already implemented in Namibia or have a realistic chance to be directly implemented by local entrepreneurs without further actions / investigation.
- Opportunities which are promising but require further actions / investigation in order to contribute to de-bushing.

All opportunities of the last category were comparatively evaluated in a matrix in order to facilitate a final selection and prioritisation of opportunities to be further developed for implementation.

(v) *Recommendations for Implementation of Promising End-use Opportunities*

Based on the assessment and comparative evaluation, recommendations for implementation are provided with main focus on required support services. Finally, cost estimates and implementation plans with time frames for the required actions were developed including the recommended involvement of private and public partners.

Despite an excellent cooperation with the personnel of the GIZ De-Bushing Project and comprehensive support by them, the execution of the Consultancy faced some unexpected challenges. For example:

- Contradicting DECOSA's experience from numerous other projects, a large number of specialists were reluctant to provide information. This included equipment suppliers and research institutions who just did not reply despite several reminders. Moreover, some private entrepreneurs in Namibia blankly refused to provide any information; they claimed they were contacted already since years with regard to de-bushing but nothing has happened.
- Several interviews of Namibian entrepreneurs involved in further processing of invader species revealed a lack of professionalism (in particular of business orientation) and thus of useful information.
- Hardly any project, whether only planned or including processing tests, considered the special situation of the raw material from encroacher bush (mixed species, properties of invader species), which requires the involvement of forestry or timber experts.
- In contrast to hundreds of other species in Africa and other continents, information on the wood properties of invader species are not available at any international research stations. Numerous publications about these species cover for example detailed description of the "trees", bark, leaves and fruits and the uses of different parts, but besides the weight no other physical and chemical wood properties which are essential to assess the potential uses of the wood.

The assessment of end-use opportunities and the formulation of recommendations has been conducted at the discretion of the author.



2. ENCROACHER BUSH RESOURCES – THE MAIN VALUE CHAIN REQUIREMENT FOR END-USE OPPORTUNITIES

2.1 Overview of Value Chain Requirements

The identification and assessment of end-use opportunities has to be based first of all on the characteristics and availability of the resources from encroacher bush (see Chap. 2.2). In addition the following industry entry requirements have to be considered:

- Complete or selected utilisation of the encroacher bush and its species.
- Other input requirements.
- Required and available technologies.
- Operational capacities / economies of scale.
- Level of investment.
- Personnel requirements.
- Demand markets and competition.

Such requirements determine the feasibility of the end-use opportunities and the effects on de-bushing. Moreover, they are the basis to identify required support services and possible locations for the utilisation and processing of encroacher bush.

2.2 Resources from Encroacher Bush

The characteristics of the resources are an essential aspect of the evaluation to process encroacher bush into value added products. In this context the types of bush, the individual species and their properties as well as the harvestable quantities are important. The possible harvesting is not only determined by the natural circumstances but also by the regulatory and institutional framework.

2.2.1 Types of Encroacher Bush

Generally encroacher bush is characterised by often multi-stemmed shrubs up to 5 m tall. Under favourable conditions (e.g. along water-courses) several species occur also as trees reaching 8 m (e.g. mopane, terminalia mesquite) or even 12 m (e.g. candle-pod acacia, umbrella thorn).

The density of encroacher bush is dependent on the climatic conditions and the disruption of the competitive balance between herbaceous and woody plants, especially by fire and browsing pressure. Bester (1996) divided Namibia into nine thickening zones (plus one in the south) based on the dominant encroaching species and average bush density (see Tab. 1). For example zone 4 was classified as *Colophospermum mopane* (4 000/ha), referring to the area or zone being dominated by *Colophospermum mopane* and containing on average 4 000 stems per hectare. With regard to the enormous variation of the bush density from 2 000 to 10 000 (see Fig. 1) bushes per hectare, it must be considered that even within the different zones the density varies from patches of dense bush to more open patches with less bush.

For several potential uses of encroacher bush it is important that, in contrast to the impression provided by Bester's categories, pure stands of individual species rarely occur. Although species may be dominant, most of the encroacher bush consists of a diversity of species of different sizes and age groups.



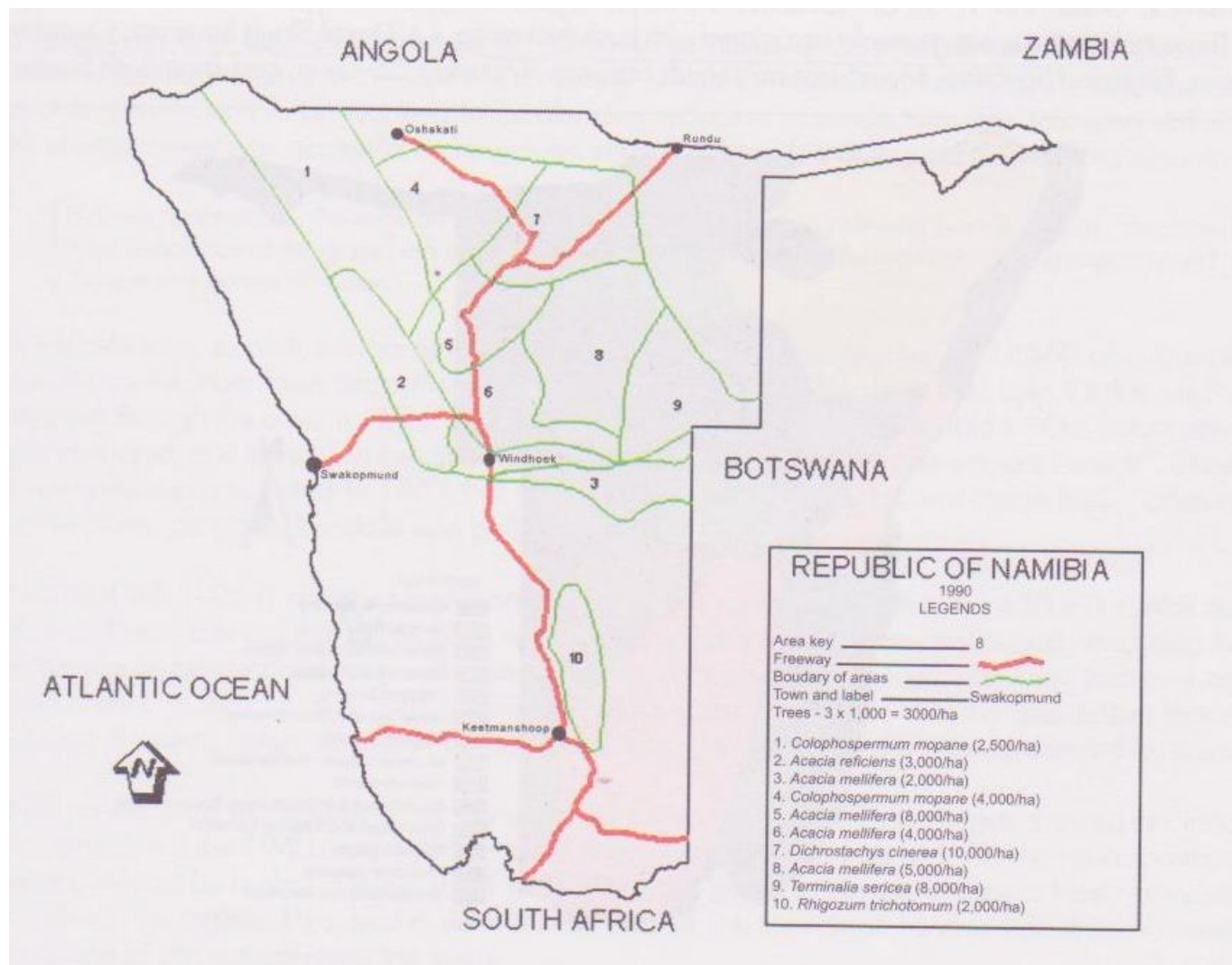
Tab. 1: Approximate Density of the Different Dominant Bush Species in Commercial Areas

Category of Thickened Bush		
Zone	Main Bush Species	Densities of Bushes
1	Colophospermum mopane	2 500 per hectare
2	Acacia reficiens	3 000 per hectare
3	Acacia mellifera	2 000 per hectare
4	Colophospermum mopane	4 000 per hectare
5	Acacia mellifera	8 000 per hectare
6	Acacia mellifera	4 000 per hectare
7	Dichrostachys cinerea	10 000 per hectare
8	Acacia mellifera	5 000 per hectare
9	Terminalia sericea	8 000 per hectare

Photo 1: Bush Encroachment with about 10 000 stems/ha (Otavi area)



Fig. 1: Occurrence of Dominant Invasive Species in the Commercial Farming Areas of Namibia



Source: Bester, 1996



2.2.2 Encroacher Species

Although the problem of bush encroachment is discussed since decades in Namibia, the Government of Namibia (GRN) has not officially defined encroacher species. The national Planning Commission Secretariat (NPCS) published a list of encroacher species in 2010 which is, according to different experts, not complete. Therefore, based on NPCS, de Klerk (2004) and DECOSA (2013), the following species are defined here as encroacher species. They can be classified into three main groups:

- i. Dominant Encroacher Species
 - *Acacia mellifera* (black thorn)
 - *Acacia fleckii* (blade thorn/sand-veld acacia)
 - *Acacia erubescens* (blue thorn/yellow-bark acacia)
 - *Acacia reficiens* (false umbrella thorn)
 - *Catophractes alexandri* (trumpet thorn)
 - *Dichrostacys cinerea* (sickle bush)
 - *Terminalia sericea* (silver terminalia)
 - *Terminalia prunioides* (purple-pod terminalia)
- ii. Species with Localized Encroachment
 - *Acacia hebeclada* (candle-pod acacia)
 - *Acacia nebrownii* (water thorn)
 - *Acacia nilotica* (scented-pd acacia)
 - *Acacia senegal* (three hook acacia)
 - *Acacia tortilis* (umbrella thorn)
 - *Combretum apiculatum* (kudu bush)
 - *Colophospermum mopane* (mopane)
 - *Rhigozum trichotomum* (three thorn rhigozum)
- iii. Alien Encroacher Species
 - *Prosopis* sp (mesquite)
 - *Lantana camara* (lantana)
 - *Leucaena leucocephala* (wonder tree)

A particular issue of discussion is the classification of mopane as encroacher species. Mopane is very common over much of its range. It can be an aggressive invader species resulting in severe bush encroachment (see Photo 2). Therefore, mopane is classified as encroaching or problem species for example by NPCS, Strohbach (2000), de Klerk (2004), Christians et al. (NAU 2011), and even in the Draft Bush Encroachment Management Policy for Namibia (Dieckmann & Muduva, 2010). Programmes to combat the encroachment by mopane have been assisted within the CBEND (Combating Bush Encroachment for Namibia's Development) programme by the Desert Research Foundation of Namibia (DRFN) and the European Union. Despite the encroachment, mopane is also classified as protected species (see Annex 3) based on the Forest Act (GRN, 2001(b)). This is the reason why harvesting and processing of mopane has been banned recently by the Department of Forestry (DoF). Although cases of over-exploitation of mopane by the charcoal industry are known, this is an example of legal insecurity that may hamper investment in processing of invader species. Already Dieckmann & Muduva (2010) stressed that the "conflict should be resolved in the legislation, either by removing mopane from the protected species list or by setting firm criteria for its inclusion in the list, and applying appropriate measures relating to its utilisation. At the moment it is in a grey zone, without clear guidelines as to its conservation and use."



Photo 2: Bush Encroachment by Mopane



Another serious constraint for the utilization of encroacher species is the lack of information about the wood properties. Most species are described in detail in different publications (e.g. Roodt, 1998; Palgrave, 1996), but the wood properties have been ignored also by research institutions in South Africa, Europe and USA. The current knowledge is limited to the following:

- All species are hardwoods which are often very heavy with air-dried weights above 900 kg / m³, for instance sickle bush (960 kg / m³), umbrella thorn (990 kg / m³), scented-pod acacia (1100 kg / m³), kudu bush (1 230 kg / m³) and mopane (1 250 kg / m³). An exemption is the very common black thorn with a weight of only about 650 kg/m³.
- Considering the small diameters to be used, the bark content related to the wood is relatively high.
- Some information about the chemical and mechanical properties, which vary to a high extent between the species, can only be concluded from traditional uses. For example
 - most species have a limited bending strength in contrast to sickle bush which is traditionally used for making archery bows;
 - only some species are termite and borer resistant (e.g. black thorn, scented-pod acacia) which is an advantage for outdoor uses;
 - most species easily splinter in contrast to sickle bush and purple-pod terminalia which are for example traditionally used for implement handles and walking or digging sticks;
 - some species have a high resin/gum content such as false umbrella thorn, mopane, three-hook acacia, which may negatively affect certain end-use opportunities;
 - the bark, roots, leaves and sometimes the wood of several species are used in traditional medicine based on their chemical content; this applies for species such as false umbrella thorn, mopane, silver terminalia, candle-pod acacia, etc.

Scientifically confirmed information about the properties of the different encroacher species are a pre-condition for several potential uses in particular for end-uses with high value addition. Important are, for example wood dimensions, weight, strength, movement, drying capability, grain, resin and other contents, cutting/gluing possibilities, differences between sapwood and hardwood as well as bark content.

2.2.3 Institutional and Legal Framework

The current institutional and legal framework in Namibia is insofar of essential importance for the utilisation of encroacher bush as it defines not only the species that could be harvested (see Chap. 2.2.2) but also the quantities. It can be briefly summarised as follows:



a) Overall Policy and Legislation

Namibia has a comprehensive policy and legislative basis which directly or indirectly affects the harvest and utilisation of encroacher bush. This includes forestry, agricultural and environmental issues. The following legislative basis is important:

- Development Forestry Policy (2001),
- Forest Act (2001) as amended by Act No 13 (2005),
- Forest Permit System,
- National Agricultural Policy (1995),
- Soil Conservation Act (1969),
- Environmental Assessment Policy for Sustainable Development and Environmental Protection (1995),
- Nature Conservation Ordinance (1975),
- Nature Conservation Amendment Act (1996),
- National Drought Policy and Strategy (1997),
- Environmental Management Act (2007),
- Draft Bush Encroachment Management Policy (2004),
- Decentralisation Policy (1997).
- The main objective and aims concerning bush encroachment and its use include
- conservation of soil and water resources, maintenance of the biological diversity and use of forest produce in a way which is compatible with the forest's primary role as the protector and enhancer of the natural environment (Forest Act);
- protection of the environment, but also wise utilisation of the country's natural resources based on the principle of optimum sustainable yield (Environmental Policy and Legislation);
- addressing the problems of desertification and environmental degradation caused by the destruction of forest cover, soil erosion, overgrazing and bush encroachment (National Agricultural Policy);
- promotion and encouragement of the development and use of alternative sources of energy with a view to reducing harvesting pressure on Namibia's woody vegetation (Forest Act);
- creation of favourable conditions to attract investment in small and medium industry based on wood and non-wood forest raw materials (Development Forestry Policy);
- control of encroacher bush and exploitation of the full potential (National Agricultural Policy);
- support for combating bush encroachment (National Drought Policy and Strategy) including payment of subsidies and grants to meet the objectives of the Soil Conservation Act.

The legislative framework of Namibia is a promising basis for combating bush encroachment and for developing end-use opportunities with value addition.

b) Institutional Framework

From the political and legal framework it is obvious that combating bush encroachment and development is not centralised and different ministries are directly or indirectly involved, namely

- Ministry of Agriculture, Water and Forestry (MAWF),
- Ministry of Environment and Tourism (MET),
- Ministry of Regional & Local Government, Housing & Rural Development (MRLGHRD) and
- Ministry of Lands and Resettlement (MLR).



The DoF within the MAWF is responsible for the forestry sector in Namibia. It is the mission of the DoF to “practice and promote the sustainable and participatory management of forest resources and other woody vegetation, to enhance socio-economic development and environmental stability” (GRN, 2001a).

According to the “Development Forestry Policy” and the “Forest Act” tasks of the DoF, which are relevant for de-bushing, include:

- i. Securing of the principles and practices of forest protection or conservation.
- ii. Implementation of the strategy for community involvement in forestry in the whole country.
- iii. Forest research and provision of information for forest management, in particular, compilation and maintenance of a national forest inventory.
- iv. Provision of baseline data, and promotion of forest products and forest-based industries.
- v. Education and training not only of their own professional and technical staff, but also of the public for example with regard to the importance of adopting effective forest management practices.
- vi. Assurance that the forest practices by private forest owners are transparent and accountable and will respect all applicable laws.
- vii. Provision of harvesting and other permits as an important policy instrument to regulate the sustainable use of forest resources.

Due to lack of human and financial resources, the DoF focuses mainly on the provision of permits, establishment of Community Forest and with some limitations on fire prevention as well as protection of the forests. The numerous other tasks play a limited role and there is in particular still a serious lack of basic data, research, forest management plans, harvesting guidelines, etc. which are important for de-bushing.

Another matter of concern is the involvement of many institutions (e.g. MAWF, DoF, MET, MRLGHRD, MLR) in forestry and the lack of coordination and cooperation. The DoF as department of MAWF is responsible for the forestry sector, but has only limited power vis-à-vis other ministries. The Forestry Council, which was established in 2012 based on the Forest Act of 2001, could become a coordinating body but seems not to function in this regards. Therefore, a coordination unit was established on 1 April 2015 to be responsible for the implementation of the National Rangeland Strategy and thus for de-bushing (Anonymous, 24.2.2015).

c) Forest Management

Sustainable forest management and the commercial utilization of encroacher bush require detailed knowledge about the resources. However, for most areas of Namibia the current available biomass is not known due to the lack of inventories or at least resource estimates. Moreover, there is a serious lack of research on the growth rates of individual species. Due to these constraints, forest management plans are hardly existent. This has already been mentioned in the “Development Forestry Policy” in 2001 as the sector's greatest challenge. Similar challenges are faced specifically with regard to the use of encroacher bush. Despite the awareness of the serious problem of invader species, Namibia has only a “Draft Bush Encroachment Management Policy – 2004”. However, guidelines are effective as to how to deal with this specific issue.

Other constraints for sustainable utilisation of encroacher bush include:

- Lack of legal or regulatory basis for selective harvesting of trees or parts of them.
- Rivers, streams or water courses, where it is not allowed to harvest within 100m, are not defined.
- Lack of control of large scale harvesting including de-bushing, although Section 23 of the Forest Act states that no more than 15 hectares may be cleared on any piece of land or several



- pieces of land situated in the same locality and the removal of more than 500 cubic meters of forest produce from any piece of land in the period of one year without approval.
- The “Forest Act” does not consider chemical cobating of bush encroachment with the result that large areas are cleared of woody biomass without control including large or even protected species (see Photo 3).

Photo 3: Dead “Forest” Stand after Aerial Application of Chemicals (Kalkfeld)



d) Utilisation of Woody Biomass

The Forest Act (Part V) states that no forest produce may be harvested, damaged or destroyed unless it has been authorised by a management plan, forest management agreement or a licence/permit. This does not apply for the inhabitants on communal land. They may– subject to customary law – cut and remove forest produce for use as household fuel, for the construction of shelter for himself or herself or for his or her livestock or for the construction of structures used to protect his or her agricultural crop.

De-bushing is not regulated by any special law or regulation. Thus the Forest Act applies, i.e. for de-bushing of more than 15 ha or removal of more than 500 m³ a harvesting permit should be required. However, the fees for permits are only defined for saw logs, poles, rafters, droppers, wood for charcoal as well as for commercial crafts, i.e. not for many potential end-use opportunities of encroacher bush, such as chips and animal feed.

In addition to harvesting permits for the commercial use of wood and further processed products from encroacher bush marketing, transport and export permits are required, as far as relevant. Tariffs for export permits have been increased in December 2014 for processed wood from N\$120 to N\$300 per 30t load and for unprocessed wood products from N\$120 to N\$900.

Currently permits are the main policy instrument used by DoF to regulate private sector forestry activities in both commercial and communal areas. Harvesting guidelines complementing the permits are only available for Community Forests and partly for charcoal producers, who may not cut any tree with a diameter above 15 cm and must cut it less than 15 cm above ground. Clear guidelines are critical for the harvesting of any wood. They should include harvestable dimensions per species, a measurable definition for water courses, and regulations relating to fire risk management. Such guidelines should then form the backbone of an evaluation of harvesting practices on farms/communal areas and the producer’s compliance with them. They would supply DoF officers conducting inspections with a measurable form of evaluation.

With regard to the harvest of encroacher bush, the 2004 Draft Bush Encroachment Management Policy, de Klerk and the CBEND project have defined some special guidelines which can be summarised as follows:

- No complete clearing but only thinning (see Photos 4-6), e.g. to avoid negative effects on soil fertility.
- Main emphasis on thinning of smaller bushes/trees.
- Less thinning in areas where mopane and silver terminalia are dominant.
- Leaving 1-4 ha bush clumps with a diversity of habitats.
- Leaving a few large dead trees per hectare (at least two irrespectively of the species).
- No harvest on slopes steeper than 12% and only partially on slopes from 5-12%.
- Limited or no harvest on sensitive soils, especially sodic and duplex soils as they are highly erosive.
- Leaving fine material in the veldt to improve soil organic matter and moisture, and nutrient levels after mineralisation²⁾.

Photo 4: Bush Encroachment by Black thorn



Photo 5: Thinned Bush of Black thorn



Photo 6: Thinned Mopane Bush

²⁾ This may negatively affect for example the production of animal feed and compost.

2.2.4 Estimation of Available Biomass

Pre-condition for sustainable utilisation of the forest resources and for combating bush encroachment is the determination of the currently available woody biomass. However, this is complicated by the lack of data on forest resources in Namibia.

a) *Area Affected by Bush Encroachment*

Bester (1999) estimated an area of 17.5 million ha be affected by bush encroachment. The size of the area increased continuously. De Klerk (2004) estimated 26 million ha and Honsbein (Coleman, 3.10.2014) 29 million ha.

According to de Klerk, of the 26 million ha 15.7 million ha are on freehold farms and 10.3 million ha on areas of communal land tenure. This highlights the importance of considering both commercial and communal areas with regard to combating bush encroachment and converting the resources into valuable end-uses.

b) *Harvestable Biomass*

National inventories of the harvestable biomass of encroacher bush are not available, only of specific relatively small areas.

According to various studies, 8-18 t/ha of excess woody biomass can be harvested per ha for utilisation (de Klerk, 2004; Honsbein, 2009; Leinonen et al., 2008; DFN, 1997). However, related to the bush density (see Chap. 2.2.4), the variations are much larger. For example the CBEND Project estimated an undesired woody biomass between 8 and 30 t/ha, Rothauge 20 t/ha for Neudamm (personal information, March 2015) and Albat (DECOSA, 2013) 0.7 - 20.3 t/ha in the various wood-thickened zones of Bester (see Chap. 2.2.1) on commercial land considering only 14 invader species suitable for charcoal production.

Based on the different estimates an average harvest of 10 t/ha – as assumed by most experts – can be realistic considering harvesting rules for de-bushing as recommended in Chap. 2.2.3 (d). However the variations underline the need for inventories of the envisaged areas before investing in facilities of further processing, such as bricks and boards / panels.

2.2.5 Strengths and Challenges

A major strength of the resources from encroacher bush for commercial utilisation is the huge quantities. Based on assumed 26-30 million hectare and a harvest of 10 t/ha on average, the encroacher bush offers theoretically 260-300 million tonnes of biomass. Positive is also the legislative framework, which is a promising basis for combating bush encroachment and for developing end-use opportunities with value addition. Moreover, the recent establishment of a coordination unit responsible for the implementation of the National Rangeland Strategy and thus for de-bushing will hopefully strengthen future actions to combat bush encroachment.

These strengths have to be seen in the light of several challenges which are man-made or based on the nature of the encroacher bush. The following challenges are most important for de-bushing and utilisation of the biomass:

- Encroacher species are not clearly defined and the classification of protected species is not sufficiently transparent. This creates insecurity, e.g. regarding the utilisation of mopane.
- Lack of baseline data, e.g. regarding the quantities of invader species and their growth rates, may affect the sustainability and larger investments for processing.
- The lack of a regulatory basis for selective harvesting and the absence of harvesting guidelines for de-bushing are the major constraint for serious investments in the utilisation and processing of encroacher bush.



- Disadvantages of encroacher bush compared to other industrial wood resources include
- the mixture of hardwoods from different species with mechanical and chemical properties which vary to a high extent;
- the dimensions of the woody biomass which are fairly small (up to 20 cm diameter, normally up to 5 m long); branches and small dimensional stems are dominating;
- the species are often very heavy hardwoods;
- the bark content is relatively high and de-barking may financially not be viable;
- the lack of knowledge about properties of individual invader species which are important for end-use opportunities such as strength, movement, drying capability, grain, resin and other contents, cutting/gluing possibilities, differences between sapwood and hardwood as well as bark content.



3. ASSESSMENT OF POTENTIAL END-USE OPPORTUNITIES

3.1 Theoretical Uses of Encroacher Bush

The Namibian encroacher bush consists of wooden trunks (often multi-stemmed) with small diameters (up to 20 cm), even smaller woody stalks and leaves. Whilst the stalks and leaves could remain as natural fertilizer in the field or be converted into animal feed, the woody material can be the basis for numerous uses. Without considering the lack of knowledge about the properties of the invader species and their mixture (see Chap. 2.2), the theoretical uses are mainly restricted by the small diameter.

Tab. 2 includes the identified products considering international best practices and research as well as traditional uses and opportunities discussed in Namibia. The products are divided into two groups:

- i. 26 products requiring large quantities of resources, considering the aim of the De-Bushing Project to upscale de-bushing, i.e. the main focus should be on products which can really contribute to harvesting on millions of hectares.
- ii. 15 products which can be produced only in small quantities, but may add considerable value on parts of the wood and create new SMEs and employment.

Namibia has very limited experience regarding the identified end-use opportunities on the basis of encroacher bush:

- Actually produced on economic scale are only compressed wood, charcoal and wood chips; however, with the exception of charcoal in smaller quantities.
- Commercial experience on very small scale – as additional income for communal and commercial farmers – is available regarding the marketing of fire wood and poles.
- Several people (mainly commercial farmers) produced from invader species individually on experimental scale, bricks from wood and charcoal, wood-plastic composites, animal feed, mulch and compost. However, only the last two products are sporadically and informally marketed.
- In the Kavango and Zambezi Regions also timber and furniture were produced as well as carved products by hundreds of carvers; however, on the basis of larger logs and not from encroacher bush. The same applies for most traditional medicine.
- A small plant for electricity generation from bio-gas exists between Outjo and Otjiwarongo, but is after four years still not operating.
- Some research (e.g. at Polytechnic) and/or studies are available regarding the use of Namibian encroacher bush, e.g. for pellets, bio-ethanol and bio-char.
- Other products have been discussed as opportunities to use invader bush, but not really investigated; this includes for instance bio-oil, particle boards, wood-sand boards, tooth picks, spatulas etc.
- The other products identified are new opportunities for the use of Namibian encroacher bush.



Tab. 2: Theoretical Uses of Namibian Encroacher Bush

Large-scale Uses	Small-scale Uses
<p><i>Residential Wood Fuel</i></p> <ul style="list-style-type: none"> • Firewood • Compressed Wood³ • Charcoal (by-products) <p><i>Industrial Heat & Power Generation</i></p> <ul style="list-style-type: none"> • Chips • Pellets • Bio-gas • Bio-oil • Bio-ethanol <p><i>Construction</i></p> <ul style="list-style-type: none"> • Timber • Poles • Wood-cement bricks • Wood-charcoal bricks • Wood-clay bricks <p><i>Boards / Panels</i></p> <ul style="list-style-type: none"> • Wood-cement boards • Wood-sand boards • Particle boards • Oriented Strand Boards (OSB) • Medium Density Fibre Boards (MDF) • Gypsum-bonded fibre boards • Wood-Plastic Composites (WPC) • Blockboards • Furniture <p><i>Agriculture</i></p> <ul style="list-style-type: none"> • Animal feed • Compost • Bio-char <p><i>Paper Products</i></p>	<ul style="list-style-type: none"> • Parquet • Shingles • Wooden frames • Kitchen boards • Transport boxes, crates, pallets • Carving • Tooth picks • Spatulas • Ice cream sticks • Sostie sticks • Sticks/handles for tools • Wood glue • Traditional medicine • Smoking/Aromatic material • Mulch for gardening

³ Also used for industrial heat and power generation.



3.2 Residential Wood Fuel

Currently the use of the woody biomass as residential fuel for cooking and heating is undoubtedly the most important value chain in Namibia. It includes the use as firewood, compressed wood and charcoal.

3.2.1 Firewood

Firewood is still the most important energy source in developing countries. According to the Food and Agriculture Organisation (FAO) of the United Nations, the world production reached 1.8 billion m³ in 2013 and Africa was producing nearly 650 million m³.

a) Current Operation in Namibia

Firewood is mainly produced informally by the rural population for own use (cooking and heating). Therefore, no statistical data are available. However, it can be assumed that many rural households produce firewood. Based on a total number of 236 000 rural households (NSA, 2013) and its number in regions where woody resources are available, it can be roughly estimated that 100 000 households are involved in firewood production. There are limited formal businesses producing firewood, but the product is sold by numerous producers in communal areas and by some commercial farmers.

With regard to the value chain, the following applies for firewood:

PRODUCTION

Preferably dead and thus dry wood is used as firewood in Namibia. It is mainly collected manually and cut into the required lengths (again manually), if necessary.

In densely populated northern areas with scarce forest resources or if the firewood is marketed, also live plants are harvested, sometimes split and then cut into lengths by using pangas and axes. Only a very few commercially oriented producers use chain saws for harvesting and cutting into length (or even small circular saws).

MARKETING CHAIN

Most producers in communal areas market firewood in smaller pieces along the main roads. Very few producers add value by packaging in plastic bags. Attempts by foreign donor agencies to formalise the sales of firewood with respective packaging and marketing are known to have failed after withdrawal of the donors (e.g. in Community Forests in Kavango).

Some commercial livestock farmers produce firewood as by-product with respective packaging.

Most of the firewood is also transported to the markets informally, i.e.

- end-consumers from urban areas buy it along the roads and transport it in their private cars or
- truck drivers load the wood on their empty trucks from the north and transport it to the main markets in central Namibia and at the coast or
- farmers transport it with their own vehicles to the markets.

In informal settlements of urban centres, the firewood is mainly sold loose by pieces. Moreover, supermarkets and petrol stations in urban areas sell firewood in 10 kg bags.

The firewood is used by lower income groups mainly for cooking and heating and by higher Namibian income groups for barbeque and heating at open fireplaces.



b) Resources

In principle all species can be and are used as firewood, although heavy species like mopane are preferred.

The harvest of life wood is a challenge not only in the northern areas, but also with regard to commercial production. Preferred is wood of stronger dimensions (e.g. 20 cm diameter) from heavy species. Thus, for example mopane is offered even by formal retailers although this species is protected. Only a small portion of the firewood derives from encroacher bush, mainly as by-product of de-bushing on commercial farms.

c) Demand Market in Namibia

The demand of firewood is, due to the informal production and marketing, very difficult to estimate. According to Rothauge (2014) about 440 000 t of wood is used annually, whilst the FAO (2014) estimates about 820 000 m³ (i.e. with an average weight of 800 kg/m³ 656 000 t) and UNDP/MET (2007) even 1.02 million m³ (i.e. 816 000 t). According to NSA (2012) firewood is used as follows⁴⁾:

- a) For heating by
 - 46.3% of all 465 000 households, i.e. 215 000 households
 - 17% of the 229 000 urban households, i.e. 39 000 households
 - 74.7% of the 236 000 rural households, i.e. 176 000 households
- b) For cooking by
 - 53.7% of all 465 000 households, i.e. 250 000 households
 - 20.2% of the 229 000 urban households, i.e. 46 000 households
 - 86.2% of the 236 000 rural households, i.e. 203 000 households

To cook one meal, about 2.5 kg of firewood are used according to investigations of DECOSA, i.e. 250 000 households require 625 t per day or 228 000 t p.a. for only one meal per day. It is estimated that one household requires 10 kg of firewood for heating, i.e. 2 150 t per day for 215 000 households. Assuming a heating period of 90 days, the annual demand would total 193 500 t. The total matches the estimate of Rothauge, whilst with two meals per day the figure of UNDP/MET appears to be realistic. Considering the leisure demand of higher income groups and that some households have more than one meal per day a total demand of 550 000 t p.a. is assumed to be a realistic minimum.

Although the future demand may be reduced by the rural electrification programmes, the effect will be minimal if not combined with higher income because the rural population often collects firewood for free. Moreover, the demand will increase with population growth and with the continuation of the migration from rural areas to urban informal settlements.

The price of firewood varies considerable from N\$1 700 per ton in Kavango to N\$3 000 per ton in Katutura (based on informal retail prices). Thus firewood is as expensive as charcoal for exports. This is one reason why people in informal settlements can often only afford one meal per day.

d) Effects on De-bushing

Based on an annual demand of 550 000 t p.a. and a harvest of 10 t/ha of encroacher bush 55 000 ha would be de-bushed p.a. if the harvesting and marketing are formalised.

Currently the effects on de-bushing are negligible since most of the firewood is either dead wood or not harvested in areas affected by bush encroachment.

⁴⁾ Figures rounded.



e) *Major Strengths and Challenges*

- Strengths
 - High acceptance as cooking and heating material.
 - Cost free energy source for most of the rural population.
 - Also mixed species suitable.
 - Vast majority of producers from previously disadvantaged background.
 - Labour intensive; no skills required.
 - Very low investment.
 - No additional inputs (e.g. water, electricity) required.
 - High local demand (ca. 550 000 t p.a.).
 - High value addition if marketed in urban centres.
 - Theoretical potential to de-bush 55 000 ha p.a.
- Challenges
 - Hardly any formal value chain.
 - Contribution to de-bushing currently negligible.
 - Harvesting in environmentally sensitive areas and even of protected species.
 - Very limited employment creation.
 - Limited value addition and income generation of the producers.
 - High prices for end-consumers who have to purchase firewood.
 - Low energy efficiency.
 - Increasing demand of low income groups in informal settlements of urban centres.

f) *Prospects of Firewood in Namibia*

Firewood has and will in future have a stable demand in Namibia. However, the current form of harvesting live wood also in densely populated areas not affected by bush encroachment will result not only in the depletion of scarce resources, but also in further increases of prices which are nowadays already hardly affordable by main buyers of firewood, i.e. the poor segment of the population in informal urban settlements.

In order to avoid such developments and to contribute to combating bush encroachment, the firewood value chain should be as much as possible formalised. This requires a set of measures:

- Continue education programmes of the rural population to avoid informal harvesting of scarce resources and protected species.
- Monitor illegal harvesting and enforce the law.
- Consider a harvesting ban for firewood in endangered areas, but respecting the rights of Traditional Authorities.
- Mobilise entrepreneurs to start formal firewood businesses based exclusively on encroacher bush; this will also contribute to avoid further price increases for end-users who have to purchase firewood.

3.2.2 Compressed Firewood

This product group is known internationally under a number of different names such as wood or biomass briquettes, biomass logs, extruded wood logs or heat logs. Namibian products are known as “Bushbloks” or “Ecologs”. Despite different production technologies they are all made by fine grinding of wood chips and subsequent compacting of the dry untreated biomass.



a) Production Process

A typical production process after harvesting of the wood consists of the following steps:

- The wood is first dried in the forest and then fed into mobile, mechanical chippers or directly chipped using automatic harvesting machines with combined chipper.
- The chips are transported to the processing plant for fine grinding to approximately 6 mm. This step, mostly done by a hammer mill, is necessary for further particle size reduction and a homogenous particle size distribution. This leads to a better subsequent compacting, so that the compressed firewood can easily be pressed.
- From the hammer mill the chips are transported via conveyor belts to a sieve to eliminate wood of unsuitable sizes, sand etc. Thereafter it is dried to 4-8% in order to produce high quality final products and to increase the calorific value. Drying is done in open sheds or better by horizontal rotating drum drier or in drying chambers before storage in silos.
- The core machine is an extruder press. By the use of pressure and heat which causes the natural lignin, cellulose and hemicelluloses in the product to form a natural binder, the chips bond and are extruded as compacted product.
- The product of a continuous length has to cool down and is cut by a saw into the required length. Typical dimensions of compressed firewood are 20x6x6 cm with a weight of 0.8-1.0 kg per piece.
- Finally the pieces are assembled into the required number of units, labelled, bundled and shrink-wrapped. The individual units may then be palletised and shrink-wrapped onto the pallet ready for shipping.

The capacity of the plant is mainly determined by the extruder press. Technologies are known with capacities from 5 000 to 50 000 t p.a. output.

b) Uses and Product Properties

The compressed firewood is mainly used for heating but also to a limited extent as substitute of firewood or charcoal. However, also industrial uses instead of wood chips or pellets might be possible.

The aim of compressing is a higher bulk and energy density compared to biomass chips, so that transport costs can be reduced and the combustion behaviour can be improved (long intense burning). The bulk density of compressed firewood is usually in the range of 450-500 kg/m³ and the energy density in the range of 5.2-7.4 GJ/m³ (STEAG, 2013). As result of the extrusion process, the product has a calorific value of some 4 870 kcal approaching coal (Bushblok, n.y.) Other positive properties include:

- International classification as “smokeless fuel” (NDC, 2002; Bushblok, n.y.).
- High density and thus much longer burning time than wood (up to one hour per block).
- Excellent glowing without open flame.
- Clean to handle and relatively easy lighting.
- Easy to pack.

In addition, the low ash content of 0.35-0.5% is mentioned by some producers as further advantage (Bushblok, n.y.). This is true compared to wood and wood chips; however, it is also a major disadvantage. Several countries have national standards. Namibian invader bush cannot comply, for example with each parameter of the European “ENplus” standard with regard to ash, chlorine, sulphur, arsenic and mercury content, but competes in terms of the remaining 11 other parameters of these standards. According to STEAG (2013), this should not be a problem for the marketing opportunities in Europe, because such a certificate is admittedly helpful but not absolutely required for the marketing. The standards act as quality proofs for the end-users so that the end-user can be sure that the



products contain no pollutants which could possibly endanger the oven (e.g. corrosion) and/or the human health. However, the non-compliance with all parameters is a risk for marketing to private consumers, but they do not apply for industrial uses.

c) Resources

Based on experience in Namibia, there seem to be no restrictions in the processing of specific species. Mixed invader bush, although dominated by acacia spp, has been processed successfully. Moreover, the heavy Namibian species have an advantage, vis-à-vis compressed firewood from other countries.

Although only woody parts of the invader species shall be used, the bark content seems to have no negative effect. It is an added advantage that the finer branches of bushes that are not suitable for the production of charcoal can be used.

The raw material losses during the processing are minimal. According to NDC (2002), at a production capacity of 6 220 tons of extruder wood per annum, the total requirement of raw material will be about 7 000 tons.

d) Experience

In addition to experience in Namibia with exports to RSA (see (e)), numerous countries produce compressed firewood with slightly different technologies since decades. For example a Japanese company developed the technology utilised in the manufacturing of the compressed firewood in the 1950's. The plant developed is long lasting; there are plants operating in Asia that are already more than 30 years old. In 1980 the company made the technology available to the West and plants were commissioned in Europe, Russia, South Africa and northern Africa (NDC, 2002).

The main challenge faced by producers in industrialised countries is the continuous availability of inexpensive wood residues in large quantities.

e) Current Operation in Namibia

Two Namibian companies are involved in the industrial production of compressed firewood:

- The Cheetah Conservation Fund (CCF) is harvesting encroacher bush as one measure to ensure the survival of cheetahs and of their ecosystem. In 2001 the CCF started research to find a habitat improvement programme that would be ecologically and economically viable. As a result the CCF Bush (Pty) Ltd was established to manufacture "Bushbloks" (see Photo 7).
- "Ecolog" has established a more sophisticated plant with main focus on overseas exports. Due to some technical problems (see below), but mainly because of the ash content of 3% which does not comply with the European standards, they are still in an experimental stage.





Photo 7: Bushblok

With regard to the value chain the following applies for the two Namibia products:

HARVESTING

Currently the material for Bushbloks is harvested only manually. Although they have some mechanised harvesting machines, for social reasons (employment creation) and because of technical problems (e.g. maintenance) they are hardly used.

For Ecologs sophisticated harvesters are used, cutting the bush with large secateurs.

PROCESSING

The processing of both companies follows in principle the production process as described under (a). However, both companies experience some challenges:

- Similar to other producers of wood chips, all different types of chippers are a matter of concern since they seem not to be adapted to the hard and heavy species from Namibian encroacher bush, whilst the hammer mills for fine grinding face no major problems.
- The main challenges regarding the extruder is the sand in the woody material. This is assumed to be one reason for interruptions of the production. For example, under normal circumstances, two of the three machines of CCF Bush are in operation, but during visits in 2011 and 2015 by DECOSA none was running. This problem is also not solved in the production of Ecologs, although they included in the production line a cyclon to eliminate the sand as far as possible.
- Remarkably, the sand seems not to affect the quality of the end-product as demonstrated by the demand for Bushbloks which cannot be satisfied by the current production. The company has a capacity of 6 000 t p.a. but produces only 500 t. Reasons seem to be not only the abovementioned technical problems, but – even more important – the lack of professional staff, since the production is seen as a sideline of the cheetah conservation. Thus the company is not profitable, but survives with donor funding that included also the initial investment of US\$1 million.



The Ecolog production, which is more sophisticated, has a capacity of 4 t/hr based on an investment of N\$5 million (excluding harvesting equipment).

► *FINAL STEPS OF PRODUCTION*⁵⁾

After cooling and cross-cutting, the Bushbloks are shrink-wrapped and labelled in packets of 10 pieces.

► *MARKETING CHAINS*

Bushbloks are mainly marketed in South Africa and in smaller quantities on domestic markets in urban centres. They are transported on pallets by forwarding agents to

- one major buyer (wholesaler) in Cape Town, and
- to retailers in Namibia, such as supermarkets and hardware stores.

f) *Employment and Skills Requirements*⁶⁾

Presently Bushblok employ 10 people (1 skilled) in the factory and the General Manager of the CCF is also responsible for the overall supervision of the production.

Manufacturing of compressed firewood requires a full-time overall manager, who is also responsible for marketing, and a technician for operation and maintenance. Such professionals are in particular important because of the limited technical experience with the production based on Namibian hardwoods and since compressed wood is a relatively new product in Namibia that requires professional marketing.

g) *Demand Markets*

For such a specialised, relatively new product, neither national nor international trade statistics are available. Therefore, the demand can only be roughly estimated and often not quantified based on little available secondary information, experts' opinions and limited research of DECOSA. The demand estimates have to distinguish between the domestic markets, markets in neighbouring countries and overseas markets, considering residential and industrial end-users.

NAMIBIAN MARKETS

Currently Bushbloks are nearly exclusively used by higher income groups for heating due to the longer burning time compared to firewood. Although the demand is still small, it often exceeds the supply in cold winter times. The main competitor is firewood, which still is much more important even at higher income groups in towns because in open fire places the consumer prefer flames. However, access to firewood will become increasingly difficult for urban consumers.

So far Bushbloks are rarely used for cooking. The majority of lower income groups get the competing firewood for free (in rural areas) and are not informed about Bushbloks. Higher end income groups prefer wood over Bushbloks for barbeque, because they are used to it and rather want an open fire also for cooking than a flameless fire. However, demonstrations by the Worcester Polytechnic Institute (WPI, 2006) and DECOSA (2013) showed that consumers in Namibia are willing to try Bushbloks, in particular informal food producers (kapanas).

The local market of private consumers could be developed with respective education and marketing, which is currently totally lacking. It must focus on the advantages vis-à-vis firewood, such as higher calorific value, less smoke and ash, longer burning time. Since the price is, with about N\$30 per 10 kg, competitive, even illiterate owners of kapanas realised the financial advantages over firewood during the demonstrations, considering the burning time of Bushbloks. It is also an advantage that Bushblok

⁵⁾ Does not yet apply for Ecologs.

⁶⁾ Excluding harvesting.



could be supplied continuously, independently of the weather (packed in plastic wrap) whilst wood supply is often inconsistent (e.g. in the rainy season).

If such markets are opened, STEAG (2013) estimates a potential of 50 000 t p.a. for domestic use. Moreover, on longer term it might be possible to penetrate, in addition, private low income groups for cooking and heating with respective education in particular if the firewood prices are further increasing.

With regard to the industrial market in Namibia, on behalf of CCF Bush, WPI (2006) investigated industries that utilise boiler system. They recommended avoiding this market because

- the energy density of a Bushblok is too low for biomass-only firing;
- co-firing in oil-fired boiler systems would change their computer automated nature and require an extremely expensive retrofit;
- boiler systems require quick-burning fuel to produce the desired amount of steam pressure per hour; extruded Bushblok fuel logs are compact and slow burning in nature and thus the heat release rate of these logs is not suitable for any type of boiler system;
- raw chips are more suitable for coal co-firing applications, but further investigation must be conducted before they can be recommended for use as a co-fired fuel.

Although in principle these constraints are shared by experts, industrial uses for biomass-only firing and co-firing with coal may have prospects. The decisive factors are the costs, in particular transport costs (see (h)), but it must also be considered that the production costs can be reduced since specific lengths, quality control, packaging etc. are not required compared to residential uses.

► MARKETS IN NEIGHBOURING COUNTRIES

The demand in neighbouring countries and the competitive advantages are demonstrated by the export of Bushbloks to South Africa where they are used for heating but also for barbeque. This demand is insofar remarkable as the country also produces compressed firewood. The only explanation can be the better burning properties based on the Namibian hardwoods. The currently small exports of a few hundred tons – based on the small production of CCF Bush – could be remarkably increased by intensive marketing. Moreover, if attempts to market compressed firewood to lower income groups in Namibia are successful, the same target group may be penetrated in neighbouring countries if the prices are competitive⁷⁾ which requires detailed market investigation. NDC (2002) estimated already more than 10 years ago a potential market of 200 000 t p.a.

Additional markets could be higher private income groups, but also industrial users in other neighbouring countries. These market segments have so far not been considered but demand is assumed, for example in Botswana, (due to the extremely limited woody resources) and in the Zimbabwean tobacco industry.

OVERSEAS MARKETS

According to NDC (2002), the major export markets with regard to private users are believed to be the European countries. Most important in Europe would be the UK, Germany, Benelux, Italy, Norway, Austria and France. Since 1996 the South African producers of compressed firewood have focused their consumer education on the UK market, where the demand for heating was estimated to be as much as 360 000 t p.a.

European countries cannot satisfy their demand and are dependent on imports. This explains also the high prices of for example in Germany N\$3 600-4 000⁸⁾ (DECOSA investigation) and even up to N\$6 000 per ton (STEAG, 2013). The private market in Europe is promising due to the advantages of

⁷⁾ Prices are with N\$30-50 per ton in RSA higher than in Namibia (STEAG, 2013).

⁸⁾ Based on 13.3N\$ = 1€.



Namibian compressed wood (purely natural, smokeless, flameless⁹⁾), however, detailed market investigation is required including transport costs and market price differences, quantities, competitors and in particular if and in which countries it is accepted that Namibian compressed firewood does not comply with all parameters (e.g. ash content) of the quality requirements.

Even more promising could be the industrial market due to the increasing demand for bio-fuel and because the strict quality requirements do not apply. Even the large German energy producer RWE showed interest in supply from Namibian compressed wood, but this did so far not materialise since Namibia could not supply the required large quantities. Moreover, as for the Namibian industrial market, the transport costs may be a restricting factor.

h) Transport Costs

Due to the overriding importance of the transport costs, in particular for industrial mass supply, they are estimated in the following, which is only a model calculation based on standard cost not considering possible options (see below):

BASIC ASSUMPTIONS

- Transport distances
 - 400 km transport on road for export to Walvis Bay by truck¹⁰⁾
 - 300 km transport on road for domestic market in Windhoek by truck
 - Shipping from Walvis Bay to Hamburg/Germany.
- Packaging
 - 50kg bags on trucks
 - 50kg bags in 40 foot container for shipping
- Transport volumes / weight
 - Weight: 550 kg/m³ 1t = 1.8 m³
 - 40 foot container: Maximum weight 28 t
 - Maximum volume 60 m³
- Maximum container packaging 28 t or 50 m³

MODEL FOR DOMESTIC MARKET

COSTS IN N\$ / T (ROUNDED)

- 300 km transport to Windhoek
 - N\$13 per running km (30 t truck)
 - 600 km (return trip) x N\$13=N\$7 800

TOTAL N\$ 260.00

MODEL FOR EXPORT MARKETS

COSTS IN N\$ / T (ROUNDED)

- 400 km transport to Walvis Bay
 - N\$13 per running km (30 t truck)
 - 800 km (return trip) x N\$13=N\$10 400

N\$ 350.00

- Port handling in Walvis Bay N\$ 100.00
- Shipping to Hamburg¹¹⁾ N\$ 650.00
- Port handling in Hamburg N\$ 200.00

TOTAL N\$ 1 300.00

⁹⁾ In contrast to Namibia flameless fire is preferred for barbeque.

¹⁰⁾ Railway is only slightly cheaper, but less reliable and requires additional transport by truck to the railway station.

¹¹⁾ Based on an exchange rate of N\$10 equals to US\$1.



MODEL OF FINANCIAL VIABILITY

	Local	Export
○ Production costs per ton	1 500.00	1 500.00
○ Transport costs per ton	260.00	1 300.00
○ Sales prices per ton ¹²⁾	2 100.00	4 000.00
○ Margin	340.00	1 200.00

The above model calculation demonstrates the importance of the transport costs for the exports.

With regard to the transport costs there are still several options which can influence the costs and thus the viability; they must be investigated in detail. For example:

- Using trucks which return empty from the North. This would reduce the costs for land transport by about 30%. However, the availability may be a matter of concern¹³⁾.
- Using railway wherever possible.
- Loading at the site into containers to reduce the loading and unloading costs.
- Transport in large sling bags (up to 1 t) or even loose in containers.
- Using part-charter vessels which are available in Walvis Bay for 5 000-7 000 t per shipment (STEAG, 2013). This would reduce the ocean freight and may be one reason that wood chips are transported currently from South Africa to Japan for only N\$450 per ton.

Other issues to be considered are

- the exchange rates (international transport is calculated in US\$),
- the storage time and costs at Walvis Bay,
- the availability of 40 foot containers in Walvis Bay, which sometime is a matter of concern, and
- the incentive for foreign investors of a rebate of 25% on local transport.

i) Effects on De-bushing

Currently the production of compressed firewood contributes to de-bushing only in the area where the CCF operates. For an annual production of 500 t Bushbloks, 560 t¹⁴⁾ of wood are required. Based on harvestable quantities of 10 t/ha, only an area of 56 ha would be de-bushed per annum.

The production of compressed wood could only contribute to de-bushing if it is considerably increased. With the estimates of the market prospects in Namibia and neighbouring countries, up to 30 000 ha p.a. would be required. A real large scale contribution to de-bushing is, however, only possible if the industrial market is penetrated particularly in Europe. In addition to the financial challenges, it must be considered that in this case compressed firewood has to compete with wood chips and pellets.

j) Major Strengths and Challenges of Compressed Firewood

STRENGTHS

- Also mixed species and wooden parts of the bush with small diameters suitable, i.e. combination with other uses (charcoal, poles) possible.
- Production also in small capacities (e.g. 5 000 t p.a.) possible.
- Good properties of the final product (natural without additives, limited smoke, not burning with flames, high calorific value, long burning time); better than compressed firewood produced in RSA and than firewood as well as wood chips from Namibia.

¹²⁾ N\$ 3000 retail price - 30% margin for retailer.

¹³⁾ One of the largest transport companies can assure 10 trucks (30t) at fixed times per week.

¹⁴⁾ 12% losses during production.



- Only electricity as additional input required and packaging material for private end-users.
- Demand in Namibia, neighbouring countries and Europe.
- Contributions to de-bushing on large scale possible if the market of industrial users (interest in Germany) can be penetrated.

CHALLENGES

- Serious technical problems with chippers (not adapted to Namibian species) and extruders (sand in raw material).
- Contribution to de-bushing currently negligible (about 56 ha p.a.).
- Only two production units in Namibia, one not in full operation yet, one producing and even exporting but with a capacity utilisation of under 10%.
- Lack of professional staff and marketing of the current Namibian producer.
- Namibian end-products do not comply with all requirements for European private end-users (e.g. regarding ash content).
- Industrial use doubted by some experts.
- Possible future larger operations create limited employment and require professionals (management, technical operation and marketing).
- Large scale production for industrial end-users competing with wood chips and pellets.
- Overseas exports only possible with customised logistics concept, still to be identified.

k) Prospects of Namibian Compressed Firewood

The current small production demonstrates a demand of private end-users from higher income groups in Namibia and RSA, mainly for heating. This demand could be considerably increased by marketing, which hardly exists. In addition, micro entrepreneurs in urban centres involved in food processing (e.g. kapaņas) signalled interest to substitute firewood due to the longer burning time and thus lower costs. Also the lower income groups in the informal settlements could become customers; however, this requires comprehensive education and marketing. Provided such measures are successful in Namibia, they could be extended to the same target groups in neighbouring countries.

Also the market of private consumers in Europe shows positive prospects. A constraint may be the quality requirements; most parameters are more than fulfilled by compressed wood from Namibia, but not all. Before starting attempts to penetrate this potentially huge market, detailed market research is required, including investigation why Namibian products have relatively high ash content and how strict the different countries are with regard to all the quality requirements.

The industrial market in Namibia and overseas could be another option, since compressed wood has competitive advantages regarding the properties compared to wood chips. It is remarkable that one of the largest energy producers in Europe signalled serious interest to import from Namibia. However, this could not be materialised due to the small existing capacities.

Independently of the different market segments, the in principle excellent prospects may be hampered by the technical problems with chippers and extruders as well as by the transport costs. Therefore, the following initial measures are recommended:

- Mobilisation of international specialists to solve the technical problems (in particular regarding the sand content), which must be possible.
- Detailed investigation about different options of transport to determine the costs of the optimal option.



Thereafter, a comprehensive feasibility study is required including an analysis of the competitiveness of compressed firewood for industrial uses versus wood chips and pellets.

3.2.3 Charcoal

Charcoal production is of overriding importance in Namibia. It is the main contributor to de-bushing and the only real industry (mainly for exports) based on invader bush.

a) Production Process

Charcoal is produced from solid wood of different dimensions (preferably 10-20 cm diameter) with processes known already in the Egyptian Empire. The wood is heated resulting in partial combustion, whereby in addition to charcoal a variety of volatile substances, such as wood gas, acetic acid and wood tar can be obtained.

There are a variety of technologies for the production of charcoal, ranging from simple earth kilns to automatic distillation plants. The various processes can be divided according to their fundamental principle into kiln or retort processes. The kiln process involves production of the necessary process heat by the wood charge itself, whilst in the retort process the heat is applied externally. The term “kiln” is to be understood as the container, in which the energy source for converting wood into charcoal is provided by burning some of the wood.

b) Products and Uses

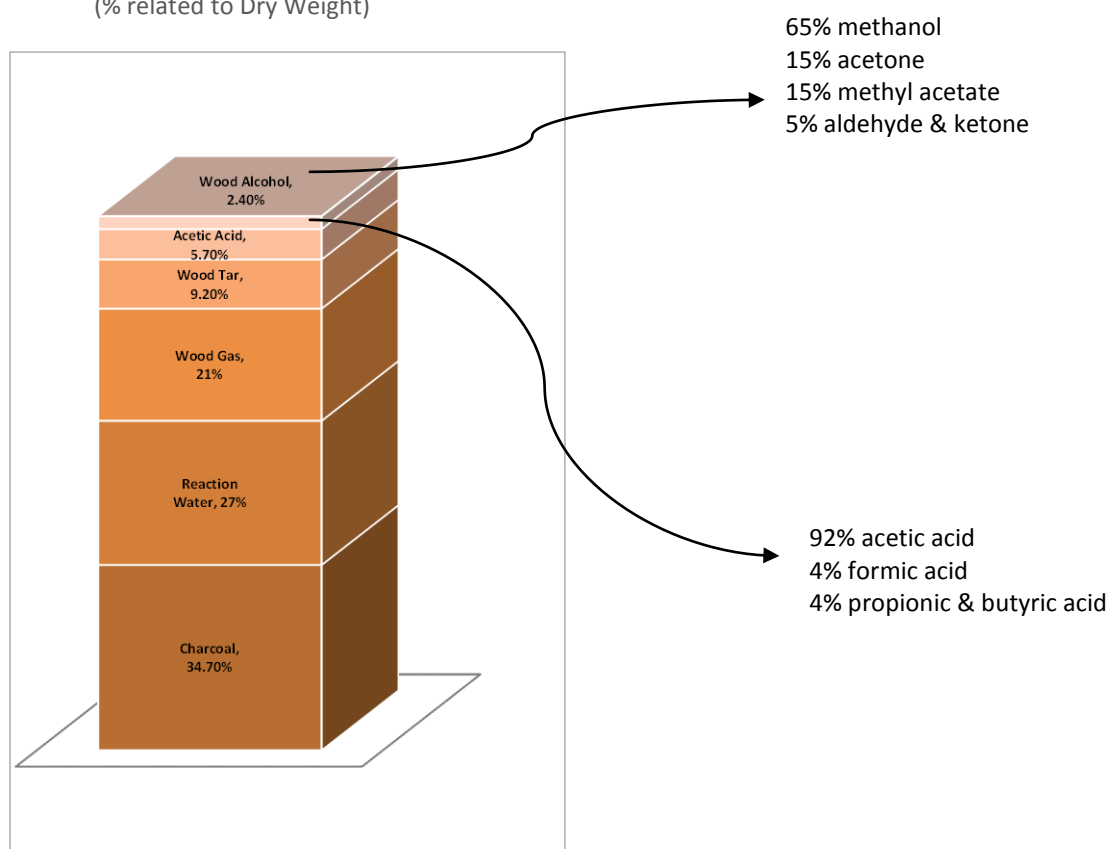
The products, which result from the carbonisation of wood, are shown in Fig. 2. The main product, charcoal, is used mainly for food preparation (traditional and barbequing), pig iron (e.g. in Brazil) and silicon production (e.g. in China). In addition, charcoal has many other applications, for example the dust is used for making briquettes, as additive to animal feed, for lining of moulds in metal foundries, as cementation granulate and in the pharmaceutical industry.

The by-products can be used for energy generation (wood gas¹⁵⁾), food preparation (wood tar as aromatic addition for smoking) as well as in the chemical industry (alcohol, acid).

¹⁵⁾ See Chap. 3.3.2.



Fig. 2: Products Resulting from of Hardwood Carbonisation
(% related to Dry Weight)



Source: ATLANTA, 1978

Remark: Percentage varies by wood species and process

c) Resources

Charcoal can be produced from wood but also from agricultural residues (e.g. coconut shells) and for example bamboo (e.g. in China). Wood is, however, the most common and suitable raw material. In principle all wood species are suitable for charcoal production. However, heavy hardwoods – as they are common in Namibia – result in the best charcoal qualities for barbecuing. Carbonisation of mixed species from de-bushing is common in Namibia. Although separate carbonisation of species with different weights would result in higher yields, it is doubted that the costs for separation will be covered by the additional yields.

Considering Namibian invader bushes, yields and qualities are to a lesser extent influenced by wood species than by the humidity and dimensions of the raw material. Most Namibian producers carbonise fresh wood, although it reduces the yield. The same applies for the use of mixed diameters since the optimal carbonisation time is related to the wood diameters. If wood is separately carbonised by diameters, theoretically also the smallest branches can be converted into charcoal. However, the market (mainly for barbecue) requires larger charcoal (Grade 1 = above 20mm, Grade 2 = 13-20mm). Therefore, and because larger resources result in larger production quantities, the industry focuses on larger raw material, sometimes even above the allowed maximum diameter. However, smaller charcoal can be processed into briquettes as done in South Africa but not yet in Namibia.

d) Experience

Charcoal production is known and applied world-wide with different technologies. For example, the large producers in South America use mainly huge stationary brick kilns based on plantation wood, whilst African producers use small mobile kilns from steel or (even nowadays) simple earth kilns.

Retorts have been used in industrialised countries, where charcoal is hardly produced anymore, but they are for example applied in the most important Asian production countries, i.e. India and China.

e) Current Operation in Namibia

Charcoal plays the most important role in using and processing wood from de-bushing in Namibia. However, despite a charcoal industry which is regulated by the Department of Forestry (DoF) and organized by the Namibian Charcoal Producers Association (NCPA), exact figures pertaining to the value chain from production to exports are not available. Based on different research (e.g. Diekmann & Muduva, 2010; DECOSA, 2013), the current charcoal industry can be characterised as follows:

- Number of active producers about 240.
- Roughly 50% of the producers are from previously advantaged background. However, they are clearly dominating the industry with regard to production quantities.
- Main production areas around Grootfontein, Outjo, Otjiwarongo and Tsumeb. Smaller production areas around Windhoek/Okahandja, Otavi, Gobabis/Leonardville, Omaruru, Okakarara and Aranos.
- 6 000 people directly and indirectly employed.
- Annual production about 85-100 000 t.
- 99% export for barbeque.

With regard to the value chain, the following applies for the Namibia charcoal industry:

HARVESTING

The wood for charcoal production is harvested manually in communal areas and on commercial farms. Only a very few producers are known to apply semi-manual harvesting methods by using bush cutters or mechanized methods with large machines to push the bush down before the pieces of wood are manually cut for carbonisation. In most cases wood with diameters from 5-20cm is manually cut to lengths and transported manually to the kilns, i.e. the majority of the biomass remains on the farmland.

CARBONISATION

In Namibia nearly all commercial producers use simple drum kilns made from steel sheets for carbonisation (see Photo 8). They have the following advantages:

- Easy production by local welders.
- Easy transport by rolling them to the harvesting areas.
- Limited skills required for operation.
- Low investment of about N\$ 2 000-3 000 per kiln.

However, the advantages have to be seen in light of drawbacks such as

- small capacity of in average 285kg charcoal per kiln,
- low yields with an average ratio of 5t wood : 1t charcoal,
- risk of bushfire, if the area around the kilns is not properly cleaned.

Because of such challenges, a few producers are known who introduced higher technologies in Namibia e.g. "Bushman Charcoal Namibia" in the Otjiwarongo area (see Photo 9) and "Green coal" in Omaruru. The latter company produces so called bio-coal or torrefied biomass pellets. Torrefaction can be described as a mild form of pyrolysis in an oxygen free atmosphere with ambient pressure and typical temperatures between 250 and 320°C. The aim of the torrefaction process (together with subsequent pelletisation) is an increase of the mass- and volume- weighted energy density so that transport costs can be significantly reduced. Although these aims have apparently been achieved, the company is not producing on industrial scale because their envisaged customer, NamPower, is not yet ready to use biomass for electricity generation. Also "Bushman Charcoal Namibia" did not achieve an industrial production, because the main market of barbeque charcoal is more than satis-



fied with the product from the drum kilns. Considering the investments and limited mobility, such technologies might only be feasible, which currently is not the case, if the by-products can be marketed. Moreover, the yield of the simple drum kilns can easily be increased by improved operation (see Chap. 5.2.2) to a ratio of 3.5t of wood for 1t of charcoal.



Photo 8: Namibian Drum Kiln



Photo 9: Chinese Retort used by Bushman Charcoal Namibia

FINAL STEPS OF PRODUCTION

After carbonisation and cooling, normally very big pieces of charcoal, non-carbonised wood and larger stones are separated manually and the remains are then sieved. Most producers use simple “bicycle rim sieves” (see Photo 10) to separate sand and ash as well as small charcoal (under 13mm) from the two saleable qualities (13 – 20mm, above 20mm). Only very few producers use semi-automatic sieves (see Photo 11). They are much more effective, and also allow separation of large and fine charcoal and thus separate sales of the two qualities.

The sieved charcoal is packed on the spot into 50kg bags, which are normally stored at central collection points on plastic sheets (to avoid humidity seeping up from the soil) and also covered with such material. Protection against humidity is essential because wet charcoal is not accepted by the buyers.

The small charcoal (under 13mm) and the dust are normally dumped. Some producers export this material to RSA for briquetting. One Namibian farm is known, where women produce briquettes manually as a social project to generate some income.



Photo 10: Utilisation of the “Bicycle



Photo 11: Semi-automatic Sieve Rim” Sieve

MARKETING CHAIN

Most of the Namibian charcoal is marketed as follows:

- Namibian or South African specialised trading companies buy the charcoal “ex- production” and transport it to their “factory” where it is finally graded before payment of the producer.
- Namibian trading companies re-pack the charcoal in 50kg bags for export, mainly to South Africa but also directly to overseas wholesalers.

- South African trading companies pack the Namibian charcoal in small bags (normally 4 or 5kg), as finally required by the end-consumers and sell them locally, but in most cases export them to overseas countries.

Very few Namibian producers are involved in retail packaging for the end consumer, although this would add considerable value to the product. Also some larger Namibian trading companies are involved in retail packaging for direct exports to overseas markets. However, 50% of the charcoal is exported in 50kg bags to RSA. Attempts were made in the past by members of NCPA that Namibian producers sent the product to foreign buyers already in retail packaging to add value. However, this failed due to limited willingness of the producers to cooperate and inconsistent qualities.

f) Employment and Skills Requirements

The employment created by the charcoal industry depends on the technologies used in the value chain. The current operation in Namibia, mainly based on manual harvesting and carbonisation with simple earth kilns, is very labour intensive; thus the producers employ currently about 5 000 – 5 500 people. In addition about 700 – 800 people are employed by large traders/exporters and retailers.

The majority of the charcoal producers confirmed that they would increase production and thus employment immediately if they could find workers. Some producers use only 50% of their capacity. It is assumed that at least 700 additional jobs are available. The certainly extremely hard work, in particular with regard to wood harvest, has been identified as main reason for the challenge to recruit workers. Neither the income, which is considerably above the minimum salaries of farm workers, nor the working conditions (accommodation etc.) have similar effects on the recruitment problems.

Based on the Charcoal Sector Development Strategy (DECOSA, 2013), the production and export of charcoal could be increased fourfold, considering the demand and the resources from de-bushing. This development potential would result in employment for 21 000 people in the production (with semi-mechanised harvesting) and in addition 2 000 jobs in other businesses of the value chain.

It is an added advantage of the charcoal production that very limited skills are required, i.e. the industry offers job opportunities to people who otherwise hardly find any employment and represent the majority of unemployed Namibians. Most workers received their knowledge in carbonisation from other workers by brief training on-the-job. With some training the yields could be increased and with some formalisation (e.g. certificates for harvesters and burners) the image of the workers could be increased. This may – together with the introduction of semi-mechanised harvesting - also facilitate the recruitment of workers.

g) Demand Markets

The high percentage of informal production and trade of charcoal is one reason why statistical data is fairly unreliable not only in Namibia, but also in most other countries. This applies also for the only two organisations providing comprehensive data on production, import and export, namely the Food and Agriculture Organisation (FAO) and the United Nations Conference on Trade and Development (UNCTAD). It is an additional challenge that no information is available which distinguishes between

- charcoal and charcoal briquettes for barbeque,
- industrial charcoal, e.g. for pig iron production, and
- special charcoal, e.g. for the pharmaceutical industry.

However, it can be assumed that the vast majority of the charcoal produced and traded internationally is used for barbeque as leisure activity, e.g. in industrialised or traditionally, e.g. in Arab countries. Industrial charcoal is only important in a limited number of countries (China, Brazil) and special charcoal produced in retorts plays hardly any role worldwide compared to the other products.



With regard to Namibian charcoal, only the use for barbeque is important. However, briquettes are also produced from Namibian charcoal in South Africa. They have the advantage of 2-3 times longer burning, but in industrialised countries they often have a negative image of not being “natural” and in some cases even harmful additives are used.

The worldwide imports are steadily increasing, with 11% annually on average (FAO, 2012). The most important charcoal importing countries (with more than 30 000 t) are summarised in Tab. 3. Eleven of the twentyone most important importers are European countries with Germany as leading importer. It can be assumed that these countries are consumers of barbeque charcoal with the exception of Belgium and Poland, which are also leading exporters. In contrast to these countries, China (for silicon production) and Brazil (for pig iron production) are importing industrial charcoal.

Main suppliers of the increasing demand of barbeque charcoal are Somalia (220 000t) for the Arab countries, Indonesia (208 000t) and Myanmar (183 000t) for Japan and Korea as well as Namibia, ranked the 6th most important exporter. Main countries of destination of Namibian exports are RSA and UK. Exporters in South Africa assume that up to 70% of the charcoal exported and locally consumed is originating from Namibia (DECOSA, 2013). Export markets to other countries are not really established. Only Portugal and the Netherlands seem to be penetrated in the last years. Sales to other countries are fluctuating enormously, which is an indicator that sales are done “by accident” and not based on established relations.

Tab. 3: Most Important Charcoal Importing Countries (2010)

Country	Imports (tons)
Germany	217 324
China	214 802
Japan	151 000
Brazil	124 188
Rep. of Korea	108 374
UK	101 941
Italy	92 000
France	87 991
Thailand	86 665
Belgium	80 195
Saudi Arabia	74 119
Bhutan	71 621
Greece	62 100
Poland	60 875
USA	55 839
Spain	47 932
Canada	39 000
Netherlands	34 800
Chile	37 000
Portugal	32 508
Norway	30 388

Source: FAO, 2012

The markets for barbeque charcoal (in particular in Europe) are under-supplied since years and there are indicators that the gap between demand and supply will further increase. This is also reflected by the “ex-producer” prices, which are continuously increasing. Currently Namibian producers get N\$1 850 per ton.



The local demand for charcoal is - with not more than 1 000 ton p.a. - insignificant compared to Namibia's exports. Although the consumption seems to increase slightly, barbeque in Namibia is still dominated by firewood.

h) Major Strengths and Challenges of Namibian Charcoal Production

STRENGTHS

- Suitable legislative framework for conservation/environmental stability and sustainable utilisation.
- Also mixed species suitable for high quality barbeque charcoal.
- 50% (by number) of producers from previously disadvantaged background.
- Simple technologies provided by local SMEs.
- Labour intensive; limited skills required.
- Low investment.
- No additional inputs (e.g. water, electricity) required.
- Cost effective for de-bushing.
- World market increasingly undersupplied.
- Strong position of Namibia (6th largest exporter worldwide, export about N\$200 million p.a.).

CHALLENGES

- Lack of control; partly illegal harvesting.
- Lack of regulations, e.g. for combating bush encroachment, harvesting guidelines, etc.
- Permit system not practical.
- Insecurity of the charcoal industry, thus lack of new investments.
- Limited organisation and productivity of the industry.
- Lack of information on operation of charcoal businesses.
- Limited co-operation within the industry.
- Due to extremely hard work, problems to mobilize workers.
- Current working conditions often not satisfactory (e.g. housing, protective clothing).
- Namibia's strong position on export markets endangered by lack of business orientation and quality consciousness of the industry.
- Long marketing chains (often via RSA).

i) Prospects for the Namibian Charcoal Industry

The charcoal industry is already the most important value chain for wood from de-bushing. Considering the demand, the production for export of barbeque charcoal could be increased from currently about 100 000 to 400 000t in 10 years (DECOSA, 2013). Assuming a harvest of 10t/ha, the industry could contribute to the de-bushing of 1 million ha step-by-step in 10 years. However, this development requires urgent elimination of the existing challenges, in particular improvements of the regulatory framework and the limited productivity; otherwise Namibia may even lose its current market share.

Whilst increases of the local demand are not expected on short or medium term, it may be considered to also carbonise wood with diameters under 5cm and briquet the charcoal. Furthermore, charcoal producers should be encouraged to use the parts of the bush, which are not used for charcoal, for the other products, such as compressed firewood, pellets or animal feed.



3.3 Industrial Heat and Power Generation

3.3.1 Wood Chips and Pellets

The importance of renewable energy is continuously increasing, in particular in the European countries. Currently these energy sources cover 18% of the production worldwide; however, only 14% of the renewable energy is bio-energy, i.e. 2.5% of the total energy production (World Bio-energy Association, 2014). Despite the currently still limited importance, bio-energy is of major interest for Namibia's de-bushing programmes, since the already huge demand in industrialised countries can often not be satisfied due to the limited resources.

Also the Namibian Government is committed to the use of bio-energy. For example, in January 2015 the Parliamentary Standing Committee of Economics, Natural Resources and Public Administration has asked parliament to discuss and adopt its recommendations that Namibia should vigorously turn to the use of renewable energy in an effort to meet the country's rising energy demand (Shigwedha, 8.1.2015). Moreover, the SWAPO Party Election Manifesto (2014) states to "promote increased electricity generation including through thermal, hydro and renewable energy source", and "commissioning of a biomass plant that is generating about 2 Megawatts for rural areas." Such measures shall make Namibia less dependent on electricity from its neighbours, but above all independent from imported fossil fuels.

Such commitments are important since industrial uses of Namibian encroacher bush for the domestic and export markets are continuously discussed, numerous research projects and feasibility studies are available and the interest of investors is reported for years (e.g. Tjaronda, 2008; Hofmann, 2009). However, with the exception of very few pilot projects, nothing has been implemented despite the energy demand locally and overseas.

Wood chips and pellets are, in addition to compressed firewood¹⁶⁾ which is mainly used as residential fuel, of special interest for heat and power generation. Both products are discussed together in the following, since on the one hand they complement each other (chips are the basis for pellet production) and on the other hand they compete with each other insofar as both focus on the same end-uses.

a) Production Processes (see Photos 12-15)

Chips are produced in the bush, i.e. after mobile chippers or automatic harvesting machines with combined chipper convert the biomass into a medium-sized solid material with a typical particle size distribution of 0 - 100mm, whereas the main particle size is mostly in the range of 30 - 60mm.



Photo 12: Raw Material for Wood Chips
in Europe (up to 10 cm diameter)



Photo 13: Mobile Chipper

¹⁶⁾ See Chap. 3.2.2.



Photo 14: Wood Chips



Photo 15: Storage of Dried Wood Chips

The chips are either directly transported to the consumer or for pellet production to the processing plant. Wood pellet production starts with shredding of chips into saw dust like particles. This step is followed by drying the particles to 10-15% moisture content and then they are pressed to form sausage like pellets having a diameter of roughly 5 mm. In many cases, in particular when bark containing wood is processed, a binder in form of starch or molasses has to be added. This processing roughly doubles the cost of pellets.

With regard to production capacities, the chip production is very flexible. One mobile chipper produces about 6-8 m³/hr and costs N\$180 000. This capacity can be multiplied by using several chippers as commonly done. Also chippers with larger capacities are available.

In Europe pellets are normally produced in capacities of fewer than 100 000 t p.a.; only a few producers, e.g. “German Pellets” in Wismar/Germany, produce in larger capacities.

b) Uses and Product Properties

Both products, chips and pellets, are used for heat and power generation. Optimal energy output can be achieved by combined generation of heat and electrical power in so-called CHP (Combined Heat and Power) plants. However, this requires consumers who need both (e.g. larger industries). Since this is not always the case, also electrical power plants in industrialised countries often dispose the heat. In Europe pellets are also used for domestic heating since they allow automatic firing of small burners.

Chipping results in a higher bulk density compared to unprocessed wood biomass, i.e. more biomass can be transported using the same transport volume. The bulk density of wood chips is usually in the range of 300-350 kg/m³. However, chips have a lower bulk density than compressed firewood (550 kg/m³), pellets (550-700kg/m³), and fossil coal (800-850 kg/m³)¹⁷⁾. Also the energy density of chips (2-3 GJ/m³) is lower than of compressed firewood (5.2-7.4 GJ/m³), pellets (7.5-11GJ/m³) and fossil coal (22-24GJ)¹⁷⁾. Moreover, compared with chips, pellets have the advantage of being a more homogeneous product and they have a better flow ability which facilitates handling.

Despite the above comparative disadvantages, standard power plants are using mainly chips, as reflected in the world production of 250 million m³ (about 125 million tons)¹⁸⁾ vis-à-vis a production of

¹⁷⁾ STEAG, 2013.

¹⁸⁾ Including other uses.



22 million tons of pellets (FAO, 2013¹⁸⁾). Main reasons are the lower production costs. However, for long distance transport, these costs are a restricting factor.

Whilst for wood chips no quality standards are defined in Europe, they exist for pellets (as for compressed wood), for example the European ENplus with three different categories. Namibian encroacher bush cannot even comply with the lowest category of ENplus with regard to ash content, chlorine and sulphur. Although the European quality requirements are optional according to STEAG (2013), non-compliance will exclude a Namibian supplier from most of the European markets since pellets are in Europe mainly used for households and small power plants. Moreover, supply and demand of high quality (certified) biomass pellets is currently fairly balanced in Europe, with limited additional market scope.

c) Resources

It is a major advantage of wood chips that all species and their mixture can be used for chip production. In principle this applies also for pellets, however, high bark content may require additional binder, but this seems not to be a problem in Namibia.

Mainly woody parts of the encroacher species shall be used, but it is an advantage that the finer branches of bushes, that are not suitable for the production of charcoal, can be used, i.e. a combined utilisation might even be considered.

d) Experience

Nowadays chips are produced in nearly every country that has forest resources or industries like sawmills which are chipping their wood residues.

Nearly 600 companies are producing pellets worldwide (see Tab. 4). Remarkably, with the possible exception of Indonesia and Brazil¹⁹⁾, pellets are only produced in countries that have softwood. Also the four plants in Africa (all located in RSA) are based on plantation wood. The pellet plants in South Africa have problems with the marketing of biomass pellets due to the missing pellet market within South Africa, small production capacities and resulting high transportation costs for an export to Europe and other continents (STEAG, 2013). It has been reported that currently none of the pellet plants is in operation.

Tab. 4: World Production of Wood Pellets (by continent)

Continent	Number of Plants	Total Capacity (in t p.a.)	Average Capacity ^{*)} (in t p.a.)
Europe	435	20 235 750	47 000
Africa	4	240 000	60 000
Asia	32	1 255 200	39 000
Australia ^{**)}	5	366 000	73 000
North America	118	8 439 000	72 000
South America	4	140 000	35 000

* Rounded

** Including New Zealand

Source: STEAG, 2013

e) Current Operation in Namibia

¹⁹⁾ It is not known but assumed that they process softwoods from plantations.



WOOD CHIPS

The main producer of wood chips is Ohorongo Cement near Otavi. They use the chips from encroacher bush to fire their industrial combustion chambers, which are designed to accept coal as well as any type of organic matter as fuel. In 2014 the total demand of Ohorongo for chips was 85 000 t/year. At full capacity, 75% of Ohorongo's energy needs could be met by wood biomass and 25% by coal. A subsidiary company, Energy For Future (EFF), is tasked with harvesting encroacher bush in a 75 km radius around the cement plant, chip and dry it and deliver it to the cement kilns. This is achieved by huge, mobile, expensive bush chippers, which harvest and chip bush in the same operation. Farmers avail their farms for bush harvesting and pay a small fee for the de-bushing. On every farm an area not larger than 500 ha on relatively flat terrain is clear-cut, leaving isolated strips or clumps of dense bush (Rothauge, 2014).

Since EFF cannot meet the demand of the cement factory, the company is buying chips from third parties. Although two companies started to supply Ohorongo Cement, their demand still cannot yet be met.

Whilst the end use (i.e. the combined firing of the combustion chambers) faces no problem, the supply (in particular the chippers) are a challenge. Rothauge (2014) reports: "They break down frequently due to the hardness of indigenous wood and its high sand content that grinds down the hardest steel within a couple of years. The roughness and dustiness of the terrain impacts the mechanical integrity of the large, heavy machines, which run up huge repair bills." Most other chip suppliers face similar problems. However, some producers report no challenges with regard to the chipper. They chip the fresh wood, whilst other producers first air-dry the wood in the field before chipping, which may cause a higher sand content.

In addition to Ohorongo Cement and their suppliers, chips are produced by CCF for their production of compressed firewood (traded as "Bushbloks") as well as by one farmer for a pilot wood gasification plant between Outjo and Otjiwarongo. This plant has been sponsored by the European Union as a public-private partnership project to supply electricity into the public grid. After four years it is still not operating, amongst other reasons because

- the mobile chippers were not adapted to the Namibian wood species;
- the technology of gasification is fairly sophisticated;
- supply of spare parts for the gasifier is a challenge; and
- the grid connection faces problems.

WOOD PELLETS

Pellets are not yet produced in Namibia. Two companies are known which tried to commence the production based on invader bush:

- "Easy Energy" mobilised a German know-how partner and agreed with the Cheetah Conservation Fund (CCF) that they would provide the wood chips. Originally the pellets should have been sold to NamPower, but since the power generation with biomass did not commence yet, it is planned to export the pellets to Europe²⁰⁾.

The project seems to be unrealistic and financing of N\$18 million could not be mobilised, for example because of the following reasons:

- CCF has already problems to supply their own Bushblok production and it is doubted that they could supply the pellet plant.
- European quality requirements have not been considered.
- A detailed calculation of the transport costs is missing.
- "Transworld Cargo" investigated in detail the technical possibilities to produce pellets in Namibia with equipment from Germany. The results were discouraging. The main problem is

²⁰⁾ Based on information of the project promoter.



the sand contained in the wood chips. It results in interruption and even destruction of the pelleting machine and low quality products.

f) Employment and Skill Requirements²¹⁾

Employment creation by the production of chips and pellets is fairly limited. A mobile chipper can be operated by one unskilled and one semi-skilled worker. If combined harvesting and chipping equipment is used, one higher qualified operator is required plus two helpers; however, the total employment creation is even lower than using (normally several) mobile chippers due to the much higher capacity of the more sophisticated equipment.

Manufacturing of pellets requires at least a full-time professional manager, technician for operation and maintenance as well as a full-time marketing manager. Such professionals are in particular important because of the limited technical experience with the production based on Namibian hardwoods and since pellets are a new product in Namibia that requires professional marketing.

g) Demand Markets

With the increasing trend towards renewable energy in several countries (particularly in Europe) and the commitment of the Namibian Government, there could be a demand for wood chips from Namibian encroacher bush for power and heat generation.

NAMIBIAN MARKET

Since wood chips and pellets are only targeting industrial end-users, the domestic market is currently limited. Pellets are neither produced nor demanded yet and the Bushblok factory as well as the wood gasification plant are designed to use their own resources for chip production. However, Ohorongo Cement is under-supplied and thus purchases chips from other Namibian producers.

Despite the current situation, an increasing demand may be assumed in the (near) future. Potential users of chips or pellets could for instance be:

- NamPower which is now in a concrete phase to initiate generation of electrical energy from invader bush. The para-statal is currently tendering to employ personnel specialised on bio-energy and a feasibility study financed by KfW will be prepared for a 20MW power plant.
- Namibia Breweries is even more advanced with the production of the required heat based on wood chips instead of heavy oil used currently. The tendering for equipment is ongoing. The required 7 000 t of chips p.a. shall be provided by the sister company, Organic Energy Solutions (OES). They will harvest on farms within a range of about 100 km with fully mechanised machines and already have agreements with farmers.
- MeatCo is interested in the possibility of co-firing their industrial combustion chambers at their two export abattoirs, but has not yet estimated the quantity of wood needed (Rothkegel, 2014).
- Other potential users of heat from biomass could be energy-intensive companies in Windhoek (e.g. from the food sector) as well as mining and fisheries companies in the Erongo Region. However, this is not expected on short-term, but only when some positive experience is available, e.g. from Namibia Breweries.

The short-term demand can be estimated as follows:

– Ohorongo Cement	85 000 t p.a.
– Namibia Breweries	7 000 t p.a.
– NamPower	150 000 t p.a.
<i>Total</i>	<i>242 000 t p.a.</i>

²¹⁾ Excluding harvesting.



If the projects have demonstrated to be successful, this demand can increase considerably through additional power plants of NamPower and Independent Power Producers (IPPs) as well as by generation of heat and probably also electric power by private end-users. For example, one investor is interested in a 50MW plant requiring about 250 000t of wood annually. On medium and longer term a demand of 500 000 t could be assumed provided the technical problems are solved and the prices are competitive.

In order to satisfy this demand, wood chips, pellets and compressed wood are competing. Based on experience in Europe as well as of Ohorongo Cement and O&L OES, chips might be the preferred biomass within a transport distance of 75-100 km. Although they have a lower bulk and energy density than the other products, they have cost advantages on shorter transport distances due to the limited processing. Moreover, biomass plants are usually able to combust dried as well as undried chips. Therefore, biomass chips, especially wood chips, are a typical fuel for biomass plants. Most of the European biomass plants are based on wood chips whereas undried chips are usually used (STEAG, 2013). Further treatment steps are only necessary when long transport distances are given due to reduction of transport costs by increasing the bulk density and/or the energy density.

MARKETS IN NEIGHBOURING COUNTRIES

In contrast to compressed wood focusing on private consumers for heating and cooking, the markets in neighbouring countries for chips and pellets focusing on industrial users are extremely limited as demonstrated by the South African pellet plants facing problems with marketing. However, possibilities to supply, for example, the Zimbabwean tobacco industry or companies in Botswana could be investigated.

OVERSEAS MARKETS

Worldwide there is a huge demand for woody biomass to be used for heat and power generation. This applies in particular for Europe with the increasing trend towards renewable energy utilisation, which cannot be satisfied by local resources.

Primarily demanded are wood chips. For example the world production of wood chips exceeds with about 250.4 million m³ (about 150.2 million tons) by far the production of pellets with 22.1 million tons. Considering that the biggest consumers of wood chips are the particle board and oriented strand board industry (world production 99.3 million m³ or 59.6 million tons p.a.) as well as the fibre-board industry (world production 88.2 million m³ or 52.9 million tons p.a.). The importance of wood chips (mainly for heat and power generation) still exceeds pellets by about 15.6 million tons. Remarkably this applies also for the world imports with 58.5 million m³ or about 35.1 million tons for chips and 12.2 million tons p.a. for pellets²²⁾.

These global figures demonstrate the huge market for both, wood chips and pellets. Whether the overseas markets can be penetrated and by which product (considering also compressed firewood), depends mainly on the following factors:

- Quality requirements

Chips and pellets from Namibian encroacher bush do not comply with European requirements. However, these requirements hamper mainly the market entrance at households and small power plants, which are the main end-user of pellets. Whether industrial users accept the Namibian qualities (as assumed) requires detailed market surveys including also certainly existing differences in the potential import countries.

- Production costs and prices

Leinonen (2007) calculated costs of N\$203.78 per ton which would result in N\$306.40 per ton in 2014 considering an annual inflation of 6%. These costs seem too low. Ohorongo Cement pays their external suppliers N\$770 per ton free factory. If they have to transport the chips over 75 km

²²⁾ All figures based on FAO, 2013.



for N\$65²³⁾, the chip producers would make a profit of over 100%. Therefore, costs (excluding transport) of N\$400 per ton are assumed for chips whilst costs for pellets may be in the same range as for compressed firewood, i.e. about N\$1 500 per ton.

World market prices of chips (free purchaser) are currently €150 (about N\$2 000²⁴⁾) per ton with 20% moisture content. However, large consumers (e.g. power plants) pay much lower prices, for instance €70 (about N\$910) per ton for fresh chips with 50% moisture content.

Typical market prices for biomass pellets in accordance with European standards are in the range of 230-270 (about N\$3 000-3 500) per ton and for non-certificated biomass pellets, the so-called industrial pellets, in the range of 130-140 (about N\$1 700-1 800) per ton (STEAG, 2013). Export opportunities to industrialised countries may exist if above price ranges including transport to overseas consumers are feasible for Namibia.

○ Technical problems

All market prospects can only materialise if the current technical problems with Namibian encroacher species can be solved. Whilst this seems to be possible with regard to the chipper, technical experts doubt that this is possible for the pelleting plant.

h) Transport Costs

Due to the overriding importance of the transport costs, in particular for industrial mass supply, they are estimated in the following, which is only a model calculation based on standard cost not considering possible options (see below):

BASIC ASSUMPTIONS

- Transport distances
 - 400 km transport on road for export to Walvis Bay by truck²⁵⁾
 - 300 km transport on road for domestic market in Windhoek by truck
 - Shipping from Walvis Bay to Hamburg / Germany
- Packaging
 - 50kg bags on trucks
 - 50kg bags in 40 foot container for shipping
- Transport volumes / weight

– Chips	300 kg/m ³	1t = 3.3 m ³
– Pellets	600 kg/m ³	1t = 1.7 m ³
- Maximum container packaging

– Chips	18 t or 60 m ³ ²⁶⁾
– Pellets	28 t or 48 m ³

MODEL FOR DOMESTIC MARKET

COSTS IN N\$ / T (ROUNDED)

- 300 km transport to Windhoek]
- N\$13 per running km (30 t truck)
- 600 km (return trip) x N\$13=N\$7 800
- TOTAL N\$ 260.00

MODEL FOR EXPORT MARKETS

²³⁾ N\$13 per km in a 30t truck.

²⁴⁾ Based on an exchange rate of 1€=N\$13.

²⁵⁾ Railway is only slightly cheaper, but less reliable and requires additional transport by truck to the railway station.

²⁶⁾ Restricted by the volume.



○ 400 km transport to Walvis Bay	
– N\$13 per running km (30 t truck)	
– 800 km (return trip) x N\$13=N\$10 400	N\$ 350.00
○ Port handling in Walvis Bay	N\$ 100.00
○ Shipping to Hamburg ²⁷⁾	
– Chips (18 t)	N\$1 000.00
– Pellets (28 t)	N\$ 650.00
○ Port handling in Hamburg	N\$ 200.00
TOTAL Chips	N\$ 1 650.00
TOTAL Pellets	N\$ 1 300.00

MODEL OF FINANCIAL VIABILITY

○ Chips	Local		Export
– Production costs per ton	400.00		400.00
– Transport costs per ton	260.00		1 650.00
– Sales prices per ton ²⁸⁾	770.00		2 000.00
– Margin	110.00		-50.00
○ Pellets	Local		Export
– Production costs per ton ²⁹⁾	1 500.00		1 500.00
– Transport costs per ton	260.00		1 300.00
– Sales prices per ton ³⁰⁾	?		3 200.00
– Margin	?		400.00

The above model calculations demonstrate the limited margin or loss of the production of chips and pellets and the importance of the transport costs. Pellets are not yet locally traded but it is doubted that cost covering prices can be achieved.

With regard to the transport costs there are still several options which can influence the costs and thus the viability; they must be investigated in detail. For example:

- Using trucks which return empty from the North. This would reduce the costs for land transport by about 30%. However, the availability may be a matter of concern³¹⁾.
- Using railway wherever possible.
- Loading at the site into containers to reduce the loading and unloading costs.
- Transport in large sling bags (up to 1 t) or even loose into containers.
- Using part-charter vessels which are available in Walvis Bay for 5 000-7 000 t per shipment (STEAG, 2013). This would reduce the ocean freight and may be one reason that wood chips are transported currently from South Africa to Japan for only N\$450 per ton.

Other issues to be considered are

- the exchange rates (international transport is calculated in US\$),
- the storage time and costs at Walvis Bay,
- the availability of 40 foot containers in Walvis Bay, which at time is a matter of concern, and
- the incentive for foreign investors of a rebate of 25% on local transport.

²⁷⁾ Based on an exchange rate of N\$10 equals to US\$1.

²⁸⁾ At Ohorongo.

²⁹⁾ Provided by local entrepreneurs; appears to be too high.

³⁰⁾ Not available.

³¹⁾ One of the largest transport companies can assure 10 trucks (30t) at fixed times per week.



i) Effects on De-bushing

Considering the current production potential and the concrete plans of Namibia Breweries and Nam-Power 250 000t p.a. of wood chips are demanded on short term³²⁾. Assuming a harvest of 10t/ha the production of wood chips would contribute annually to the de-bushing of 25 000 ha. However, on medium to longer term a local demand of 500 000 t p.a. is possible provided the current constraints are eliminated, i.e. 50 000 ha would be de-bushed p.a.

j) Major Strengths and Challenges of Chip and Pellet Production in Namibia

WOOD CHIPS

- Strengths
 - Also mixed species and wooden parts of the bush with small diameters suitable, i.e. combination with other uses (charcoal, poles) possible.
 - All technologies known.
 - Flexible equipment from small mobile chipper to fully mechanised harvesting and chipping machines available.
 - Limited skills required.
 - Lower production costs than pellets and compressed wood.
 - Demand for dried and undried chips.
 - Increasing demand in Namibia: 250 000t short term; up to 500 000t medium term
 - Worldwide preferred for heat and energy generation; demand in several industrialised countries not satisfied.
 - No quality requirement defined in Europe.
 - Contribution to de-bushing on large scale possible if the market of industrial users in Namibia can be penetrated.
- Challenges
 - Technical problems with chippers (not adapted to Namibian species) but should be solvable.
 - Limited employment creation.
 - Competing with pellets and compressed firewood.
 - Lower bulk and energy density than pellets and compressed firewood.
 - Only competitive in Namibia with short transport distances (up to 100 km).
 - Limited value addition.

WOOD PELLETS

- Strengths
 - In principle mixed species and wooden parts of the bush with small diameters suitable, i.e. combination with other uses (charcoal, poles) possible.
 - Technologies known.
 - Only electricity required as additional input, if not too high bark content.
 - Higher bulk and energy density than compressed firewood and wood chips.
 - Lower transport costs per GJ than compressed firewood and wood chips.
 - Contributions to de-bushing on large scale possible if the market of industrial users (interest in Europe) can be accessed .
- Challenges
 - Serious technical problems (hardly solvable) with sand content of Namibian wood chips.
 - Possibly binder required (if too high bark content).

³²⁾ Not considering the current production of 500t Bushbloks p.a.



- Higher production costs than wood chips.
- Production for industrial end-users competing with wood chips and compressed wood.
- No current local demand and hardly any in neighbouring countries (competing with producers in RSA).
- Pellets from Namibian encroacher bush do not comply with quality requirements of main European end-users.

k) Prospect of Namibian Wood Chips and Pellets

Worldwide there is a huge demand for wood chips and pellets with imports of 35.1 million tons of chips and 12.2 million tons of pellets per annum. Of particular interest are the European countries with the trend to renewable energy. Both pellets and wood chips are suitable resources for heat and power generation and are applied worldwide for these uses; chips mainly for shorter and pellets for longer transport distances.

Based on the current limited knowledge with pellets from Namibian encroacher bush the production bears considerable risks, in particular regarding

- the quality requirements of the major end-users in Europe, which cannot be fulfilled, and
- the technical problems with the pelleting machines (sand content of the raw material) which according to European specialists can hardly be solved.

Due to the not yet existing demand in Namibia and the limited demand in neighbouring countries with strong competition from South Africa mainly exports to overseas countries could be envisaged. However, this requires first that the technical problems are solved and then market surveys to identify large scale customers, who are prepared to purchase pellets of Namibian quality. Moreover, the costs (in particular different transport options) must be investigated in detail. Finally, the competition with wood chips and compressed firewood – having the advantage of experience in Namibia – must be considered.

The prospects for pellets are not very promising as also demonstrated by the closure of South African plants. This contradicts some studies and opinions in Namibia but is underlined by the fact that for years potential buyers and investors from Europe, India and Brazil have visited Namibia to purchase pellets but nothing materialised.

An immediate opportunity is the production of wood chips in Namibia. Experience is locally available and the technical problems seem to be solvable. Furthermore, Namibia has already a domestic demand of 85 000 t p.a. which is currently not satisfied and will increase on short term to 250 000 t p.a. If the planned projects are successful a demand of 500 000 t is assumed on medium term. Due to the relatively low bulk and energy density chips are mainly used for short transport distances between the supplier and consumer. Preliminary calculations showed that chip exports to overseas are not viable.

However, based on statistics of FAO (2014) chips are also traded across borders, i.e. detailed investigation about different options of transport to determine the costs of the optimal option are recommended to decide whether exports are feasible. In this regard not only the huge demand in overseas countries, but also the comparatively limited possible demand in Botswana and Zimbabwe should be considered.

3.3.2 Bio-gas

a) Production Process

Biomass gasification from wood must be clearly distinguished from bio-gas produced using wet crops and residues to generate methane gas.



Gas from wood is produced from wood chips by pyrolysis, i.e. a process that converts the biomass by the use of heat with limited supply of air into gas, oil and tar. The mixture depends on the temperature, an increasing temperature shifts the mixture towards gas.

Wood gasification systems consist of four main components:

- Fuel preparation (chip production), handling and feed system;
- Gasification reactor vessel;
- Gas cleaning, cooling and mixing system; and
- Energy conversion system (e.g. internal combustion engine with generator or pump set, or gas burner coupled to a boiler or kiln).

The vessel or reactor (commonly called “gasifier”) is the core of the system. The wood is fed into the gasifier along with a limited supply of air. Heat for gasification is produced through partial combustion of the feed material. The chemical breakdown of the fuel and internal reactions result in a combustible gas, called “producer gas”.

b) Product Properties and Uses

Producer gas has a calorific value of only 10-15% of the value of natural gas. It is another challenge that in its raw form the gas tends to be very toxic because of its high levels of carbon monoxide.

Although the gas is not a high quality fuel, it can be used for two main applications:

- Power generation

The gas is used in internal combustion engines for the production of shaft power, which in turn can be used for generating electricity, pumping water, milling, running compressors, motive power, etc. Although producer gas can be combusted in gas turbines, its application in this area has not been adequately demonstrated to warrant serious consideration.

- Heat generation

Producer gas can be used to fuel external burners for heating of driers, ovens etc., e.g. in mining, fishing and food industries.

One of the important differences between the two systems is that power gasifiers must produce a clean gas because of the very strict fuel quality demands of an internal combustion engine. The opposite is true for producer gas combusted in external burners. As a result, heat gasifier systems are less complicated and costly compared to power gasifiers.

c) Resources

Wood gasification has the advantage that all species of invader bush can be used. For effective production, the wood is chipped before feeding the plant and only specific sizes of wood are usable, i.e. the chips need to be sieved/sorted. The only plant in Namibia (see(e)) can therefore only use 40% of the harvested wood.

Moreover, the chips need to be dried to at least 12%, which is done in Namibia by blowing hot air into the hall where the chips are stored.

A small decentralised plant (as available in Namibia) requires about 30 t of wood to produce 20 000 KWh per week. Furthermore, 10 000 l of water are necessary per day for cleaning of the gas.

d) Experience

The technology of biomass gasification has been known since the late 18th century and commercial applications were first recorded in 1830 (NDC, 2002). By the 1920's, producer gas systems were used



to operate trucks and tractors in Europe, when petroleum fuels were scarce. During World War 2 biomass gasification systems were widely used for both stationary and mobile applications. These systems were, however, abandoned with the emergence of relatively cheap petroleum fuels after the war. Interest in biomass gasification technology was revived in the late 1970's by the high petroleum prices. However, with the subsequent decline in petroleum prices there are now only a small number of commercial biomass gasifiers operating globally. The majority of these units are charcoal powered gasifiers and wood or charcoal heat gasifiers located in Latin America, primarily Brazil.

According to NDC (2002) there are a number of commercially proven heat gasifiers available. These systems are acceptably reliable. However, the track record for successful commercial power gasifiers is limited and the reliability of these systems operating in the field is quite low. This technology must be viewed as a lesser quality alternative compared to more conventional options, such as steam turbines. Although the technology has been refined by research institutions since 2002 (e.g. in South Africa) and equipment producers (e.g. in Asia and South America) the commercial application is still limited.

e) Current Operation in Namibia

In Namibia one plant to generate electrical power has been established as pilot project on the farm Pierre between Otjiwarongo and Outjo. The project with a capacity of 20 000 KWh per week required an investment of about N\$14 million (financed mainly by the European Union). It should be operated by the owner of the farm, who should pay lease to a trust owning the equipment. The electricity generated by the small Independent Power Producer (IPP) should be fed into the public grid.

The experience with this plant, which is fairly sophisticated, underlines the critical evaluation of NDC. Although the plant was taken over in September 2009, it is still not operational. Main challenges include:

- Technical problems, e.g. with the chippers and even with the vibration sieves.
- Difficulties to connect the plant with the public grid with full efficiency.
- Lack of a permanent technical supervisor.
- Challenges to get spare parts from the Indian producer or elsewhere.

Moreover, the economic viability is doubted even by the consultants who were responsible for the project planning and implementing.

f) Employment and Skills Requirements

For the plant in Namibia, ten unskilled workers are required for manual wood harvesting as well as four people for each of the two shifts in the plant plus one supervisor.

The technical skills requirements in the plant are relatively high considering permanent maintenance and control (e.g. of the filters). EADI (2012) concluded that insufficient knowledge and skills for operating power plants are a major challenge.

g) Demand Markets

The demand to generate heat is limited in Namibia. Some potential users, such as the beverage and meat industry, started to change to bio-energy but with much simpler technologies using wood chips to heat boilers directly.

The domestic demand for electrical energy is much higher than for heat generation. However, again simpler technologies (e.g. with steam turbines) are preferred – as far as known – also by NamPower planning a 20 MW bio-energy plant.



h) Effects on De-bushing

The project in Namibia claims to de-bush 800 ha p.a. (Tjaronda, 14.1.2010) which is a minimal contribution to de-bushing. This area has to be seen in light of the following:

- 1500 t p.a. are needed, however, practical experience demonstrated that only 40% of the harvested wood can be used, i.e. a larger harvesting area is required (about 2 000 ha) and about 2 250 t are dumped, if not used elsewhere.
- The de-bushing area has been calculated on the basis of 10 t/ha of invader bush of which only 20% shall be used. This is a very limited contribution to de-bushing. Harvesting of 70% is recommended by experts (e.g. Rothauge, pers. Information, March 2015). In this case only much smaller areas need to be de-bushed.

i) Major Strengths and Challenges

STRENGTHS

The strengths of wood gasification in Namibia and elsewhere are very limited. They only include:

- Possibly de-centralised power generation as IPP in remote rural areas with capacities up to 5MW.
- Utilisation of all invader species, also mixed.

CHALLENGES

Wood gasification faces enormous challenges not only in Namibia. The following are of overriding importance:

- Relatively sophisticated technology resulting in technical problems and limited reliability in particular with regard to power gasifier.
- Special skills and knowledge required.
- Financial viability doubtful (e.g. low calorific value) also in competition with conventional heavy furnace oil burners; therefore, production subsidised in some countries.

In addition to these challenges, the following has to be considered:

- Low effects on de-bushing.
- Only dry wood chips accepted.
- Toxicity of the raw gas.
- Clean gas from power gasifiers required resulting e.g. in high demand of water.
- Negative experience in Namibia.
- Special engines or considerable modification of existing ones necessary.
- Gas difficult to transport, i.e. location of plant close to public grid or consumer required.

j) Prospects of Wood-gas in Namibia

The feasible application of power gasifiers is doubted for Namibia, although it they might be effective in remote off-grid rural areas. Heat gasifiers may be considered in industries that require the production of large quantities of steam or heat as an input for their respective production processes. However, heat and power generation from woody biomass is more promising with other technologies. Therefore, the production of bio-gas is not recommended for Namibia.



3.3.3 Bio-oil

a) Production Process

Bio-oil is produced from dried wood chips by pyrolysis, i.e. a process that converts the biomass by the use of heat with limited supply of air into gas, oil and tar. All products have to be separated and thoroughly cleaned. The mixture depends on the temperature; increasing temperature shifts the mixture towards gas. The pyrolysis process can produce bio-oil with yields up to 680 kg per 1000 kg of wood (NDC, 2002).

(b) Product Properties and Uses

The density of the oil is very high, at around 1.2 kg/litre, compared to light fuel oil at around 0.85 kg/litre. This means that the liquid has about 42% of the energy content of fuel oil on a weight basis, but 61% on a volumetric basis (NDC, 2002). Bio-oil has the advantage vis-à-vis bio-gas of being easily transportable and storable.

Bio-oil can substitute or complement fuel oil or diesel in many static applications including boilers, furnaces, engines and turbines for electricity generation. Also up-grading to transportation fuels is technically possible, but not financially feasible. The main application is nowadays co-firing of a few large scale power plants in Europe.

A range of chemicals can also be extracted or derived from specialties, such as levoglucosan to commodities such as resins and fertilizers.

(c) Experience

No experience on laboratory, pilot or industrial scale exists in Namibia. However, the GemGroup in Karibib was involved over years in research and planning of a bio-oil plant. The project was ceased, since reliable technologies for de-centralised small scale production could not be identified and the production is financially not viable.

Also internationally the production of bio-oil from wood plays a limited role compared to the production from agricultural plants. The suitability of Namibian invader species would need to be investigated.

(d) Employment and Skills Requirements

Although pyrolysis is a known process, the technical skills requirements are relatively high, considering the sophisticated technology with necessary cleaning and use of chemical by-products.

(e) Demand Markets

Although bio-oil could substitute fuel oil or diesel, no real demand could be identified, neither locally nor internationally. It must be assumed that the product is not yet competitive to other bio-energy or conventional fuel.

(f) Strengths and Challenges

STRENGTHS

- Very high energy density of 20 GJ/m³ which exceeds even wood pellets (7.5-11 GJ/m³ (STEAG, 2013).
- Clean energy with an ash content of 0.02 which is about 100 times lower than compressed firewood and pellets.
- Easier transport and storage than bio-gas.



CHALLENGES

The production of bio-oil faces enormous challenges. The most important ones are:

- No demand in Namibia (NamPower focuses on other bio-energy sources).
- No international demand or trade could be identified.
- Limited international experience with plants based on wood (in contrast to agricultural plants), i.e. enormous technical risks.
- Financial viability strongly doubted; might be possible in very large factories, if also all by-products are used and marketed.
- Not competitive to other sources of bio-energy.

Other challenges include:

- No experience at all with Namibian invader species and mixed resources.
- Only dried wood useable.
- High skills required (including engineer, chemist) and no international partner available/known.
- Limited employment creation.
- Modification of equipment of potential end-users required.

(g) Prospects

On short and medium term other technologies based on woody resources are more competitive and less risky. Bio-oil might have long-term prospects if the chemical by-products can be used within a bio-refinery concept, in which the optimal combination of fuels and chemicals are produced. Provided the chemical properties of the species from de-bushing allow the utilisation of mixed wood species, the production of bio-oil could have positive effects on larger scale de-bushing. However, currently bio-fuel is not recommended for Namibia.

3.3.4 Bio-ethanol

a) Production Process

Bio-ethanol is produced from glucose, which can be generated from glucose containing polymers like starch. Glucose from sugar cane can be directly fermented into bio-ethanol, which is one of the oldest technologies. Starch and cellulose are hydrolysed with mineral acids or by enzymes to form sugars which are converted into ethanol. Enzymatic degradation of starch from maize, potatoes or other starch containing plants is state of the art.

The process of ethanol production from woody biomass is much more complex and expensive, since enzymatic hydrolysis of cellulose is more difficult compared to starch, because cellulose is more stable. Cellulose content of wood is roughly 40%. Another 30% carbohydrates in wood are hemicelluloses, which primarily consist of 5-carbon sugars, which cannot be easily fermented into ethanol. An additional problem of wood based ethanol production is the limited enzyme accessibility of wood. A high fermentation rate requires a specific pre-treatment of wood.

b) Uses

Bio-ethanol is mainly used as addition to petrol for vehicles, although higher than 15% blend requires modification of the vehicle. It is generally accepted that bio-ethanol fires at 70% carbon dioxide reduction versus petrol.



Ethanol is also being used to formulate a blend with diesel fuel and as a replacement for leaded aviation gasoline in small aircrafts. Furthermore, ethanol is a basis for several synthetic materials, such as polyethylene.

c) Resources

The extended utilisation of bio-ethanol, notably in Brazil and the USA, is mainly based on corn or sugar cane. Also other plants containing starch or sugar are used to produce bio-ethanol. Since such cultivated resources are competing with food production, also agricultural residues (e.g. straw) and wood are considered.

d) Experience

In contrast to the vast commercial experience of bio-ethanol production on the basis of agricultural plants and residues, the production from wood is mainly on a research level. However, according to UNDP/MET (2007), ethanol from cellulose material, such as woody biomass, holds potential due to the wide spread availability and relatively low costs of these materials. This has driven interest around the world (notably in the United States) over the past thirty years or so to develop processes that are economically feasible.

e) Demand Markets

The demand of bio-ethanol is steadily increasing (Renewable Fuel Association, 2015) to a production of 24.6 billion gallons in 2014 with USA being the largest producer (58.1%³³⁾) followed by Brazil (25.2%), Europe (5.9%), China (2.6%) and Canada (2.1%). Internationally bio-ethanol is traded in large quantities with Brazil being the largest exporter. However, the demand is exclusively covered by bio-ethanol from agricultural plants.

Whether a future bio-ethanol production based on Namibian encroacher bush could benefit from this demand depends on the production costs. According to UNDP/MET (2007), the costs of ethanol from invader bush in Namibia were only 5% higher than the basic fuel price for petrol. Thus it was recommended that Namibia should pursue bio-ethanol as a real future option for reducing imports of petroleum fuels and reducing the greenhouse gas emissions from transport. However, the optimistic cost estimation contradicts other investigation. A costs analysis carried out by the United States National Renewable Energy Laboratory (NREL), based on data from pilot plants suggest that with the current technologies, ethanol from woody biomass can be produced at US\$2.2 per gallon or 59US cents per litre, which is double the cost of ethanol from corn (UNDP/MET, 2007).

f) Major Strengths and Challenges of Bio-ethanol Production in Namibia

STRENGTHS

- Probably lower costs of input material from encroacher bush than from cultivated agricultural plants.
- Considerable reduction of carbon dioxide of all types of bio-ethanol versus petrol.
- Reduction of Namibian imports of fossil fuels.

CHALLENGES

- Much more complex production process of wood based compared to agricultural plants based bio-ethanol production.
- No commercial production (only pilot) based on wood despite research in the leading country, USA, since 30 years.
- Currently not competitive versus bio-ethanol based on other resources and fossil fuel.

³³⁾ % of world production.



- No knowledge even on research level with the possible utilisation of Namibian invader species.
- Acceptance by consumer problematic, e.g. in USA only provided by 700 of 165 000 petrol stations in 2010 (Wikipedia, 2015).

g) Prospects

The optimistic prospects of UNDP/MET for a bio-ethanol production in Namibia based on invader bush are not shared on short and medium term since the costs seem to be too optimistic and the production is worldwide not feasible and thus not available on commercial scale. Only after commercial plants in other countries proved to be viable and competitive, could production in Namibia be envisaged, but even then the suitability of Namibian encroacher species must first be investigated considering that they may create specific problems due to their high wood density and bark contents. Currently the production of bio-ethanol from encroacher species is not recommended.

3.3.5 Special Bio-ethanol Refinery

A European group claims to have developed a special process of bio-ethanol production with main focus on plastic packaging, according to information of one of the developers, the process

- focuses on wood based biomass,
- can use mixed species as they are available from de-bushing,
- would require 300 000 t of biomass per annum, and
- has already mobilised interest of large consumers (Nestlé, Unilever, Coca Cola) for packaging material.

The developer signalled general interest to establish the first processing plant in Namibia because of the vast resources from de-bushing.

Due to the limited information available the prospects cannot be assessed. However, it is recommended to keep contacts with the developers.

3.4 Construction Materials

With the exception of cement, some poles and stones, Namibia is lacking the production of own construction materials. Therefore, value chains from encroacher bush in this sector would be of particular interest.

3.4.1 Sawn Timber

a) Production Process

The production of timber is a simple process. The logs are harvested and thereafter cut into planks. Depending on the size of logs and required capacities, different types of saws are used to produce sawn timber (planks). For logs with very large dimensions – as they are common in tropical African forests – only huge band saws are used, whilst for logs from plantations in South Africa and from forests in the northern hemisphere, smaller band saws or frame saws are used. The latter cut several planks from one log with several vertical saws at the same time; production is only feasible with a minimum capacity of 10 000 m³ output. This requires an input of about 20 000 m³ since the yield of sawn timber is commonly 50% of the volume of the logs. The residues are in industrialised countries normally chipped and then sold to energy, chipboard or fibreboard producers.



For the production of sawn timber in small capacities from logs with small dimensions (under 50 cm) also saws as they are common in joineries are used, for instance table circular saws. However, this production process cannot compete with a sawn timber mass production.

b) Product Properties and Namibian Resources

Production of timber requires bigger size logs (normally with diameters above 50 cm). Furthermore, commercial timber must have homogenous properties and since most species have specific characteristics, the timber can only be marketed separately by species.

These requirements can and have so far only been fulfilled based on trees from the Kavango and Zambezi Regions. Encroacher bush is in most cases mixed with different species and the sorting requires extra efforts and costs. The most important restrictive factor is, however, the fact that invader species seldom have diameters for the production of sawn timber and such trees shall not be harvested.

An exemption is *prosopis* (mesquite), a species which originally comes from the south-western USA, and has become naturalized. It is an extremely invasive species, widespread in central and southern Namibia and abundant in the river systems of the south-east. *Prosopis* occurs also in larger diameters (up to 35 cm) and harvesting thereof is allowed due to the species invasive nature.

c) Current Operation in Namibia

Sawmills were established and successfully operated in the Kavango and Zambezi Regions, but closed down with the harvesting ban for logs. However, small scale sawmilling is done on the basis of *prosopis*, e.g. in Leonardville. The timber in width between 15 cm and 35 cm is used mainly for furniture production, but after treatment also for outside construction, stairs etc.

Due to the limited availability of stronger logs from *prosopis*, additional capacities for sawmilling are not required although the demand for the end products cannot be satisfied. The current employment creation is limited and the harvest of logs contributes to de-bushing only when also smaller bushes are harvested. Some producers of sawn timber produce in parallel charcoal, a positive example of combined utilisation of encroacher bush with value addition; the effect on de-bushing is currently limited (less than 100 ha p.a. estimated).

The combined production of sawn timber, the special demand for this species and the high value addition (e.g. furniture production) are reasons why small scale sawmilling based on *prosopis* is feasible.

d) Prospects for a Sawmilling Industry in Namibia

Despite the enormous demand considering Namibian imports of timber for construction in the value of N\$192 million in 2014 (NSA, 2015) and the available know-how, there are no prospects for larger scale local production. Restrictions stem from the small diameters of invader species, which are allowed and should only be harvested for environmental reasons. The only feasible value chain is based on *prosopis* wood and is already developed in very limited quantities, due to the lack of sufficient larger *prosopis* resources.

3.4.2 Poles

a) Products, Properties and Production Process

The products considered with regard to de-bushing include poles of different sizes and uses, mainly for construction of traditional houses, fencing but also special applications such as garden bed edge-



ings. Large poles, e.g. for telephone lines are excluded here, because such dimensions are not available from encroacher bush.

Normally the market requires the following (not always in Namibia, e.g. for traditional building and fencing):

- Standardised straight length and diameters.
- Differentiation by timber species.
- Resistance against decay and termites because of the outside uses.
- De-barked products.

In the formal trade worldwide (including imported poles in Namibia), these requirements are easily fulfilled. Nearly all commercial poles are from man-made forests with clear separation by species and age (determining the dimensions) and straight growth. After harvesting and cutting to length, the poles are manually or mechanically de-barked, in most cases already in the forest. Thereafter, they are transported to wood protection plants where they are treated under high pressure, e.g. with salt that enters the cells. Such poles have a guaranteed lifetime of up to 30 years.

b) Namibian Resources

After firewood, poles are the main product currently produced from Namibian forests and encroacher bush. Pieces from about 5 cm in diameter can be used, i.e. pole harvesting competes with other existing or possible uses, such as charcoal or chip production.

Disadvantages of pole production from invader bush are

- the growth form which is in most cases not straight, and
- the mixture of different species, which requires sorting for certain end uses.

On the other hand it is an advantage that some species are resistant to decay and termites (e.g. terminalia and mopane).

c) Current Operation in Namibia

Traditionally poles are harvested wherever needed and available also in diameters above the allowed harvesting limit. After harvesting and cutting into length, they are often used directly for construction or fencing, but also different simple forms of further processing and value addition are applied. For example:

- Manual de-barking or burning to remove the bark.
- Grooving to receive strands for the fencing wire.
- Painting the ends with tar to delay rotting.
- Cutting off-cuts into standard short lengths for garden bed edgings, which are sold directly or even further processed, for instance by binding them together with wire.

Poles are mainly used by communal and commercial farmers, but are also sold informally, whilst formal sales are very limited. The only known commercial resale of from Namibia poles is that by Pupkewitz Megabuild in Windhoek, Katutura.

Due to the informal character of the production and marketing of poles, neither the quantities nor the number of producers or employment and income generation are known.

d) Demand Market

The demand on the domestic market is huge, particularly at commercial farms and in communal areas. According to UNDP/MET (2007), Namibia produces 334 000 m³ of poles per annum; moreover,



wooden poles to the value of about N\$ 2 million are imported (NSA, 2015). In addition to wooden poles, farmers use mainly imported poles from metal and synthetic material for fencing. The contribution of locally made poles to the formal market is very limited and some retailers (Pupkewitz Meg-abuild, nurseries) indicated that they could sell more poles.

e) Strengths and Challenges of Namibian Pole Production

STRENGTHS

- High local demand.
- Resources available at low cost.
- Some species resistant against decay and termites.
- No skills required.
- Very low investment.
- Potential of income generation for disadvantaged people as self-employed or SMEs.
- Few additional inputs required.

CHALLENGES

- Competition from imported wooden poles and poles from other materials.
- Hardly any formal value chain in place.
- Business opportunity often not known.
- Harvesting sometimes in environmentally sensitive areas and even of protected species.
- Seldom really straight.
- Opportunity not yet explored with mostly unreliable supply and production not in line with demand requirements (e.g. no grading by species, limited treatment).

f) Prospects of Poles in Namibia

Poles have a stable demand in Namibia that will continue in the future. The prospects for a local production can be seen positively. Most of the technical problems can easily be solved, for instance debarking, separate sales of poles from resistant higher value species and full painting with tar. This will already increase the value, although the disadvantages versus important wooden poles (limited straightness, no pressure treatment) have to be balanced by the prices. Another option to increase the value of the harvested poles is a planned cutting by lengths (which is not known at all), considering right from the beginning the different products demanded to reduce the waste.

Furthermore, the market share of locally produced poles can be considerably increased if local entrepreneurs are informed about opportunities and mobilised to start formal pole businesses in an organised market. This requires some training, e.g. in marketing and a mobilisation campaign.

3.4.3 Wood-Cement Bonded Bricks and Boards

Construction materials based on wood and cement are produced in numerous types and forms within the two main groups bricks/blocks and boards/panels. The wood particles are essentially an organic aggregate in the concrete mixture, while cement acts as wood particle binder.

a) Production Process

The manufacturing methods are essentially the same for the different products based on cement and wood particles. A typical production process, after harvesting of the wood, consists of the following steps:



- The wood is de-barked, chipped and fine grinded. The wood particles are graded and classified as coarse and fine. Coarse material is used for the inner board layer, fine material for outer layers.
- The particles are dried to a moisture content of about 6%.
- The wood particles are mixed with cement, chemical additives and water in a mixing drum. Additives are used for example as curing accelerators and to increase the fire resistance of the product.
- The mixture is conveyed to a forming machine, where it is distributed and deposited on steel plates, previously sprayed with an oil to prevent bonding between the steel plate and the board, to form the end product. The finest particles contact the steel plate, the coarse fraction forms the middle layer and the surface consists of fine particles.
- The plates with the mattress are stacked to a certain number depending on the thickness of the products to be manufactured. The thickness of the final board can vary between 8 and 60 mm. The stack is then compressed on the trolley that transports it, forming the boards. The set of boards that is pressed is called the batch.
- The batch is placed in a curing chamber, which accelerates the curing process. Under steam, pressure, humidity and time, the product is hardening and can be processed further.
- The press is removed from the batch and the boards are separated from the plates.
- The boards are cut and then stacked and placed in curing which takes some days. During this time the boards achieve their final technical properties. This process can be accelerated by passing the boards through a drying tunnel, which reduces its humidity.

The wood content of the end products varies between 25% and 13% of the weight, depending on the product, with bricks having a higher and panels a lower wood content.

Although small capacities of 10 000 m³ p.a are reported (NDC, 2002), economically viable plants in industrialised countries have an output of 50 000 m³ p.a. and require investments of €20-30 million.

Major technical challenges of production in Namibia are the timber species. All commercial plants are operating on the basis of softwood without bark. Several hardwoods might not be suited. Sugars present in wood impede curing of the cement and resulting boards do not solidify. The bark content of Namibian bush chips causes the same problems. Chemical additives may be used (e.g. sodium chlorite, aluminium sulphate) to overcome this problem by acting as cement curing accelerators (NDC, 2002).

b) Products, Uses and Properties

Numerous products are manufactured on the basis of wood and cement, such as solid or hollow bricks, panels and prefabricated walls. They are used as outdoor construction material, for partitioning, ceilings, acoustics applications, wall cladding, roofing and shuttering.

A major application in Namibia could be the construction of both, single or double-storey houses. Double skin cavity walls are assembled, using wire clips and no framing needs to be used.

Wood-cement based products are commonly accepted by the markets, in particular in industrialised countries, because of their excellent properties exceeding those of conventional building materials. They have an excellent thermal insulating capability and the products have a low or non-combustibility, a characteristic of extreme importance in the construction industry. The products also have excellent sound insulating properties. In the case of coarse-surfaced porous boards, these can easily be plastered and they normally hold the plaster well. Panels with compact surfaces have excellent durability against exterior exposure and it was found that these boards also have excellent resistance against fungal attack. Additional important properties of these products are that they can be worked by normal woodworking tools and are environmentally friendly.



c) Resources

Sufficient raw material from encroacher bush is available in Namibia, but the following challenges have to be considered:

- The normal resource basis is softwoods and most hardwoods are not suitable or require additional additives in the production process. Encroacher bush consists only of hardwoods and their properties are not known, i.e. it is necessary to determine first the wood properties of the species.
- It is assumed that not all (if any) species can be used, i.e. sorting by species is required to eliminate those which are not suitable (e.g. too high sugar content).
- Bark hampers the production or even makes it impossible. Therefore, it must be tested whether any bark content is acceptable or the wood must be de-barked. If possible at all, this together with sorting and the required additives increases the costs.
- Only part of the bush, namely the woody material can be used. Considering the low yield of encroacher bush compared to man-made forests the raw material costs may not be competitive.

An advantage of a Namibian production is the availability of cement. Thus only additives need to be imported.

d) Experience

The production of different products on the basis of wood and cement is known and commercially proven over a long time. Also the Council of Scientific and Industrial Research (CSIR) in South Africa did extensive research in terms of product development and application in this regard, and the products are established in the RSA. However, practical and research experience covers mainly softwoods. The Technical University in Dresden/Germany was involved in a research project in Vietnam that included the use of some wood species, also acacia mangium. With organic binders (UF and PF resin) products were prepared on laboratory scale.

e) Demand Markets

Statistical data about the demand of the respective products are not available, but it is a matter of fact that the demand is steadily increasing in particular in environmentally oriented industrialised countries. Main reasons are that the production is based on natural resources and the products have excellent properties.

In Namibia the products are hardly known, but based on a model calculation already in 2002 a domestic demand of 40 000 m³ p.a. was estimated (NDC 2002). Due to the fact that with the exception of cement most building materials are imported, it should be possible to mobilise the demand especially amongst high-end customers. Depending on the price, also the low cost housing sector could be an option for panels, since they can easily be assembled.

f) Major Strengths and Challenges

STRENGTHS

- Excellent properties, e.g. with regard to acoustic and thermal insulation, vapour diffusion, resistance to moisture penetration, durability etc.
- Panels easy to assemble and workable with normal woodworking tools.
- Increasing demand in industrial countries and potential in Namibia.
- Possible substitution of other imported building materials.
- Main input materials (wood, cement) locally available.



- Value addition to both cement and wood from encroacher species.
- Known and applied technologies available.
- Competitive costs compared to other building materials³⁴⁾.
- Employment creation for about 100 people at a plant with 50 000 m³ output.

CHALLENGES

- Difficulties in processing of hardwoods and bark; suitable species from encroacher bush to be identified and sorted from the harvested biomass.
- Additives in small quantities to be imported.
- High investment (€20-30 million) for a minimum output of 50 000 m³.
- Most personnel to be semi-skilled and skilled; 5-10 high-skilled employees required.
- Only wooden parts of the bush useable, i.e. possibly competition to other uses.
- Limited effect on de-bushing since only 13-25% of the weight of the material is wood.
- Considerable marketing required to introduce the “new” products in Namibia.

g) Prospects for Wood-Cement Bonded Bricks and Boards in Namibia

Wood-cement bonded products might be an interesting option for the Namibian construction sector, because of their excellent properties. The latter and the fact that the end products are easily workable and environmentally friendly are the reason for the increasing demand in industrialised countries. The in principle positive prospects – also for a production in Namibia – may be hampered by technical problems in particular with regard to the processing of hardwood timber species from the Namibian encroacher bush. However, due to the uniqueness of the products and assumed demand, it is recommended to further investigate the possibility to establish a plant in Namibia. This would require the following actions step-by-step:

- Determine the properties of the invader species and select suitable ones.
- Test the production with the selected species considering also the effect of the bark content.
- Prepare a full feasibility study considering the competition from South Africa and the possibilities to market products locally and in neighbouring countries, which are of good quality but may not comply with the international standards.

It is strongly recommended to involve an international partner with experience in the production of wood-cement bonded products. This partner should be identified and mobilised after step (i) and should be involved latest in the preparation of the feasibility study.

3.4.4 Wood-Clay Bonded Bricks and Boards

Clay is the world’s oldest mineral building material. More than 100 years ago it has been substituted in developed countries and was mainly used for traditional housing in several developing countries by the poorest segments of the population. However, currently clay is experiencing a renaissance in some industrialised countries. In mixture with biomass, bricks/blocks and boards/panels are used as construction material.

a) Resources and Production Process

It is a major advantage that clay is available nearly everywhere, also in Namibia. However, the consistency of clay is different and not all material is suitable for modern application in construction. The suitability of Namibian clay deposits is not known.

³⁴⁾ According to NDC (2002); needs to be verified.



Clay can be mixed with cellulose fibres such as jute, reed, straw or wood chips to produce blocks or panels for construction. Other organic materials are more common than wood for clay bonded products. There is only limited industrial experience with softwood and none with hardwood similar to the Namibian encroacher species.

The production processes are widely varying depending on the use of the final product. Mostly hand-craft technique is used. In industrial or semi-industrial manufacture, the process is similar to wood-cement bricks. The common production can be summarised as follows:

- Clay is mixed with wood particles or fibres together with water.
- The mixture is filled into a forming chest and pressed. The density of the final product varies between 0.9 and 2.0 kg/dm³, primarily depending on the ratio clay to wood. Industrial manufacturing uses extrusion technique to form a continuous strand which is cut after forming.
- Raw products have to be dried carefully to prevent cracking.

b) Uses and Properties

Clay bonded bricks and panels are used for ecological construction purposes mainly indoor, but also outside. In the latter case, surface treatment is required since clay is not water resistant and must be protected from direct contact with water. Faulty workmanship can result in mould. Other challenges include shrinking or expanding with various moisture levels, a process that can result in cracks.

Such disadvantages have to be seen in light of several strengths. This building material offers high thermal and noise insulation (if the walls are thick enough) as well as moisture conditioning. Moreover, repairs are relatively easy.

c) Employment and Skills Requirement

Production of clay bricks and boards as well as the actual building with these materials is fairly labour intensive. On the other hand the material is sensitive towards incorrect workmanship, i.e. experience and skills in handling are required, involving a high number of qualified specialists.

d) Demand Markets

In industrialised countries modern construction material based on clay targets environmentally conscious, unconventional customers seeking an innovative image. This is a small but growing niche market.

It is doubted that such a market exists in Namibia. On the one hand clay has a negative image of traditional dwellings and on the other hand the products are more expensive than competing ones, in particular due to the costs of specialists required.

e) Major Strengths and Challenges

STRENGTHS

- Environmentally friendly, no chemical processes involved.
- Availability of the required resources.
- Labour intensive production and construction.
- High value addition.
- Some excellent properties such as insulation and moisture conditioning.
- Buildings relatively easy to repair.



CHALLENGES

- Less industrial experience than with competing products such as cement bonded bricks and boards; also generally with the use of wood and in particular regarding hardwood similar to Namibian encroacher species.
- Suitability of Namibian clay not known.
- Properties not competitive vis-à-vis competing cement bonded products (e.g. water resistance).
- Highly qualified personnel required that is not commonly available in Namibia.
- Small niche market in industrialised countries; hardly any demand in Namibia expected (negative image, high prices).

f) Prospects for Clay Bonded Bricks and Boards in Namibia

Due to the overriding challenges (suitability of local resources, required qualified personnel, limited international experience) and the limited competitiveness, the production of wood-clay bonded products is currently not recommended for Namibia.

3.4.5 Wood-Charcoal Bonded Bricks***(a) Production Process***

Similar to bricks from cement or clay mixed with wood, the wood can also be substituted by charcoal. Such a product is said to have even better insulation effects and an excellent strength.

b) Operation in Namibia

One charcoal producer in Namibia started to produce wood-charcoal bricks in a mainly manual process some years ago. The first results were very promising. The end product was attractive because it could be offered in different colours depending on the percentage of charcoal and cement. Also the strength was excellent at the end of the production process. However, after three months the bricks lost their original strength and were no longer suitable for construction. Since the reasons could not be identified the production was ceased.

(c) Prospects for Wood-Charcoal Bonded Bricks in Namibia

Based on the negative experience a production is not recommended. Even if the technical problems could be solved, the feasibility of such a project is doubted. The end product has to be more expensive than competing bricks with biomass since charcoal has higher value than wood chips. In addition, the introduction of such a new product will require considerable marketing efforts. These disadvantages clearly outweigh the strengths, such as exclusive use of locally available resources and low investment as well as high employment creation of a semi-mechanical production.

3.4.6 Wood-Sand Boards

The University of Namibia (UNAM) and Leibniz-Institut für Neue Materialien (INM) from Germany recently started the joint implementation of the project “Natural and Mineral-based Binders for Ecological Building Materials” (NaMiBIND). This pilot project is budgeted with about €350 000 and mainly financed (70%) by the German Federal Ministry of Education and Research (BMBF). The project has two main aims, namely

- development of adhesives from Namibian natural resources and
- production of sustainable building materials.



a) Envisaged Products and Resources

It is planned to develop an alternative adhesive based on two different natural resources (INM <http://www.inm-gmbh.de>):

- Sand shall be turned into glass using simple, proven processes with potassium carbonate. This glass shall then be powdered and converted to a “water glass suspension”.
- In addition natural ingredients in encroacher species, mainly acacia³⁵⁾, shall complement the binder.

These adhesives shall be used to produce simple construction boards similar to particle boards. Based on information of INM, it is hoped that the panels are highly heat resistant, water repellent and antimicrobial.

It is an advantage that the resources are abundantly available in Namibia. Within the research project it is also planned to analyse the selected timber species systematically and first of all establish, which components, for example rubber or phenolic resins, they contain and how – carefully extracted and combined – they could be suitable for flame resistant and durable building materials (<http://www.inm-gmbh.de>). INM indicates already that only a few species might be useable, i.e. sorting by species is required.

b) Experience

Due to the limited knowledge about the chemical properties of Namibian encroacher species, NaMiBIND will provide valuable additional experience. This applies also to the production processes to be developed.

It should be considered that the process to gain adhesives from sand is known in the timber industry, but not commercially applied because of the costs and – even more important – because conventional tools are not suitable to work with the panels.

Also regarding the extraction of adhesive from wood some experience is available, e.g. in RSA and Chile, but based on other than the Namibian species. Technically these projects were successful, but not economically viable. Therefore, they are not applied commercially.

The NaMiBIND project should clarify whether it is feasible to produce adhesives and boards based on the specific Namibian resources.

c) Prospects for Wood-Sand Boards in Namibia

At this point in time it is not possible to assess the prospects. However, even if NaMi-BIND proves the technical and economic feasibility, it may still take years until an industrial production might be implemented.

3.5 Products Mainly for Indoor Uses

3.5.1 Particle Boards and Oriented Strand Board (OSB)

a) Products and Production

Particle boards were one of the most important panel products worldwide. Today they are more and more replaced by OSB, which is fairly similar to particle boards. OSB is produced from larger flat chips

³⁵⁾ It is assumed that tannins shall be used which are included to a remarkable extent in acacia spp.



(10-15 mm long, 2-3 cm wide), called flakes. They have a higher bending strength and are more attractive, thus they are more suited for interior construction (wall panels), furniture production etc. Particle boards and OSB are the most important panels for indoor uses with a world production of over 99 million m³ (FAO, 2013). Also in Africa some plants were established (notably in RSA), however, African plants currently only make out 0.8% of the world production. As a typical mass product, particle board and OSB plants nowadays require huge capacities (from 500 000 m³ upwards) to be competitive. Moreover, they are operated fully automatic by a limited number of employees including highly qualified specialists.

b) Resources

Particle boards and OSB are mainly produced from softwood (also in RSA). Hardwood can only be used if their weight is lower than 550 kg / m³ since the market requires low density boards and heavier species affect also the mechanical properties. Bark is not tolerated since it affects the properties and appearance of the boards. Also small branches are not suited to form acceptable particles or flakes.

The species from Namibian encroacher bush fulfil none of the resource requirements for particle board and OSB production. Wood density is too high which results in heavy-weight boards. Bark content of the material impairs properties and appearance of the board. Moreover, the exclusion of smaller branches would limit the effect on de-bushing.

c) Demand Markets

The huge world production underlines the demand for particle boards and OSB. This is also confirmed by the world trade with about 26 million m³ exports and 25.6 million m³ imports in 2013 (FAO, 2013).

However, both products are not established in Africa. The whole continent imported only 145 000 m³ in 2013 and Namibia only 20 290 m³ (FAO, 2014), i.e. 4% of the annual production of one plant with the minimum capacity.

d) Prospects for Particle Boards and OSB in Namibia

The production of particle boards and OSB cannot be recommended at all for the use of Namibian encroacher bush, because

- the resources are not suitable,
- the demand is very limited all over Africa, and
- the economies of scale require huge capacities.

3.5.2 Medium Density Fibre Boards (MDF)

MDF are worldwide the second most important panels with a production nearly as large as particle boards and oriented strand boards (OSB), namely about 88 million m³ in 2013 (FAO, 2014).

(a) Production Process

A typical production process after harvesting, de-barking and chipping consists of the following steps:

- Wood chips are steamed before passing a refiner for defibration. Resulting fibres are sorted according to size. The coarse fraction is used for the inner layer of the board, the fine fraction for the outer layers.
- After defibration the fibres are dried, e.g. in a drum dryer to less than 10% humidity and glued with 10-13% urea formaldehyde (UF) or a mixture of UF and melamine resin or even pure melamine formaldehyde glue, depending on the final use of the board.



- Glued fibres are fed into a forming machine to form a mat which is pre-pressed before final pressing in a continuous or multi-opening hot press is performed. In the latter case, the continuous mat has to be cut into sheets before pressing. Board density varies from 650-850 kg/m³, thickness from 2-60 mm.
- After pressing the boards are cooled, trimmed and sanded and are ready for selling or can be laminated.

The normal capacity of a modern MDF plant is 500 000 m³ output per annum, requiring an investment of about €200 million. However, also smaller plants with capacities of 75 000 – 100 000 m³ can be viable depending on the material and labour costs as well as local market prices.

(b) Properties and Uses

MDF boards are characterised by a smooth, more homogenous structure than particle boards. This allows easy lacquering, laminating and printing.

According to their properties, the most important applications are furniture production, building boards and laminates for furniture and flooring.

(c) Resources

Main input materials for the MDF production are wood chips also from smaller branches. From encroacher bush in Namibia sufficient raw material is available, but the following challenges have to be considered:

- Preferred raw material for MDF is softwood of which fibres are longer than from hardwood and their density is lower. Hardwoods can be used in a mixture. Higher hardwood shares require more intensive gluing and the dimension stability of the board is affected.
- Generally, high density of the wood is a draw back with regard to chipping, refining and (high) board density. MDF made of this material is more expensive compared to MDF from pines and will have problems in the international market penetration.
- Bark reduces the quality of the boards. For furniture production bark is not accepted at all since with sanding the bark may come off and reveal small holes.

In addition to wood, glue is required which is easily available but needs to be imported. The same applies to laminates.

(d) Experience

MDF production is well established worldwide and the required technologies are readily available.

There is no production in Namibia, but tests have been made by one entrepreneur in Outjo. The following experience was made:

- Mainly thin branches were used because it was easier to process them and because the stronger wood was used for charcoal production.
- Fibres were produced with a hammer mill and afterwards cooked and washed.
- The fibres were put manually in a form and pressed without using additives (glue).

According to personal information provided, the tests did not work with mopane but fairly well with acacia. This may be explained by the natural binding properties of acacia spp. The strength of the products was tested in South Africa with satisfactory results.

Although the project was not developed to an industrial scale, due to a lack of financial means, it indicates at least that a production of fibreboards might be possible from invader species even with



bark. However, it must be assumed that the quality does not comply with international requirements.

e) Demand Markets

The huge world production underlines the demand for MDF. This is also confirmed by the world trade with about 16 million m³ exports and 15 million m³ imports in 2013 (FAO, 2014).

Africa has a small production (226 000 m³ in 2013), but MDF boards are much more established than the competing particle boards and OSB. The continent imported five times more MDF (738 000 m³ in 2013). An exception seems to be Namibia with imports of 20290 m³ particle boards & OSB but only 210 m³ of MDF according to FAO (2014).

f) Effects on De-bushing

A small plant of 75 000-100 000 m³ p.a. would require 110 000-140 000 m³ of woody biomass. Since only selected species can be used the effects on de-bushing are limited. However, it is an advantage that – according to available information – also smaller wood can be processed. This means it might be possible to combine harvesting for MDF and for other value chains (requiring stronger dimensions).

g) Major Strengths and Challenges

STRENGTHS

- Known and applied technologies available.
- Selected invader species suitable for production, including small branches.
- Employment creation for about 100 people.
- High demand in other African countries (export possibilities).
- Possibly import substitution of comparable materials.
- High value addition by use in the furniture industry.

CHALLENGES

- For penetration of the world market capacities of 500 000 m³ p.a. required (investment about €200 million); smaller capacities available (75-100 000 m³ p.a.) and might be feasible.
- Most personnel to be semi-skilled and skilled; 5-10 highly skilled employees required.
- Hardwood from invader bush less suitable than softwood (lower quality higher glue content, i.e. costs).
- Only selected species suitable, i.e. sorting required.
- Bark reduces board quality.
- Glue and laminates to be imported.

h) Prospects for MDF Production in Namibia

Competitive production for the world market is not possible, since MDF based on Namibian encroacher bush with its hardwood cannot fulfil the international quality requirements. Furthermore, production for the world markets would require a plant with an output of 500 000 m³ p.a. and investments of about €200 million.

However, a production in small capacities could be envisaged, targeting the domestic market and other African countries. In this case it might be possible that also lower quality requirements are accepted and such a production could substitute imports of competing products such as particle boards.



Considering a MDF production in Namibia would require the following actions step-by-step:

- i. Determine the properties of the invader species and select suitable ones.
- ii. Test the production with the selected species, considering also the effect of the bark content and the glue requirements.
- iii. Investigate the domestic market and the demand in other African countries with emphasis on quality requirements and possibilities to substitute other wood based boards.
- iv. Prepare a full feasibility study for a plant capacity of 75 000-100 000 t p.a. and compare the viability with large scale international plants based on softwood.

3.5.3 Gypsum Bonded Fibre Boards

a) Resources and Production

Gypsum bonded fibre boards are produced from recycled waste paper. Theoretically also wood fibres could be used. The typical production process includes the following steps:

- Waste paper is sorted and impurities are removed. The paper is shredded and milled to produce fibres.
- Fibres and gypsum are mixed with water in a mixing drum and fed into a forming station. The former distributes the wet material homogeneously on a continuously running sieve belt forming a mat.
- The mat is partly dewatered and densified in a sieve belt press.
- The mat passes a drying tunnel and is finally cut into boards which can be sanded to homogenise its surface.

If wood would be used as input material, wood chips are required first. They have to be steamed before passing a refiner, i.e. additional production steps are required.

A competitive plant in industrialised countries has a capacity of about 100 000 m³ p.a., requires an investment of about €50 million and employs about 200 people.

b) Uses

Gypsum bonded fibre boards target specific uses, namely indoor construction of walls and ceiling. Their main advantage is the high fire resistance but the water resistance is low due to the high content of water soluble gypsum.

c) Prospects for Gypsum Bonded Fibre Boards in Namibia

Although the products are well established in some industrialised countries, a production in Namibia should not be considered because of the following reasons:

- In addition to gypsum the normal raw material is waste paper. Experience with wood is limited and not existing with regard to Namibian invader species.
- Even if wood can be used the production requires additional preparatory processes and will therefore not be competitive versus paper based boards.
- Competitive capacities (100 000 m³ p.a.) and investment (€50 million) are very high.
- The product range is limited and local product knowledge hardly existing. The demand for indoor construction of walls and ceilings could be satisfied by medium density fibre board with the advantage of more diversified applications (e.g. also furniture production).

3.5.4 Wood – Plastic Composites (WPC)

WPC contain a large group of products, and the mixed use of the two materials is relatively new also in industrialised countries.



(a) Production Process

WPC consists of a mixture of saw dust like wood particles and polypropylene or polyethylene. The weight ratio of wood and plastics varies between 70 to 20% and 20 to 80%. Market products contain at least 30% plastics.

The production process comprised the following steps:

- The bush material is delivered in form of medium-sized chips and twigs (2 cm²). The chips have to be dried to a moisture content not exceeding 8%. The two alternatives used are a curing oven (high energy consumption, very effective) or mash-wire with continuous rotation for wind drying.
- The dried chips are shredded to the desired size (3 mm powder) depending on the intended surface appearance of the finished product.
- The shredded fibres are pelletised (6-5 mm diameter); through the pelletising of the fibre a better mixing property of the fibre is achieved.
- All raw materials are dozed at a dozing unit and directly fed to the feed chute off the extruder machine.
- The extruder machine mixes and melts all material and presses it in moulds. Alternatively of this “extrusion moulding”, “injection moulding” may be applied.
- After the material is moulded, it is cooled down and cut to pre-programmed lengths.

The investment for the equipment and machinery varies considerably depending on the degree of mechanisation, whether pellets are purchased or pelleting has to be done at the plant, etc. A huge cost factor is the moulds, which determine the shape of the end product. One mould costs, between N\$50 000 and N\$200 000, for extraordinary shapes even up to N\$500 000. Considering these factors, investments between N\$10 million and N\$30 million are required.

(b) Products, Uses and Properties

Depending on the moulds, a huge variety of products can be manufactured in a WPC plant, for example

- poles or droppers for fencing, vineyards etc.,
- sticks and handles for tools,
- boards for kitchen tables and cupboards,
- school furniture,
- interior design parts for cars,
- strips for rooms such as cornices and skirting,
- outdoor flooring.

Within these product groups nearly every design can be offered. This applies not only for the shapes, but also for the appearance of the surface; thus for example luxury cars use WPC with an appearance like wood for interior design.

The reason why WPC substitutes similar products from wood is their properties. The products are highly water resistant, stable against shrinking and biodegradation. Furthermore, they can be worked with normal wood working tools.

(c) Resources

Softwood and hardwood can be used as filler for WPC. Tests with biomass from Namibian encroacher bush revealed that the mixed species composition is suitable as input material. It is an added advantage that not only selected parts but the entire bush can be used including even leaves.



In addition to wood, plastic products are required as input material. Although being imported, they are readily available in Namibia.

(d) Experience and Demand

Although being relatively new, the WPC industry is well established in industrialised countries.

In Namibia a producer of polymer products, who is in the market for a long time, conducted comprehensive research and tests regarding WPC production based on encroacher bush. He provided the woody material in form of chips, and different products were manufactured in Germany. According to personal information from him, the end products were up to standard. However, the implementation of a WPC factory was hampered by a lack of information about the demand since a market survey is quite complicated considering the huge number of sometimes totally different special products. At this stage the project was ceased and also no financial evaluations were conducted. According to research of NDC in 2002, the products are more expensive than similar ones from other material (e.g. wood, foam). This is also the case with regard to industrial produce in Europe, however, they are accepted by the market due to their excellent properties.

e) Major Strengths and Challenges

STRENGTHS

- Excellent properties, e.g. regarding water resistance, shrinking, biodegradation; workable with normal woodworking tools.
- Mixed species and all parts of encroacher bush useable according to local information.
- Known and applied technologies internationally available.
- Considerable know-how and experience in polymer industry available in Namibia.
- Large, variable product range.
- Import substitution possible.
- High value addition.
- Flexible investment (N\$10-30 million).
- Employment creation for 20-25 people including 5 professionals.

CHALLENGES

- Plastics to be imported.
- Product specific moulds fairly expensive.
- Considerable market research required to determine optimal product range.
- Products relatively expensive, i.e. marketing efforts required to introduce “new” products in Namibia.

f) Prospects for WPC in Namibia

WPC might be an interesting option for special products of indoor construction, furniture production and agriculture in Namibia. The excellent properties and the fact that the end products are easily workable are the reason for the increasing demand in industrialised countries.

The advantage of the huge variety of WPC is also the major drawback for the implementation of the production in Namibia. Most products target niche markets with a demand currently not known, i.e. a direct investment would be extremely risky despite the technical know-how available in Namibia. Therefore, it is recommended to further investigate the possibility to establish a plant in Namibia. This would require the following actions step-by-step:



- i. Verify the suitability of mixed invader species and all parts of the bush for the WPC production by limited tests of independent institutions.
- ii. Determine the production costs for a very limited number of products and compare them with similar competing products on the Namibian market.
- iii. Identify specific products (by a thorough market survey) which could be produced in Namibia and determine the demand possibly including neighbouring countries.
- iv. Prepare a comprehensive feasibility study.

Ideally a WPC production should be implemented by or in cooperation with the existing plastic industry in Namibia, since their know-how would be an asset for the project. Therefore, it is recommended to identify and mobilise potential partners and involve them already in the planning phase from step (ii) onwards.

3.5.5 Blockboards

(a) Production and Uses

Blockboards are produced from small strips of sawn timber which are glued together for panels of different sizes. Thereafter the boards are laminated, e.g. with wooden veneer.

Originally blockboards were developed to use residues, e.g. from sawmills, and convert them into high value products. Nowadays they are established products, in particular for joineries, and are produced in fairly sophisticated special factories.

(b) Resources

Since blockboards are produced from small strips of sawn timber, they could be an option to add considerable value to the wood from encroacher bush. However, based on the Namibian species, they would be too heavy, e.g. for furniture production. Therefore, they are currently only produced from coniferous wood. Furthermore, for blockboard production only the biggest part of the invader species could be used, i.e. the effect on de-bushing is negligible. Another drawback for a Namibian production is the availability of veneer which is hardly on the market and must therefore be imported.

(c) Demand Markets

In contrast to several other countries, Namibian joineries are hardly using blockboards. They prefer directly competing products, such as particle or fibre boards. The reason is that these products are readily available in Namibia despite being imported.

(d) Prospects for Blockboards in Namibia

A blockboard production from invader bush should not be considered – despite the high value addition – because of the following reasons:

- There is hardly any demand because Namibian joineries are not used to this but to competing products.
- Although technically possible, it is doubted that a production would be viable considering the costs of sawing strips from the relatively small wood available in encroacher bush.
- The invader species are too heavy for blockboard production.

3.5.6 Furniture

Furniture production from wood of encroacher species would be of high interest, because it would result in the highest value addition.



(a) Production and Experience

Wooden furniture is mainly produced on the basis of imported sawn timber and/or different panels (e.g. particle or fibre boards). Namibia has hundreds of furniture producers from informal businesses on village level up to semi-mechanised medium size producers, i.e. local experience is available. It is a further advantage to the high value addition that furniture production is fairly labour intensive and requires skills as offered for example by most local vocational training institutes.

Experience with invader species is also available in Namibia. However, this is limited to one species, *prosopis*. The wood is harvested and sawn by a few suppliers and then further processed in several joineries.

(b) Resources

Several species from encroacher bush could be suitable for special uses requiring high density wood, such as table tops, book shelves and case fronts. However, a furniture production based on invader species is hampered by the following facts:

- In order to produce sawn timber as input material for the furniture production, bigger sized logs are required (normally with diameters above 50 cm). They are hardly available in encroacher bush and if, they shall not be harvested.
- The sawn timber must have homogenous properties and an attractive appearance. This means that furniture producers require sufficient quantities of individual species. This requirement can hardly be fulfilled by the Namibian encroacher bush with its mixed species.

The sawn timber must have special properties or a special attractive design. Otherwise its price must compete with imported timber from mass production; this is not possible on the basis of invader species.

An exemption is *prosopis* (mesquite), a species which originally comes from the south-western USA, and has become naturalised. It is an extremely invasive species, widespread in central and southern Namibia and abundant in the river systems of the south-east. *Prosopis* occurs also in larger diameters (up to 35 cm), which seem to be allowed to be harvested possibly because it is an exotic species. This special situation and the fact that *prosopis* is seldom mixed with other species and that its properties are known, are the reason that *prosopis* is sawn in small quantities and further processed to furniture.

(c) Prospects of Furniture Production from Invader Species

Despite the enormous demand and the available know-how, prospects to produce furniture from invader species are restricted by the small diameter of bushes that are allowed to be harvested. Moreover, individual species are often not available locally in sufficient quantities to allow a competitive production of sawn timber.

An exemption is the furniture production from *prosopis*, but this value chain is already developed in limited quantities due to the lack of sufficient larger *prosopis* resources. Therefore, an additional furniture production based on resources from encroacher bush is not recommended.

3.6 Agricultural Implements

Several products from de-bushing could contribute to the agricultural sector. This includes poles and droppers directly harvested in the bush or as wood-plastic composites produced with wood particles. Moreover, animal feed, compost and bio-char can be produced from encroacher bush.



3.6.1 Animal Feed

Agriculture in Namibia is traditionally and commercially dominated by livestock. One of the major challenges is the availability of feed in the veldt because of over-grazing and periodical draught. Therefore, production of animal feed from encroacher bushes would be an ideal value chain.

a) Current Knowledge and Experience

Production of animal feed from encroacher bush is a controversial point of discussion. It is only generally accepted that animal feed can be produced from invader species and that

- not all species are suitable as feed because extractives like alkaloids and phenols can be harmful to cattle;
- the main components of wood, cellulose and hemicelluloses, can be digested by the micro-organism in the rumen of livestock.

Differing views further cover the following:

- the question whether the whole edible species can be used for fodder production or only parts of them,
- the importance and possible digestion of lignin contained in wood,
- which production processes are required.

The current different knowledge and practical experience is demonstrated by the following examples:

- Rothauge (2014) reports besides others that “No formal chains that add value to bush by using it in animal feedstuffs are operational in Namibia. ... because lignin, by mass the dominant ingredient in wood biomass, is completely indigestible ... The only digestible matter in bush biomass comes from un lignified twigs and branchlets from the leaves, fruit and seeds attached to branches and from whatever sap the bush biomass may contain”. He also mentions that tannins contained in the wood are indigestible. Rothauge therefore concludes that for animal feed either very young and small bush (from re-growth), or only the outer layer of a bush canopy shall be harvested separately and used for fodder production.
- Some farmers produced during draught survival feed from encroacher bush. Although not done on a scientific basis, but with a “trial and error” method, some results are remarkable and contradict the above information. This is demonstrated by a farmer from the Outjo district. His production for survival of his own 900 cattle is characterised by the following³⁶⁾:
 - Utilisation of selected species only. For example, mopane is not suitable in contrast to purple pod terminalia.
 - Utilisation of the whole bush including all wood, although bush with leaves provides better results.
 - Drying of the bush to avoid attacks by fungus and chipping it finally with a conventional hammer mill.
 - Mixing the bush material with sodium hydroxide (NaOH) and water, and leaving it in that solution for 2-3 days.
 - Adding molasses, salt, minerals and mixing it again.
 - Feeding the cattle with fresh, wet feed (like silage).

The example of utilising the whole invader species contradicts the opinion that lignin, which forms 20-30% of the woody biomass, is completely indigestible (Rothauge, 2014). According to other experts, lignin only hampers the digestion process (NDC, 2002). The common belief that lignin adversely affects animal digestive processes is also questioned by the only known commercial producer in southern Africa, WES enterprises from Thabazimbi in RSA. This producer claims that lignin has little effect on the digestive process.

³⁶⁾ Based on personal information and Facebook discussion “Farming Namibia Forum” (<http://farmingnamibia.namweb.cc>).



Most sources agree on the need of additives like molasses as one major component of the feed (e.g. Masaire, 2014; NDC, 2002). The bush content of such feed varies between 80% (survival feed) and 10% (comprehensive feed). WESenterprise produces the popular “Boskos” and “Wes Horse” pellets, which contain only 30-35% bush matter, 65-70% is concentrate feed. However, these imported pellets are more expensive in Namibia than a lucerne pellet, according to Rothauge (2014). In contrast to these examples, one Namibian farmer reported that he fed cattle over years in times of grass shortage with chipped small branches and leaves without any treatment only adding some salt.

Independently of the different opinions and experience, the following can be concluded:

- Animal feed can be produced from selected invader species.
- Small branches and leaves are the best input material, however, separate harvesting requires additional effort and costs although special machines are available in Namibia.
- Wooden parts of the invader species can also be used. Lignin certainly hampers the digestion process, but this is not a serious matter and could be balanced, if necessary, by steaming the wood chips at a higher temperature (190-200°C) and subsequent defibration to produce separate fibres which are highly accessible.
- Sapwood (recently grown outer layers) is much more nutritious than the older heartwood because it contains in particular sugars and minerals whereas heartwood contains extractives which preserve wood against biological degradation; these compounds may be harmful to cattle feeding thus only selected species shall be processed.

b) Resources and Production Processes

Considering the current controversial stage of knowledge, the production can either be based on young parts of the bush only (twigs and leaves) or on whole invader species, in both cases provided they are edible and not harmful for the livestock. If only young parts are used, the harvesting requires insofar additional effort as they have to be harvested separately, but the remaining parts containing most of the wood can be converted into other products.

The production process is directly linked to the resources, i.e. parts of the bush to be used. The controversial opinions about the processing of young parts or whole bushes require additional research³⁷⁾. It is only generally accepted that in both cases the raw material must be chipped as fine as possible and should finally be mixed with different additives.

Due to the numerous options of the production process, it is difficult to estimate the required investment for a commercial production plant. According to NDC (2002), a processing plant with a capacity of 2 t/hr was estimated at that time to cost about N\$2.5 million, i.e. based on an inflation rate of 6% N\$5.7 million currently. This is in the same range as estimates of Masaire (2014) of N\$6.5 million including pelleting.

c) Demand Markets

The local demand is highly variable depending on the annual rainfall and price of the bush based fodder. The fluctuation of the demand is for example demonstrated by the imports of feed³⁸⁾, namely

- 2 000 t in 2012,
- 14 600 t in 2013, and
- 3 200 t in 2014

By far most important is lucerne.

³⁷⁾ Information from WES enterprises was not available.

³⁸⁾ NSA import statistics 2015.



The imports do not at all reflect the actual demand which is by far higher and mainly covered to locally produced lucerne. It is estimated that irrigated lucerne is grown on about 1 600 ha in Namibia, yielding about 20 t / ha (Sweet, Burke, n.y.).

Moreover, it should be considered that even in years of normal rain there is often not sufficient feed in communal areas for optimal livestock husbandry. If the price for bush based fodder is considerably lower than for lucerne, it would open additional markets. NDC (2002) estimated a demand that can range between 10 000 tons p.a. for a normal rainy season to as much as 150 000 tons p.a. in times of drought.

In contrast to the domestic market, the export prospects are not promising. In neighbouring countries the natural feed supply is either better than in Namibia or it is doubted that a new producer could compete with the established South African supplier.

d) Major Strengths and Challenges

STRENGTHS

- Production of animal feed from selected invader species is technically possible.
- With competitive prices high local demand.
- In contrast to other actual or potential uses, main emphasis on small twigs, leaves, etc.
- Probably lower costs than competing feed (e.g. lucerne).
- Substitution of imported feed.
- Decentralised production, also in communal areas, is possible.

CHALLENGES

- Lack of reliable information regarding use of parts or whole edible bushes as well as production process.
- Only selected species edible.
- Wood component in feed between 10% and 80%; influences feed quality.
- Demand strongly fluctuating.

e) Prospects for Animal Feed from Encroacher Bush in Namibia

Production of feed is definitely an opportunity for the use of biomass which should be considered building on and enhancing existing initiatives in Namibia. Despite numerous uncertainties and discrepancies of the current know-how, feed production is a promising value chain considering the importance of livestock husbandry and the climatic conditions in Namibia as well as the positive experience in Europe, North America and Australia.

The open questions and contradicting issues should be clarified. This requires research by a team of internationally recognised specialists for the biological and chemical composition of wood as well as for digestion of livestock and game. It is recommended to develop the project further in the following steps:

- Identify invader species which could be suitable for feed production.
- Clarify in practical tests at research institutions whether lignin is digestible or how it could be made digestible.
- Test the suitability of wooden parts in the feed and compare it with feed prepared only from smallest branches and leaves.
- Develop different compositions of feed and test them in practice at a research station.
- Develop at least two production processes for decentralised small scale manufacturing on farm level and for centralised production including pelleting.



- Prepare a full feasibility study including cost calculation (comparison to costs of lucerne) and a detailed demand analysis in particular considering communal farmers

Attempts could be made to get the necessary financing from the Government of Namibia, considering that the Ministry of Lands and Resettlement decided to repay land tax to all commercial farmers for the financial year 2012/13, because of the severe draught. Such expenses and the loss of livestock can be avoided if sufficient feed is available also in years of drought.

3.6.2 Compost

a) Resources and Production

Not useable parts of encroacher bush remain as natural fertiliser or they are – more commonly – burned. But they could also be converted into compost. However, the lignin content and other components of wood delay the composting considerably. Therefore, the remains from the encroacher bush should be shredded and stacked in piles as close as possible. In addition, the piles should be watered in the dry season to facilitate the composting.

b) Current Operation in Namibia

Some farmers produce compost from the remains of de-bushing, mainly for their own demand. One charcoal producer started compost production based on smaller parts of the bush, which are not suitable for carbonisation. He is the only one known, who states that he is marketing the compost not only for gardening but also to maize farmers in the Grootfontein area.

Indirectly also the company Greenfield Organic Fertilizers close to Okahandja contributes to the bush to feed value chain. This company produces compost on commercial scale (15 t per day, 26 employees), mainly from animal dung with additions of tree bark and charcoal leftovers.

c) Demand Markets

There is a huge need for compost and other fertilisers in Namibia at commercial and communal farms. However, farmers prefer to use either their own animal dung or known brands of fertilisers. The owner of Greenfield Organic Fertilizers stated that after being in business for more than two years, the biggest challenge is still the local market. “People told me that this organic stuff will not work, and farmers are still scared to use our products” (Coetzee, 23.2.2015). The only stable market is gardening of higher income groups with sales via retail chains, e.g. Agra, Pupkewitz, or nurseries / garden centres.

Prospects of Compost Production in Namibia

Theoretically, compost could be produced from encroacher bush for parks and gardening. However, due to the lignin content it cannot be assumed that such compost is competitive. Furthermore, the current production exceeds already the demand. Therefore, compost production from encroacher is expected to remain a side product for nice markets or direct off-farm sales.

3.6.3 Bio-char

Bio-char is defined as fine grained charcoal with high organic carbon content produced during pyrolysis.

a) Production Process

Bio-char is produced together with other products, such as bio-oil and wood-gas from dried wood chips by pyrolysis, i.e. a process that converts the biomass with limited supply of air. Commercial production of bio-char requires that at least bio-oil or wood-gas is also used. However, no commer-



cial pyrolysis plant based on wood is known that developed bio-char into a product of real commercial interest.

b) Uses and Properties

Bio-char shall be used as soil amendment. It is said that bio-char

- absorbs chemicals or water;
- increases the soil's carbon pool by preventing the rapid disintegration and release of carbon dioxide into the atmosphere when buried in the soil; and
- has soil-enhancing properties and its addition to soils can reduce the requirements for fertilisers and water, which in turn improves arable land and agricultural yields.

The conversion of biomass to bio-char is therefore seen to offer a mechanism to effectively remove carbon dioxide from the atmosphere, while producing bio-fuel and bio-char that have beneficial carbon-reducing features (von Oertzen, 2009).

c) Demand Market

Considering the effects on the release of carbon dioxide and of the soil amelioration, there is a need for bio-char more in several industrialised countries than in Namibia. However, no country is known where bio-char is used on larger scale. Considering the fact that Namibian farmers are fairly conservative, it is more than doubted that bio-char could be marketed on short or medium term. The only realistic possibility to market bio-char would be to convince the Government of Namibia to use bio-char on public farms (or to highly subsidise the sales price) in order to prove the positive effects as basic measure for commercial marketing on longer term.

d) Prospects for Bio-char in Namibia

Bio-char could only be considered on longer term as by-product of pyrolysis, if ever implemented in Namibia. Commercial production is not known and this product is so far not even used in industrial countries. Independently of the costs, it will be extremely difficult to create a market in the Namibian agricultural sector.

3.7 Pulp and Paper

a) Production

Pulp production, as first step for paper production, is only competitive in large capacities, because pulp is a typical mass product. This means that today pulping is a sophisticated technique which demands mills that should have capacities exceeding half a million tons of pulp per year to be competitive. Such mills require an investment of about €1 billion and personnel of highest qualifications. Added to this have to be investments and also specialised personnel for a local paper production if the pulp shall not be fully exported.

b) Resources

A competitive pulp plant with an output of 500 000 t requires about 2 million m³ of solid wood or about 1.6 million tons p.a. Theoretically such a demand would really contribute to de-bushing with 160 000 ha annually. However, neither mixed nor heavy hardwood is able to produce the required quality of pulp. The only species that proved to be suitable for pulping (Khider et al, 2012) is acacia mellifera (black thorn), one of the few relatively light invader species (650 kg/m³). Although this species is common in encroacher bush, it is doubted that there are sufficient quantities within an acceptable transport distance. Furthermore, the sorting and de-barking of the small wood will make acacia mellifera too expensive for a competitive pulp production.



An additional drawback is the water demand for pulp production. Even with modern systems of water recycling and waste water treatment about 40 m³ of water are required per ton of pulp.

c) Demand Markets

The worldwide demand of pulp and paper is enormous with pulp imports of 110 million tons and paper imports of 107 million tons in 2013 (FAO, 2014). Also Africa has a huge demand with imports of 1.3 million tons (pulp) and 4.6 million tons (paper) respectively. Namibia imports hardly any pulp (47 t in 2013) due to the lack of further processing facilities, but imported 10 400 t of paper (FAO, 2014).

d) Prospects for Pulp and Paper in Namibia

A theoretical pulp and paper production from encroacher bush would have the advantages of a huge demand and processing of 1.6 million tons of wood p.a. However, only one invader species, black thorn, is suitable. A production cannot be recommended due to

- the extraordinary large capacities and investments,
- the high qualified personnel requirements, and
- the resource requirements, i.e. exclusion of mixed and heavy species, de-barking, high water demand.

3.8 Small Scale Uses

The following products have been identified or are discussed in Namibia:

- Parquet
- Shingles
- Wooden frames
- Kitchen boards
- Transport boxes, crates, pallets
- Carving
- Tooth picks
- Spatulas
- Ice cream sticks
- Sostie sticks
- Sticks/handles for tools
- Wood glue
- Traditional medicine
- Smoking/aromatic material
- Mulch for gardening

Provided the manufacturing of such products is feasible, it has to be taken into account that they will not significantly contribute to de-bushing since they only use small quantities and special parts of the bush. However, they should be considered within a de-bushing programme, because they may add considerable value as by-products of large de-bushing value chains. Furthermore, their manufacturing can contribute to the development of small and medium enterprise (SMEs), one of the priorities of the Government of Namibia.



3.8.1 Parquet

This type of flooring relives renaissance in European and North American countries, but also at higher income groups in Namibia. For parquet, wood of high density is required, a condition that is fulfilled by many invader species. The single elements are relatively small and if larger elements are required, strips could be glued together. Insofar invader species could be considered for a production in Namibia.

However, it must be considered that the wood has to fulfil also the following requirements, among others:

- Availability of sufficient quantities of one species with attractive appearance.
- Limited shrinking, swelling and bending.
- Good gluing properties.

These may be challenges together with the production costs of first sawing the small round-wood and afterwards drying the sawn timber in a kiln.

Despite the challenges, it is recommended to further investigate the option of parquet production from invader species, i.e. identify species which might be suitable and test their properties.

3.8.2 Shingles

Shingles are a traditional roofing material in particular in southern Germany, Austria and Switzerland (see Photos 16 and 17). Also they relive renaissance with increasing demand. They are, even in these countries with very high labour costs, mainly produced manually. There are no specific machines available. “Split Shingles” are more natural as they are split by, e.g. an axe along the natural fibre. “Saw Shingles” are cut without considering the natural fibre directions. This could partially be done with a customised, partly mechanised “log splitter”.

Important requirements, such as the natural durability, should be given by some invader species. Drawbacks might include

- the conservative demand, since the traditionally oriented customers may prefer to use local species;
- the small dimensions of the round-wood from invader species; and
- the fibre direction, which must be straight.

It is recommended to consider shingles as a value addition product, but to investigate the demand before testing the properties.





Photos 16 and 17: Shingles as Roofing Material

3.8.3 Wooden Frames and Kitchen Boards

Both products have the advantage that they are and can, respectively, be produced from small strips of sawn timber which can be glued together. They are currently nearly exclusively imported. The imports of frames into Namibia amount to a remarkable value of over N\$5 million³⁹⁾ p.a. between 2012 and 2014 (NSA, 2015).

It can be assumed that suitable species are available within the encroacher bush. A challenge can be the costs, because the wood has first to be sawn, which requires at least a table circular saw. Moreover, only the strong wood is suitable.

The production of frames and kitchen boards can be feasible. It does not require any detailed investigation but an entrepreneur who tests this potential use with high value addition.

3.8.4 Transport Boxes, Crates and Pallets

These products are of limited value and are manufactured in larger quantities for a limited lifetime. Based on the very small dimensioned round-wood of the encroacher bush, which has to be debarked and then converted into sawn timber, a small scale Namibian production would never be competitive. It is of similar importance that these transport means must be as light as possible, a condition that is not fulfilled by most of the invader species.

3.8.5 Carving

Carving is a traditional activity in several parts of Namibia, nowadays focusing mainly on the tourism market. Suitable species are available. Due to the widespread local experience and the assistance a lot of carvers received in the past as well as the knowledge about suitable timber species amongst carvers, no special actions are required. However, it should be considered to supply carvers with wood from de-bushing since currently local carvers often use (also illegally harvested) bigger trees.

3.8.6 Tooth Picks, Spatulas, Ice Cream Sticks and Sostie Sticks

These uses have been discussed in Namibia (see Tjarongo, 2008) since the products are extremely small and thus it has been assumed that they could be produced from the small round-wood of the encroacher bush.

³⁹⁾ For most other products import data is not available from NSA.

This opinion contradicts the reality. All products must be produced from very soft wood species (e.g. birch, poplar) to avoid injuries. Furthermore, they are mass products with very limited value addition and any such production could thus not compete with international market leaders.

3.8.7 Sticks and Handles for Tools

Currently some sticks and handles are produced manually in rural areas with very poor quality for the poorest segment of the population. Also manually produced are traditional walking sticks of better quality for local people and as souvenir for tourists. However, the vast majority of these products are imported.

Machines to manufacture broom sticks and different handles (e.g. for brushes, hammers) are available for US\$1 800 - US\$2 100⁴⁰⁾ (ex Peoples Republic of China). They have production capacities, which are assumed to exceed the entire local demand, but a demand certainly also exists in northern neighbouring countries. No detailed investigation is required, but a local entrepreneur should be identified to select suitable wood species from encroacher bush and start the business.

3.8.8 Wood Glue

It is a known fact that glue can be produced from ingredients of wood, e.g. tannins. Research is ongoing in Namibia to develop a natural binder from invader species for sand boards. However, there is also concrete experience in other countries including RSA.

Outstanding questions are the financial viability versus competing glues, the availability of invader species with sufficient suitable ingredients and the local demand.

Considering the already existing experience, it is recommended instead of further investigation to approach experienced companies, e.g. from RSA, which may have a stake in using their knowledge for an economic commitment in Namibia.

3.8.9 Traditional Medicine

Hundreds of plants are used in Namibia for traditional medicine. Although traditional medicines in Namibia have often been replaced by imported pharmaceutical products (especially among the younger generation), they still play an important role nationally but also internationally. For example, the annual trading volume in South Africa is estimated to be at least 300 million Rand. In Asia and Western countries, traditional medicine enjoys increasing demand. Namibia exports only devil's claw. However, collection, processing and marketing of other traditional medicinal plants available in encroacher bush could be a promising business for sale in Europe and North America with high value addition.

Such a use could only become reality after longer term research, which should include the following main steps:

- Identification of invader species and respective parts of them which are used as traditional medicine; this should be done together with experienced local people.
- Determination of the available quantities based on the planned inventory of the areas affected by bush encroachment; only if sufficient quantities for exports are available, the project may become feasible.
- Investigation on the possible applications and acceptance by foreign health authorities.
- Preparation of a comprehensive feasibility study.

⁴⁰⁾ For one type of handles.



- Identification of international partners with respective experience to plan and implement the project.

3.8.10 Smoking /Aromatic Material

Smoking material for meat and fish has a small but increasing local (particular private) market. It could be considered as by-product (residue) of wood chipping, sawing (if any) or production of sticks and handles since it is currently often imported.

Production of smoking material can only be a very small business, but the effort and investment are minimal. A local entrepreneur has only to test which types of saw dust or chips are suitable and demanded depending on the timber species. Thereafter, only investments in packaging and marketing are required.

3.8.11 Mulch for Gardening

Normal mulch from wood will – similar to compost from wood – not be competitive. However, there is a small market of decorative mulch for gardening at higher income groups. This product is already marketed by a few farmers. Since there seems to be no unsatisfied demand, mulch is not recommended as additional new business but could be used more by the farmers themselves.



4. EVALUATION AND RANKING OF END-USE OPPORTUNITIES

4.1 Pre-selection of Opportunities

Based on the assessment in Chap. 3, the identified opportunities can be grouped into three categories:

- i. Opportunities, which are already implemented in Namibia or have a realistic chance to be directly implemented by local entrepreneurs without further action/investigation (see Tab. 5). Not included in this, but in category (ii) are firewood, poles and charcoal, although they are not only ongoing, but even currently the most important uses. However, different measures are required to improve these value chains and to assure that they are in future mainly based on wood from encroacher bush. Thus category (i) covers mainly small scale uses.
- ii. Opportunities which are promising but require further actions/investigation in order to contribute to de-bushing. These opportunities are summarised in Tab. 6 and further evaluated in Chap. 4.2 and Annex 4.
- iii. Opportunities without a realistic chance to be implemented or only on long-term. These opportunities are summarised in Tab. 7. They are currently not recommended to be considered as value chains of de-bushing. An exemption is the production and marketing of traditional medicine. This is also an opportunity that might only be implemented on long term, but is included in category (ii) because of the possible very high value addition and employment creation.

Tab. 5: Promising Opportunities – Not Requiring Further Research

Opportunity	Remarks
Furniture*	<ul style="list-style-type: none"> Only based on prosopis Small diameters of other invader species not suitable / financially viable
Wooden Frames & Kitchen Boards	<ul style="list-style-type: none"> Import substitution targeted Entrepreneur to be identified to test feasibility
Carving	<ul style="list-style-type: none"> Widespread local experience Promotion of / support to utilising wood from encroacher bush recommended
Sticks & Handles for Tools	<ul style="list-style-type: none"> Import substitution & export targeted Low investment for mechanised production. One entrepreneur to be identified to test feasibility
Wood Glue	<ul style="list-style-type: none"> Experience in other countries available Foreign partners to be mobilised to investigate feasibility
Compost	<ul style="list-style-type: none"> Mainly for own use by farmers Small current commercial production in Namibia exceeds demand
Mulch for Gardening	<ul style="list-style-type: none"> Mainly for own use by farmer Small current commercial production in Namibia exceeds demand
Smoking/Aromatic Material	<ul style="list-style-type: none"> By-product of wood processing Import substitution targeted Local entrepreneur to be identified



*Only prosopis is suitable because the harvesting is not limited by diameters and the species grows concentrated, seldom mixed with other invader species. However, the value chain via sawn timber to furniture is already developed and can hardly be enlarged due to limited larger dimensioned prosopis resources.

Tab. 6: Promising Opportunities - Requiring Further Research

Opportunity
<ul style="list-style-type: none"> (a) Charcoal (b) Wood Chips (c) Compressed Firewood (d) Firewood (e) Animal Feed (f) Wood Pellets (g) Poles (h) Wood-Cement Bonded Bricks or Boards (i) Medium Density Fibre Boards (MDF) (j) Wood-Sand Boards* (k) Wood-Plastic Composites (WPC) (l) Parquet (m) Shingles (n) Traditional Medicine

* Research in Namibia ongoing - results only expected in years

Tab. 7: Not Recommended Opportunities

Opportunity	Remarks
Bio-gas	<ul style="list-style-type: none"> Other technologies of heat & power generation technically more promising Financial viability doubtful Negative experience in Namibia
Bio-oil	<ul style="list-style-type: none"> No domestic & international demand Limited international experience with commercial production based on wood No experience with mixed species Financial viability doubtful
Bio-ethanol*	<ul style="list-style-type: none"> Wood based not competitive versus agricultural plant based production No commercial production known based on wood Special problems with invader species expected (density, bark)
Sawn Timber**	<ul style="list-style-type: none"> Small diameters of invader species not suitable (exemption prosopis)



Opportunity	Remarks
Wood-Clay Bonded Bricks & Boards	<ul style="list-style-type: none"> Limited international experience Properties not competitive versus cement-bonded products Limited demand (if any)
Wood-Charcoal Bonded Bricks	<ul style="list-style-type: none"> Negative experience in Namibia Feasibility doubtful
Particle Boards & OSB	<ul style="list-style-type: none"> Resources from encroacher bush not suitable Huge capacities/investments required for competitiveness Small demand in Africa incl. Namibia
Gypsum Bonded Fibre Boards	<ul style="list-style-type: none"> Normally produced with waste paper; limited experience with wood Large capacities & investments required for competitiveness
Block Boards	<ul style="list-style-type: none"> Hardly any local demand Invader species not suitable
Bio-char	<ul style="list-style-type: none"> Only possibly feasible if other products of pyrolysis process also used No commercial production known. Currently no markets
Pulp & Paper	<ul style="list-style-type: none"> Extraordinary large capacities required for competitiveness Most invader species (exemption e.g. black thorn) not suitable High water demand
Transport Boxes, Crates, Pallets	<ul style="list-style-type: none"> Production from invader species not competitive Heavy species not acceptable
Tooth Picks, Spatulas, Ice Cream Sticks, Sostie Sticks	<ul style="list-style-type: none"> Invader species not acceptable Cheap and small mass products with very limited value addition

Remarks:

* A possible value chain might be a bio-refinery which – according to an interviewed developer – is in the final planning stages. The project requires an annual input of 300 000 t and can use mixed hardwoods. Therefore, Namibia is considered as a possible location.

** Only prosopis is suitable because the harvesting is not limited by diameters and the species grows concentrated, seldom mixed with other invader species. However, the value chain via sawn timber to furniture is already developed and can hardly be enlarged due to limited larger dimensioned proopis resources.



4.2 Evaluation and Ranking of Promising Opportunities

The end-use opportunities of encroacher bush, which are promising but require further action/investigation, are comparatively evaluated on the basis of the assessment in Chap. 3. It is the aim of this evaluation and the subsequent ranking to facilitate the final selection and prioritisation of the opportunities, with the objective to implement as soon as possible realistic value chains that will contribute to de-bushing.

The methodology for evaluation of identified opportunities has to take into account that

- the different opportunities are not directly comparable,
- quantitative data on the different opportunities are not always available⁴¹⁾,
- several opportunities can only be finally assessed after further investigation, e.g. of the wood properties.

For these reasons, DECOSA applied the internationally recognised method of matrix evaluation. The evaluation by matrix considers all essential information, which has been collected with regard to the different value chains, and comparatively evaluates it according to a set of criteria. Considering overall national objectives, the objectives of the De-Bushing Project and technical as well as economic requirements of the different value chains, the following criteria are defined for the matrix evaluation:

- Suitability of the resources
 - Properties
 - Availability of required quantities
 - Required other resources than invader bush
- Processing technologies
 - Positive experience in Namibia
 - Sophisticated or adapted technologies
 - Minimum capacities
- Markets (domestic and foreign)
 - Quantitative demand
 - Qualitative requirements
 - Competition
 - Potential for Namibian value chains
- Personnel
 - Employment creation
 - Skills requirements
 - Local availability
- Effects on de-bushing
 - Whole use of encroacher bush or only selected species
 - Whole use or only partial use of individual species
 - Size of de-bushed area
- Financial issues
 - Investment
 - Viability
 - Value addition
- Required support services

⁴¹⁾ This would have exceeded the frame of the Consultancy and was therefore not requested by the ToR.



- Institutional and regulatory support
- Research
- Foreign know-how partners
- Capacity building
- Strategic documents (e.g. feasibility studies)
- Time horizon for implementation
- Assumed feasibility, sustainability and risks

The promising end-use opportunities, which require further action/investigation, are evaluated in Annex 4⁴² based on the defined criteria. The evaluation provides some indications for project developers, investors, farmers, etc. to decide which opportunities they intend to follow-up primarily.

The opportunities can only be compared within the following categories:

- Opportunities which require limited technology, skills and investment and can be based on the mixed encroacher bush without selection of species with specific properties. They bear the lowest risk, but their stage of processing is limited. The most promising opportunities within this group are
 - charcoal,
 - wood chips, and
 - firewood.
- Real manufacturing industries which require investments in technologies, skilled personnel and in most cases selection of suitable species. Priority opportunities within this group are
 - compressed firewood, and
 - animal feed.
- The other opportunities, namely wood pellets, wood-plastic composites, wood-cement bonded products and medium density fibre boards are ranked lower, mainly because they still require investigation, e.g. regarding the suitability of invader bush for the processing, and the demand.
- Opportunities with limited effect on de-bushing but possibly high value addition. Promising within this group might be
 - parquet,
 - shingles, and
 - traditional medicine.

It must be considered that the ranking does not mean that products ranked lower are not recommended. All possible businesses are selected from a wider range of opportunities and can contribute to use invader bush with value addition. A final decision is only possible after further investigation (see Chap. 5.2.2). Lower ranked opportunities may even be more viable than higher ranked ones.

⁴²Excluding wood-sand boards because limited information are available, but research is on going.



5. RECOMMENDATIONS FOR IMPLEMENTATION OF PROMISING END-USE OPPORTUNITIES

5.1 Locations

5.1.1 Location Requirements

The selection of the optimal location is essential for the success of any business. Traditionally, the proximity and access to input materials and markets were valued as the most important criteria to determine a location. However, with the increasing globalisation and the permanently improving transport logistics, these criteria are only part of a larger range of location requirements. The following are important criteria to determine possible locations for businesses based on encroacher bush:

Resources from De-bushing

- Quantities (absolute, t/ha)
- Qualities (e.g. timber species, mixture)
- Physical access (terrain, roads)
- Permissible access (readiness of farmers to allow harvesting)
- Costs (e.g. harvest, transport)
- Procurement risks (e.g. infrastructure, reliability & number of suppliers)

Other Input Materials (availability, reliability, costs)

- Raw materials (e.g. cement, plastics)
- Water
- Electricity
- Auxiliary materials

Demand Markets

- Access
- Proximity

Personnel (availability, costs)

- Professionals
- Skilled personnel
- Social facilities (accommodation, schools, medical services)

Services (availability, reliability, costs)

- Communication
- Banking
- Administrative services (e.g. DoF office for permits)
- Maintenance



Land and Buildings (availability, costs)

Although these criteria have generally to be considered within each location analysis, their importance differs between the end-use opportunities. For example:

- All businesses need, of course, resources from de-bushing. However, really important are the quantities, access, costs and procurement risks⁴³⁾ mainly for mass products, like wood chips and for industrial further processing with larger capacities.
- With regard to the quality of the biomass, it must be considered that some end-products, like wood-cement bonded bricks, can only process species with specific requirements (chemical composition) whilst for instance all mixed species can be converted into charcoal.
- The procurement risk is in particular important when the bio-mass is further processed in industrial scale (e.g. WCP) or the market expects continuous supply.
- With regard to “Other Input Materials”, there are huge differences concerning the location requirements. Some products, like charcoal, are based on the woody biomass only, whilst others require additional raw material, water,⁴⁴⁾ electricity and auxiliary materials (e.g. wood-cement bonded boards).
- Access to the demand markets is a precondition for all end-use opportunities. Based on the good Namibian infrastructure and its international links, only a few products require proximity to the local markets.
- For industrial investments personnel requirements are one of the most important criteria to select a location. Lack of suitable personnel may not only increase labour costs considerably, but it also requires enormous additional costs, e.g. for schooling, housing and social welfare. On the other hand, businesses based mainly on semi-skilled and unskilled personnel do not consider these issues as important criteria for the selection of a location.
- Availability, reliability and costs of services are influencing the selection of a location, also mainly with regard to larger and/or industrialised businesses.
- The availability and costs for land and buildings are in principle important for all businesses. However, less important for those not requiring a site for manufacturing.

In Tab. 8 an attempt is made to evaluate the importance of each location requirement for potential businesses based on encroacher bush.

The table demonstrates, that complex value chains have the highest location requirements (would-cement bonded products, fibre boards), whilst end-use opportunities, that can be produced with relatively simple technologies, are characterised by limited location requirements. This possibly explains the nature of the current Namibian biomass industry: only value chains of moderate and low complexity exist; businesses shy away from high investment/implementation complexity.

⁴³⁾ Mainly important if harvesting and further processing are different businesses.

⁴⁴⁾ Water for human consumption and packaging material is not considered here.



Tab. 8: Location Requirements and their Importance for Different End-use Opportunities from Encroacher Bush

Criteria \ Products	Firewood	Compressed Firewood	Charcoal	Wood Chips	Wood Pellets	Poles	Wood-Cement Bonded Bricks/Board	Medium Density Fibre Boards (MDF)	Wood-Plastic Composites (WPC)	Animal Feed	Parquet	Shingles	Traditional Medicine
Resources from De-bushing													
• Quantities	1	2	2	3	3	1	3	3	2	2	1	1	2
• Qualities	0	0	0	0	1	1	3	3	1	3	2	2	3
• Physical access	1	2	1	3	3	1	2	2	1	2	1	1	1
• Permissible access	3	3	3	3	3	3	2	2	2	3	1	1	3
• Costs	1	2	1	3	3	1	2	3	2	3	1	1	1
• Procurement risks	1	3	3	3	3	1	3	3	3	2	3	3	3
Other Input Materials													
• Raw materials	0	0	0	0	0	0	3	0	3	0	0	0	0
• Water	0	0	0	0	1	0	3	3	0	3	0	0	1
• Electricity	0	3	0	1	3	0	3	3	3	3	3	0	0
• Auxiliary materials	0	0	0	0	0	0	3	3	1	3	1	0	0
Demand Markets													
• Access	3	3	3	3	3	3	3	3	3	3	3	3	3
• Proximity	2	0	0	3	2	2	0	0	0	2	0	0	0
Personnel													
• Professionals	0	2	0	0	1	0	3	3	3	1	0	0	0
• Skilled personnel	0	2	1	1	3	0	3	3	3	2	2	2	0
• Social facilities	0	3	1	1	3	0	3	3	3	2	0	0	0
Services													
• Communication	1	3	2	2	2	1	3	3	3	2	2	2	2
• Banking	1	3	1	2	2	1	3	3	3	1	1	1	2
• Administrative services	1	2	2	2	2	1	2	2	2	1	1	1	2
• Maintenance	0	3	0	1	3	0	3	3	3	1	1	0	1
• Land & Buildings	1	3	1	1	2	1	3	3	3	1	2	2	2
TOTAL	16	39	21	32	43	17	53	51	44	40	25	20	26
RANK	13	6	10	7	4	12	1	2	3	5	9	11	8

0 - 3 Importance: 3 = Most important



5.1.2 Suitability of Locations

Before recommending possible locations for de-bushing projects with value addition, the options of urban versus rural locations as well as locations in commercial or communal areas will be assessed.

(a) Urban versus Rural Locations

The first step of the value chain, the harvesting, can only take place in rural areas affected by bush encroachment. In order to recommend locations for further steps, advantages and disadvantages of urban versus rural locations have to be compared considering the relevant location requirements.

MATERIAL TRANSPORT

The transport costs for raw material are higher than for semi-finished and finished products due to the higher transport volume. This is the reason why wood is always chipped at the harvesting area and not at an urban location. However, also the transport risk has to be considered. Sensitive products, like wood-plastic composites, may be destroyed on gravel roads from a rural production site and are therefore preferably produced in urban areas.

PROCUREMENT RISK

Physical separation of the harvesting from the processing and sales, increases the risk of discontinuous supply and requires additional management personnel (if harvesting is part of the business and not done by farmers or independent de-bushing companies), i.e. rural locations are advantageous.

SUPPLY OF OTHER INPUT MATERIALS

Normally urban locations have the advantage that water and electricity are available and other raw materials as well as auxiliary materials can be procured easier than in rural areas. However, it must be considered that water and electricity are fairly unreliable in some urban centres. In particular water supply may be better on some commercial farms with own boreholes.

DEMAND MARKETS

With regard to most products, urban locations have clear advantages. Concerning products targeting the domestic market (e.g. firewood, building material), the demand and purchasing power are higher. Moreover, generally urban centres have better infrastructural links than rural areas to other domestic markets as well as for exports. However, poles, droppers, etc as well as animal feed have their main demand in rural areas.

PERSONNEL

In this regard, urban centres are clearly preferred locations. It is easier to recruit personnel of different qualifications (including un-skilled workers), and housing, schools, medical facilities are in most cases available. Moreover, most professionals prefer to live in towns.

SERVICES

Even more obvious than with regard to personnel, are the advantages of urban areas concerning services. They are hardly available in rural areas (e.g. banking) or only at higher costs than in urban areas (e.g. maintenance).

LAND AND BUILDINGS

Several towns in Namibia lack even of unserviced industrial land. In rural areas it is easier to obtain land, which must be serviced by the investor who has also to construct own buildings.

This comparison demonstrates that in principle urban locations outweigh rural ones. However, this cannot be generalised. Product, company and locations specific issues have to be taken into consideration. This means for products with a low degree of processing or with mainly a demand on farms, a rural location could be preferred. The same may apply if the processing company is also responsible



for harvesting or if hardly any personnel is required, or if a rural location offers a better infrastructure than an urban centre as well as suitable land.

As a rule of thumb, the following lists indicate the most suitable location for the specified products:

RURAL LOCATION

- Firewood
- Charcoal
- Wood Chips
- Poles
- Animal Feed

URBAN LOCATION

- Compressed Firewood
- Wood-Cement Bonded Bricks or Boards
- Medium Density Fibre Boards (MDF)
- Wood-Plastic Composites (WPS)
- Wood Glue

RURAL AND /OR URBAN LOCATION

- Wood Pellets
- Parquet
- Shingles
- Traditional Medicine
- Wooden Frames & Kitchen Boards
- Carving
- Sticks & Handles for Tools
- Smoking Material

(b) Commercial versus Communal Areas

It is even more challenging to assess commercial versus communal locations than urban versus rural locations. One reason is that communal areas may be close to towns, as for example in Oshana Region. Businesses in that region are known which invested just outside the town borders since land is easier to purchase and they are less hampered by administrative burden. Although the decision about locations is more influenced by urban or rural sites, some advantages and disadvantages of commercial and communal areas for investment in de-bushing and further processing are summarised in the following considering the relevant location requirements.

QUANTITIES OF RAW MATERIAL

The area affected by bush encroachment and the total quantities of harvestable biomass are larger in commercial areas. However, this is insofar not really relevant as the potential supply of raw material exceeds the demand and some communal areas have a higher bush density and thus harvestable yield. However, a disadvantage of communal areas is the traditional rights to harvest wood for own use of the local people. This may create conflicts of interest, for example with formal businesses focusing on firewood or poles.

PHYSICAL ACCESS TO RAW MATERIAL

Generally the road infrastructure is better in commercial than in communal areas. With several road construction and maintenance programmes, this disadvantage of communal farm land is more and



more balanced and some areas affected by bush encroachment are directly located along asphalt roads.

PERMISSIBLE ACCESS TO RAW MATERIAL

A matter of concern with regard to de-bushing is the fact that several commercial farmers are reluctant to allow third parties harvesting on their land. Access to communal land is easier although permission of the traditional authorities is required.

OTHER INPUT MATERIAL

Whilst the supply of auxiliary materials depends on the infrastructure (access to farmland) and is mainly a question of urban or rural locations, water and electricity supply are often better on commercial than on communal farms.

PERSONNEL

Both areas normally lack of social facilities and skilled personnel. However, commercial farms have the disadvantage vis-à-vis communal areas that also un-skilled personnel may not be available and external people are often not allowed to operate businesses on private land, whilst most traditional authorities promote business development in their areas.

LAND AND BUILDINGS

Both areas have a lack of buildings, but land is easier to be acquired in communal than in commercial areas because commercial farmers do not want third parties on their farms.

All other location requirements (e.g. demand markets, services) are generally similar in communal and commercial areas, but both are often disadvantaged compared to urban locations.

The comparison shows that it is not possible to distinguish generally between communal and commercial areas with regard to the preferred location. Both areas could be suitable, but the selection must be based on the specific situation of a site, such as the existing infrastructure and the willingness of private farmers to cooperate. It is therefore not possible to recommend products which should preferably be manufactured in communal or commercial areas. However, for both areas the same businesses as for rural locations (see (a)) should mainly be considered.

(c) Preliminary Recommendations for Possible Locations

A final decision pertaining to, the optimal location, depends on the selected end-use opportunities as well as on detailed analyses considering the different requirements (see Chap. 5.1.1). Therefore – based on the currently available information – possible locations can only be preliminarily recommended.

General basis for the selection of macro-locations should be the available resources. Due to the lack of inventories, the zones of thickened bush defined by Bester (see Chap. 2.2.1), which cover only commercial farmland, and the regional information (see Tab. 9) provided by UNDP/MET (2007) can be a basis to determine possible macro-locations.



Tab. 9: Forest Wood Volume by Regions

Region	Density, in m ³ /ha	Volume, in 1000 m ³
Caprivi	21.37	30 916.0
Erongo	0.10	635.9
Hardap	0.10	1 096.6
Karas	0.05	805.4
Kavango	18.00	87 269.4
Khomas	0.25	921.5
Kunene	0.20	2 303.1
Ohangwena	20.00	21 388.0
Omaheke	2.00	16 888.0
Omusati	3.22	8 538.4
Oshana	0.90	781.4
Oshikoto	11.44	44 237.3
Otjozondjupa	3.90	41 080.3
Total		256 861.3

Source: UNDP/MET, 2007

Based on Tab. 9 the following regions could be preferred macro-locations:

- Kavango
- Oshikoto
- Otjozondjupa
- Zambezi (Caprivi)
- Ohangwena
- Omaheke

The Oshikoto Region has, according to Bester, the highest bush density (10 000 per ha) followed by Omaheke and Otjozondjupa (both 8 000 per ha).

In addition to the available resources, the selection of the macro-locations should also consider

- proximity to markets/transport costs,
- economic strengthening of communal areas,
- proximity to urban centres for further processing.

Based on these global location requirements, possible locations are preliminarily recommended in Tab. 10.

With regard to these preliminary recommendations, it must be considered that most products could also be produced at other locations and that the productions may compete against each other with regard to the available resources, since the quantities of the resources are not known. This may be the case in Omaheke, where several productions might be feasible due to the proximity to the main Namibian market, Windhoek.



5.2 Support Service Requirements

After nearly 20 years of discussion and permanently increasing bush encroachment in Namibia, it is of national interest that de-bushing commences on large scale. This is only promising if the biomass is converted into marketable products, preferably with highest value addition. In order to reach this aim, private initiative with public support is required. The support service has to cover on the one hand general issues of importance for all projects of a de-bushing programme and on the other hand support for specific end-use opportunities.

5.2.1 Basic Requirements

(a) Coordination and Cooperation between Stakeholders

With the private sector as well as MAWF, MET, MRLGHRD, MLR and Traditional Authorities (TA), there are many stakeholders involved directly or indirectly in the protection and utilisation of forest resources. Challenges include the overlapping of tasks as well as lack of cooperation and coordination.

The combating of bush encroachment on the one hand and the protection and sustainable utilisation of the resources on the other hand, call for cooperation between the different institutions of the Government, which is the custodian of nature, and the private business sector.

Tab. 10: Possible Locations for Different End-use Opportunities

Possible Location	Possible Productions
Oshikoto Region with processing in Tsu-meb or Omuthiya and harvesting in commercial & communal areas	<ul style="list-style-type: none"> • Compressed firewood • Chips/pellets • Poles • Wood-cement bonded or medium density fibre boards • Animal feed • Traditional medicine
Omaheke Region with processing in Windhoek or Gobabis and harvesting mainly in commercial areas	<ul style="list-style-type: none"> • Chips/pellets • Compressed firewood • Poles • Wood-cement bonded or medium density fibre boards • Parquet and/or shingles • Small products
Ohangwena Region with processing in Eenhana and harvesting on communal land	<ul style="list-style-type: none"> • Firewood • Charcoal • Animal feed • Traditional medicine • Small products
Kavango Region with processing in Rundu and harvesting on communal land and state owned farms	<ul style="list-style-type: none"> • Firewood • Charcoal • Wood-cement bonded or medium density fibre boards • Traditional medicine • Small products
Otjozondjupa Region with processing in Otjiwarongo and harvesting mainly in commercial areas	<ul style="list-style-type: none"> • Charcoal (already ongoing) • Compressed firewood (already ongoing) • Poles • Wood-plastic composites • Animal feed • Parquet and/or shingles



Attempts of improved coordination have been made in the past, such as the establishment of the Forestry Council in 2012, however, with limited success. It is planned that the establishment of a co-ordination unit on 1 April 2015 to be responsible for the implementation of the National Rangeland Strategy and thus for de-bushing, shall fill the existing gap.

(b) Improvement of the Regulatory Framework

Namibia has a promising legal basis for the forestry sector, including combating bush encroachment and development of end-use opportunities, but the regulatory framework is weak. Already in 2003, DRFN recommended as key issue that the regulations on harvesting need to be reviewed. The current regulatory framework hampers development. It is difficult to mobilise private investors because the regulations create insecurity within the private sector and do not meet even the basic requirements of any serious investor, i.e. clarity and consistency of the regulatory framework. Therefore, the following measures are needed:

DEFINITIONS

Encroacher and protected species must be clearly and transparently defined to avoid insecurity, e.g. regarding the utilisation of mopane.

Insecurity exists also with regard to the rule that it is not allowed to harvest within 100m of rivers, streams or water courses. Since it is not defined how wide a water course must be, this important regulation is in practice often ignored. Possible definitions and regulations could for example be no harvesting on both sides

- on a width of 5 m if the water course is less than 1 m wide,
- on a width of 15 m if the water course is less than 1-10 m wide,
- on a width of 100 m if the water course is more than 10 m wide.

HARVESTING GUIDELINES

Despite the awareness of the serious problem of invader species, Namibia has only a “Draft Bush Encroachment Management Policy – 2004” and no guidelines are effective as how to deal with this specific issue. Therefore, only the Forest Act applies, i.e. for de-bushing of more than 15 ha or removal of more than 500 m³ wood, a harvesting permit is required. However, this is either not known or often just ignored.

Harvesting guidelines, which are binding for the producers, are a precondition for sustainable utilisation of the forest resources. They have to consider primarily environmental issues and the aim to combat bush encroachment. Such guidelines are also important for investors who require security. Therefore, they are of first priority for de-bushing projects.

The basis for the urgent development of harvesting guidelines is available from several publications. Critical issues to be considered include (see Chap. 2.2.3 (d)):

- General rules such as
 - no complete harvesting but thinning in the areas affected by bush encroachment;
 - no or limited harvesting on slopes;
 - no harvesting along rivers.
- Rules for selective harvesting considering
 - no harvesting of stronger trees;
 - no harvesting of protected species;
 - harvesting of trees and branches with poor growth form (see Photo 16)
- Species specific guidelines, such as unlimited harvesting of particularly aggressive encroacher species (e.g. black thorn) and alien invader species (e.g. prosopis).





Photo 16: Purple-pod Terminalia with Poor Growth Form

HARVESTING PERMITS

Permits are the main policy instrument used by DoF to regulate private sector forestry activities in both commercial and communal areas. Harvesting permits are required for specific products (e.g. poles, charcoal, etc.), but according to the Forest Act also for any larger de-bushing. The current permit system fails to satisfy both ecological and economic requirements. The lack of clarity, short-term changes, harvesting bans imposed and the short validity lead to insecurity without protecting the resources.

In addition to such challenges, the importance of harvesting permits is over-emphasised. Much more important are binding harvesting guidelines. If they are available, it is recommended to issue harvesting permits for de-bushing with a validity of 5-10 years. However, DoF should monitor continuously the fulfilment of the harvesting guidelines and – if necessary – cancel the permit. This system would provide long-term security for investors on the one hand and assure protection of the environment on the other hand.

(c) Determination of Harvesting Technologies and Costs

Currently four methods of harvesting encroacher bush are applied in Namibia:

- Manual harvesting with axes and pangas (see Photo 17) which is most common in the charcoal industry, but also the producer of “Bushbloks” harvests mainly manually.
- Semi-manual harvesting with bush cutters (see Photo 18); this method is used by a few charcoal producers.
- Fully mechanised harvesting with bulldozer of different size equipped with saws (see Photo 19) or hydraulic shears.
- Large rollers or a chain between two tractors, clearing the whole bush.

Photo 17: Manual Harvesting by Axe



Photo 18: Semi-mechanical Harvesting with Bush Cutter



Photo 19: Mechanised Harvesting

For investments in de-bushing and further processing, the harvesting costs are essential, in particular with regard to mass products with limited value addition (e.g. wood chips and pellets). Therefore, a detailed investigation is required (currently initiated by the MAWF/GIZ Support to De-Bushing Project), comparing the different harvesting methods. This investigation should consider

- harvesting costs for different types of raw material such as wood for firewood, charcoal, poles, etc. and fine material, e.g. for production of animal feed;
- costs and technologies for chipping;
- costs of sorting the biomass by species;
- ecological requirements of selective de-bushing; and
- labour issues, such as recruitment problems for manual harvesting, employment creation, social issues (e.g. accommodation) and skills requirements.

(d) Assessment of the Biomass Resources

Sustainable management and the commercial utilisation of encroacher bush require detailed knowledge about the resources. The current lack of information is a drawback for investments in de-bushing and further processing. Therefore, inventories about the available biomass, separated by species in specific areas, are urgently required. This is underlined by the estimated huge variations of the harvestable quantities (0.7-30 t/ha) in different areas (see Chap. 2.2.4 (b)).

On national level no information is available which could be a basis for investment decisions and even an overview about existing inventories is not available. However, several inventories have been executed for specific areas, not only for example for Community Forests and by the Cheetah Conservation Fund and DECOSA (2011), but also on private farms. For instance, it is a precondition of charcoal producers, who want to be internationally certified by the Forest Stewardship Council (FSC), to provide and continuously update forest management plans and thus inventories⁴⁵⁾.

Due to the importance of resource information the Support to De-bushing Project initiated two research projects, a national GIS mapping on bush encroachment complemented by a detailed assessment of local biomass resources in a selected area.

In addition to information about the currently available resources, a long-term sustainable utilisation has to consider the growth rates of individual species. Hardly any information is available in this regard. Although the determination of growth rates requires long-term research, it should at least commence as soon as possible.

(e) Provision of Incentives

Greater security for investors by an improved regulatory framework would already be a type of incentive. Moreover, several incentives are in place which could probably be used by local and foreign investors, for instance

- diverse programmes of MTI to support SMEs;
- the Export Processing Zone (EPZ) status which provides export oriented industries with tax and other incentives;
- the status of infant or strategic industries which can protect investments in Namibia against imports;
- a 25% land transport rebate for foreign investors.

Independently of such available incentives, various experts for rangeland management share the opinion that combating bush encroachment requires additional financial incentives⁴⁶⁾. The GRN is aware of the need to sponsor combating bush encroachment financially. According to NDP4, the strategy of addressing the challenge of bush encroachment is to “invest in and scale up the MAWF’s de-bushing project across the country”. Furthermore, the Soil Conservation Act also provides for the payment of subsidies and grants to meet the objectives of this act and therefore constitutes a legal basis for support (NAU, Oct. 2012).

Financial incentives could really boost de-bushing on large scale. They should be in particular considered for producers of wood chips and pellets targeting heat and power generation, in order to increase the national and international competitiveness of these products, which are in line with the GRN’s target to promote energy generation based on biomass. In addition also incentives for large investments with relatively sophisticated technologies (e.g. MDF, WPC) should be considered. It is therefore recommended to urgently investigate the needs of different businesses based on de-bushing, as well as an optimal system of financial incentives for instance considering subsidies, tax exemptions, soft loans, etc.

Costs for incentives should be seen in light of benefits, not only the balancing of the estimated N\$1.6 billion loss in livestock carrying capacity, but also the employment creation, promotion of manufacturing etc.

⁴⁵⁾ In 2013, 31 commercial farms had a FSC certification.

⁴⁶⁾ Schneider and de Klerk (NAU, 2012).



5.2.2 Product Specific Requirements

In addition to the general support needed for the de-bushing and promotion of value chains, some end-use opportunities require additional support as recommended in the following (see also Chap. 3.2 - 3.8)

a) Determination of the Wood Properties

As long as the wood is only used – as currently – for basic products with limited value addition (firewood, poles, compressed firewood, charcoal, chips and pellets for power generation), the properties are of secondary importance or the traditional knowledge can be and actually is used, e.g. regarding carving.

For small end-use opportunities only practical tests by interested local entrepreneurs are recommended.

With regard to all other products, the properties are of such an importance that they may decide about the feasibility of the production. Since no information about the properties of individual invader species is publically available, scientific testing (see Tab. 11) considering the end-uses is required (see also Chap. 3).

In addition to these tests, the bark content and relation between heartwood and sapwood need to be determined. This can be done in Namibia.

b) Mobilisation of Investors and/or Know-how Partners

This is normally a critical issue of industrial development. However, remarkably investors need not be mobilised for several end-use opportunities from de-bushing. This applies for the following products:

WOOD CHIPS, PELLETS, COMPRESSED WOOD

Local investors are available and some are in production, but technical problems with equipment need to be solved and additional markets to be opened.

BIO-REFINERY

This business idea, based on new technologies and end products, has been developed by a European group that is currently assessing the possibility to implement the refinery in Namibia. Projects like this require guaranteed long-term access to large volumes of biomass (i.e. need for a biomass supply concept), while responsibility for developing the end use technologies remains with the project developers.

CHARCOAL

Existing producers are prepared to extend their capacities and new local investors are informed about the positive prospects. Required is primarily the improvement of the regulatory framework.

CARVING

Hundreds of carvers with respective know-how are available in Namibia. They shall in future only be provided with raw material from de-bushing.



Tab. 11: Required Scientific Wood Property Tests for Different End-use Opportunities

Product	Tests
Compressed firewood	<ul style="list-style-type: none"> • Reasons for high ash content • Possibilities for reduction of ash content
Wood-cement bonded bricks & boards	<ul style="list-style-type: none"> • Chemical properties (e.g. pH value, sugar content) • Wood-cement shear tests
Medium density fibre boards	<ul style="list-style-type: none"> • pH value • Buffer capacity (for gluing)
Wood-plastic composites	<ul style="list-style-type: none"> • Production tests with mixed species
Animal feed	<ul style="list-style-type: none"> • Chemical composition • Digestion tests (lignin, etc.) • Final feed composition
Parquet	<ul style="list-style-type: none"> • Hardness • Grain direction • Quelling • Shrinkage • Gluing properties • Drying capability
Shingles	<ul style="list-style-type: none"> • Grain direction • Dimension stability under climate testing
Traditional medicine	<ul style="list-style-type: none"> • Possible applications • Acceptance by health authorities

In contrast to the above end-use opportunities, others require the mobilisation of investors and/or know-how partners as core support service for implementation. The required actions and target groups vary considerably depending on the type of business:

FIREWOOD & POLES

Hardly any preparation is required. Local entrepreneurs need only to be informed about the opportunities to start formal (!) businesses, probably after some training.

SMALL USES

The production of wooden frames, kitchen boards, sticks and handles for tools and smoking material can be promoted immediately amongst local SMEs. They must only be informed about the opportunities and shall test suitable species from encroacher bush themselves.

WOOD-PLASTIC COMPOSITES (WPC)

Similar to the following products, the implementation of a WPC production requires several preparatory steps. However, potential local investors and know-how partners should come from the existing plastic industry in Namibia since their know-how would be an asset for the project. Therefore, it is recommended to identify and mobilise potential partners and involve them already in the planning phase.



WOOD-CEMENT BONDED BRICKS AND BOARDS

A similar approach as for WPC is recommended for these products, however, focusing on foreign partners with experience in the production of wood-cement bonded products. The partner should be identified and mobilised early and should be involved latest in the preparation of the feasibility study.

MEDIUM DENSITY FIBRE BOARDS AND TRADITIONAL MEDICINE

Also these productions should be implemented with foreign partners. However, due to the current limited knowledge about the prospects in Namibia mobilisation of partners has only a chance to be successful after further investigation.

ANIMAL FEED, PARQUET, SHINGLES

These productions should be implemented by local investors. Otherwise the same applies as for the aforementioned products, i.e. before mobilisation of investors further investigations must demonstrate the prospects.

WOOD GLUE

The promotion of this product differs insofar from the others, as it is recommended to consider a small scale production only after experienced foreign companies have been approached and demonstrate interest in a production in Namibia.

(c) Determination of Optimal Production Technologies

Although international (and in some cases even national) experience is available for all possible end-use opportunities, some production technologies have to be adapted to the Namibian conditions, in particular to the raw material from encroacher bush. This applies for the following equipment or production processes:

CHIPPERS AND EXTRUDERS

Chippers are required for several products and extruders for compressed firewood. Several types of machines are in operation in Namibia, but none works satisfactorily in large scale applications. It is therefore recommended to support the mobilisation of international specialists to solve the technical problems which must be possible.

PELLETING MACHINES

They have been tested in Europe with wood chips from Namibian encroacher bush, but the results were disappointing due to the sand content. It could be envisaged to engage specialists, although it seems to be difficult to solve this problem. If that is not possible, pelleting for international markets cannot be recommended.

CHARCOAL KILNS

Although the currently used simple drum kilns produce barbecue charcoal, which is internationally in high demand, improved steel kilns with higher productivity should be tested.

PRODUCTION PROCESSES FOR WOOD-CEMENT BONDED PRODUCTS AND MEDIUM DENSITY FIBRE BOARDS (MDF)

If species can be identified with suitable properties, production tests are required to determine suitable processes considering the effect of the bark content and the glue requirements (for MDF).

PROCESSES FOR ANIMAL FEED PRODUCTION

Only different processes based on experiments of Namibian farmers are known. Due to the high priority of this value chain, specialists should be involved to develop two production processes, for decentralised small scale manufacturing on farm level and for centralised production including pelleting.



d) Education and Capacity Building

Generally it is of utmost importance that all workers involved in de-bushing, but also their supervisors, are practically trained in species identification (see Photos 20), since the harvest of protected species is often based on lack of knowledge. The same sometimes applies for harvesting rules. In addition, education and training are required for the development of several value chains.

COMPRESSED FIREWOOD

A comprehensive educational campaign is recommended to convince micro entrepreneurs involved in food processing, but also lower income groups in informal settlements, regarding the advantages of using compressed instead of normal firewood.

CARVING

It should be considered to supply carvers with wood from de-bushing since currently they often use (also illegally harvested) bigger trees. This requires education and the development of supply chains.

Photos 20: Training in Species Identification



POLES

In addition to general business training, entrepreneurs who intend to get involved in this type of business require limited short capacity development, including selection of suitable wood, improvement of the quality (e.g. de-barking, treatment with tar), etc.

CHARCOAL

Although charcoal is the most developed industry based on encroacher bush, a need for capacity building has been identified in several areas, for example

- production planning from harvesting up to sales,
- economic effects of team instead of the currently applied individual work,
- optimisation of carbonisation times,
- monitoring and control of harvesting and carbonisation,
- quality consciousness
- marketing and sales.

ANIMAL FEED

After a process for small de-centralised production has been developed, communal and commercial farmers should receive production oriented training.

SMALL SCALE USES

It is assumed that SMEs being interested in specific end-use opportunities require capacity building in business operation, in particular regarding marketing and financial management. This may apply for all small uses but also for poles, firewood and - as mentioned - also for charcoal.

(e) Preparation of Strategic Documents

Different types of strategic documents are required to promote and implement the end-use opportunities.

ANALYSES OF TRANSPORT OPTIONS

Transport costs are in particular critical for export oriented mass productions, such as wood chips, pellets and compressed firewood. Since different options are available (depending on the quantities, packaging etc), which may finally decide about the feasibility of the business, detailed analyses are recommended already at an early stage of the project development.

SPECIAL ANALYSES OF THE COSTS

The production costs are an important factor for any type of business and are part of every feasibility study. However, for some end-use opportunities they are so critical that it is recommended to analyse them specifically at an early stage of the project development. This applies for the production of wood chips, pellets, compressed firewood, wood plastic composites and parquet. It is remarkable that cost analyses are required for wood chips and compressed firewood, although such businesses are already operating in Namibia. However, they do not have detailed and reliable information about their production costs.

With regard to charcoal, a special analysis is recommended to determine the viability of local processing and/or export marketing of fines and charcoal dust.

SPECIAL MARKET SURVEYS

Similar to the costs, the demand markets are so critical for some end-use opportunities that they should be investigated in detail at an early stage of the project development before, for example, investing in full scale feasibility studies. This applies for

- compressed firewood, including investigations of how strict international consumers are in applying the quality requirements which are not all fulfilled by Namibian products;
- wood pellets requiring similar investigation with regard to the acceptance of Namibian qualities in Europe and in addition identification of potential large scale consumers;
- possible markets for wood chips in Botswana and Zimbabwe, which could be considered;
- medium density fibre boards, which require investigation of the domestic market and the demand in other African countries with emphasis on quality requirements and possibilities to substitute other wood based boards;
- wood-plastic composites for which a selection of a few products from the possible wide range is required, based on market surveys in Namibia and neighbouring countries;
- parquet which requires only an investigation of the high-end local market;
- shingles, for which niche markets in a few European countries may exist, require respective market surveys even before testing wood properties to identify suitable species.

FEASIBILITY STUDIES

For several end-use opportunities feasibility studies are required. In some cases parts of such studies have already been investigated in advance (e.g. production and transport costs, markets) and can be integrated in the full scale studies.

Feasibility studies are required for

- compressed firewood with emphasis on the competitiveness versus wood chips and pellets for industrial uses;



- wood-cement bonded boards and bricks, considering the possibilities to market products locally and in neighbouring countries, which are of good quality but may not comply with the international standards;
- medium density fibre boards for a plant capacity of 75 000-100 000 t/p.a., considering the viability compared with large scale international plants based on softwood;
- wood-plastic composites, considering in particular the possible wide range of products, each requiring expensive moulds;
- medium to larger scale productions of animal feed, including cost calculation (comparison to costs of lucerne) and a detailed demand analyses, in particular considering communal farmers;
- shingles (fairly simplified);
- traditional medicine - at a later time - if quantitative surveys, investigation on the applicability, etc. demonstrated positive prospects.

5.3 Implementation Plans

The necessity of combating bush encroachment in Namibia is accepted on political, economic and technical level and considered in different policies, laws and regulations. De-bushing has been discussed for several decades, but the actual implementation is limited. Therefore, an action and time plan is prepared in the following, which shall facilitate the implementation.

The plan is based on the aim to convert the biomass from encroacher bush into marketable products, as far as possible with high value addition. They include recommendations for the implementation of end-use opportunities from encroacher bush as well as directly related necessary measures to create an enabling environment for de-bushing, processing and marketing of products from invader species.

It has to be considered that the plans

- are not all inclusive since they focus on the utilisation of encroacher bush, i.e. additional measures may be required for a comprehensive and successful de-bushing programme, and
- are living documents; if the assumptions, in particular with regard to the timing vary, the plans have to be, and easily can be, modified.

5.3.1 Action Plan

Tab. 12 includes a summarised plan of actions for the implementation of the different identified end-use opportunities and the directly related measures to improve the regulatory and institutional environment.

The following remarks apply for this plan:

- The actions and remarks are summarised. Details as described in Chap. 2.2.3, 2.2.5, 3.2-3.8 and 5.2 shall be considered during implementation.
- For each action/project a lead driver is recommended (indicated in bold in the table under the heading Partners Involved).
- The most important or major restricting factors, respectively, are indicated in italic in the table.
- The list of potential stakeholders to get involved includes but is not limited to
 - Consultants/Trainer (CON)
 - Coordinating Body (CB)
 - De-Bushing Advisory Service (DAS)
 - De-Bushing Project (DBP)



- Directorate of Forestry (DoF)
- Foreign Specialists (FS)
- Health Authorities (HA)
- Indigenous Products Task Team (IPTT)
- International Partners (IP)
- Local Experts (LE)
- Local Plastic Enterprise
- Ministry of Agriculture, Water and Forestry (MAWF)
- Ministry of Environment and Tourism (MET)
- Ministry of Finance (MOF)
- Ministry of Lands and Resettlement (MLR)
- Ministry of Regional and Local Government, Housing and Rural Development (MRLGHRD)
- Ministry of Trade and Industry (MTI)
- Namibia Agricultural Union (NAU)
- Namibia Biomass Industry Group (NBIG)
- Namibia Chamber of Commerce and Industry (NCCI)
- Namibian Charcoal Producers Association (NCPA)
- Namibia National Farmers Union (NNFU)
- Private Entrepreneurs (PE)
- Private Small and Medium Enterprises (SME)
- Regional Councils (RC)
- Research Institutes (RI)
- Traditional Authorities (TA)

5.3.2 Time Plan

Fig. 3 provides an overview of the estimated time frames for the individual actions. The following needs to be considered:

- It is assumed that improvements of the institutional and regulatory framework will be conducted with highest priority, since they are a precondition for the development of most end-use opportunities.
- The development of end-use opportunities depends on
 - the commencement of larger scale de-bushing,
 - the priorities finally set by the stakeholders,
 - the human capacity of the implementing stakeholders which currently limits the development of several opportunities in parallel, and
 - the available financial resources.

Due to these uncertainties, the plan is based on starting to develop all opportunities in year 2, with the exemption of already ongoing actions / consultancies. Since this is not realistic, the plan will need to be adapted according to the actual progress achieved throughout the implementation process.



Tab. 12: Plan of Actions for Implementation

Action	Partners Involved	Remarks
BASIC REQUIREMENTS		
Institutional and Regulatory Requirements	DBP	
• Coordination and cooperation between stakeholders	CB, MAWF, DoF, RCU, MET, DBP, MLR, MRLGHRD, NAU, NNFU, TA	Coordination unit for implementation of the National Rangeland Strategy established 1.4.2015 (Rangeland Coordination Unit)
• Improvement of the regulatory framework	DoF, DBP, TA, CB	Definitions (encroacher & protected species etc), preparation of harvesting guidelines (priority), revision of permits
• Strengthening of existing incentive schemes and development of new incentives	DBP, CON, CB, MAWF, MTI, MOF, Meatco/ Meat Board	
Other Requirements	DAS	
• Training in species identification & harvesting rules	DAS, CON, NCPA, NAU, NNFU, PE	Target groups: Harvesters, supervisors, DoF officers
• Determination of harvesting technologies & costs	DBP, CON, PE	On-going
• <i>Assessment of biomass resources</i>	DBP, CON	On-going
DEVELOPMENT OF END-USE OPPORTUNITIES		
Firewood	DAS	
• Education of the rural population	CON, RC/TA, NNFU	Primarily utilisation of wood from bush encroachment areas
• Promotion of formal firewood businesses	DAS, SME, MTI	Based on wood from de-bushing
• Basic business training	DAS, CON, SME, MTI	Depending on know-how of entrepreneur



Action	Partners Involved	Remarks
• Monitoring of illegal harvesting & law enforcement	DoF	
Compressed Firewood	NBIG	
• Solving the issue of sand/dust content in bush material (impacting on technology/processes)	NBIG, FS	Supporting international technical expertise required
• Educational campaign	DAS, CON	Demonstration of advantages versus firewood targeting micro food processors & lower income groups in informal settlements
• Research regarding high ash content	NBIG, RI	Investigation of reasons; possibilities for reduction
• Investigation transport options/costs & production costs	NBIG, CON	Costs critical factor for exports to overseas
• Market survey among private households locally, in SA region and overseas	DBP, CON	Consideration of European quality requirements
• Market survey of industrial consumer	DBP, CON	Covering Namibia & overseas countries
• Feasibility Study	DBP, CON	Considering competitiveness versus firewood, chips & pellets
Charcoal	NCPA	
• Upscaling de-bushing / harvesting methods	NCPA	With the aim to ensure full bush utilization
• Testing improved steel kilns	NCPA, CON, PE	With the aim to ensure productivity gains
• Capacity building	DAS, NCPA, CON, PE	Local entrepreneurs & workers to increase productivity, export & reduce illegal harvesting
• Analysis feasibility of briquetting	NCPA, CON	From charcoal fines
• <i>Improving regulatory environment and law enforcement</i>	DoF	



Action	Partners Involved	Remarks
Wood Chips	NBIG	
• Developing chipper technology customised to harsh Namibian conditions	FS, PE NBIG	Supporting international technical expertise required
• Investigation transport options/costs & production costs	NBIG, CON	Critical factor for local and export markets
• Market surveys in SA region and overseas	NBIG, CON	If transport costs are competitive
Wood Pellets	NBIG	
• Solving the issue of sand/dust content in bush material (impacting on pelleting process / technology)	FS	Foreign specialists required
• Investigation transport options/costs & production costs	NBIG, CON	Foreign specialists required
• Market survey regarding large scale overseas consumer	NBIG, CON	Acceptance of Namibian qualities
Bio-refinery	DBP	
• Technical cooperation with potential European investor	DBP, IP	
• Assisting investor in implementation	DBP, IP	
Poles	DAS	
• Identification of local entrepreneur interested in formal business	NCCI, RC/TA	
• Capacity building of local entrepreneur	MTI, CON, SME	Short term, e.g. planned cutting by lengths, painting with tar, grading/sales by species
Wood-Cement Bonded Bricks & Boards	MTI	



Action	Partners Involved	Remarks
• Selection of suitable species	DBP, CON, RI	Property test required
• <i>Property tests with suitable species</i>	RI	Considering also effect of bark content
• Identification & mobilization international partner	DBP	Know-how required
• Feasibility study	DBP, CON, IP	Considering quality & markets in Namibia & neighbouring countries
Medium Density Fibre Boards (MDF)	MTI	
• Selection of suitable species	DBP, LE, RI	Property test required
• <i>Property test with suitable species</i>	RI	Considering also effects of bark contents & gluing requirements
• Market surveys	DBP, CON	In Namibia & other African countries considering board qualities
• Feasibility study	DBP, CON	Considering competitiveness vis-à-vis large scale international plants
• Identification & mobilization of investors	DBP	
Wood-plastic Composites (WPC)	MTI	
• Verification suitability of mixed invader species	DBP, RI	Production tests abroad
• Mobilisation of partner from the Namibian plastic industry	DBP	Possibly only know-how partner; to be involved already in planning phase
• Cost calculation for limited number of products	DBP, CON, LPE	Determination of competitiveness versus similar products from other resources
• <i>Identification of specific products & market survey</i>	DBP, CON, LPE	Reduction of large product range; markets in Namibia & neighbouring countries



Action	Partners Involved	Remarks
• Feasibility study	DBP, CON, LPE	Considering the product range
Animal Feed	MAWF	
• Identification of suitable invader species	DBP, LE, RI	Based on local experience & tests of chemical composition
• Digestion tests	RI	Considering lignin content
• Tests of the whole use of bushes or only smallest branches & leaves	RI	
• Development of feed compositions	RI, LE	Required additives (e.g. molasses) & their availability
• Development of production processes	RI, LE	Small scale de-centralised and larger scale production
• Feasibility study	DBP, CON	Considering costs compared to other feed (e.g. lucerne) and demand/acceptance by communal farmer
• Identification and mobilization of local investors	DBP	
• Training of farmers in small scale production	DAS, LE	
Parquet	DAS	
• Market survey	DBP, CON	Only high-end domestic markets
• Selection of suitable species	DBP, LE, RI	Property test required
• Property tests	RI	
• Cost analysis	DBP, CON	Considering sawing and kiln drying



Action	Partners Involved	Remarks
• Identification & mobilization of local investor	DBP	
Shingles	DAS	
• Market survey in Europe	DBP, CON	Only specific areas in Europe (e.g. Alps)
• Selection of suitable species	DBP, LE, RI	Property tests required
• Property test	RI	
• Simplified feasibility study	DBP, CON	
Traditional Medicine	IPTT	
• Identification of species (parts) used as traditional medicine	IPTT, DBP, TA	
• <i>Determination of available quantities</i>	IPTT, DBP, CON	Based on ongoing bio-mass inventories
• Investigation of possible application & acceptance by foreign health authorities	RI, HA	
• Feasibility study	DBP, CON	Considering high marketing costs
• Identification & mobilisation of international partners	DBP	Know-how required, in particular marketing
Wood Glue	DAS	
• Mobilisation of international expertise/technology partner	DBP	Project only considered if experienced foreign company demonstrates interest
Carving	DAS	



Action	Partners Involved	Remarks
• Education of wood carvers	MTI, DAS, RC/TA	Utilisation of wood from bush encroachment areas
Frames, Kitchen Boards, Sticks, Handles, Smoking Material	DAS	
• Mobilisation of local SMEs	NCCI, MTI, MRLGHRD	
• Tests of suitable species & production	SME	Only practical tests by local entrepreneurs
• Capacity building of local SMEs	MTI, CON	Business operation, in particular marketing & financial management



Fig. 3: Action and Time Plan for Implementation

Action	Year 1 (quarters)				Year 2 (quarters)				Year 3 (quarters)				Year 4 (quarters)			
	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12
BASIC REQUIREMENTS																
Institutional and Regulatory Requirements																
• Coordination and cooperation between stakeholders																
• Improvement of the regulatory framework																
• Development & approval of an incentive system																
Other Requirements																
• Training in species identification & harvesting rules																
• Determination of harvesting technologies & costs																
• Assessment of biomass resources																
DEVELOPMENT OF END-USE OPPORTUNITIES																
Firewood																
• Education of the rural population																
• Promotion of formal firewood businesses																
• Basic business training																
• Monitoring of illegal harvesting & law enforcement																
Compressed Firewood																
• Solving technical problems with extruder																
• Educational campaign																
• Research regarding high ash content																
• Investigation transport options/costs & production costs																
• Market survey private consumer in Europe & neighbouring countries																
• Market survey for industrial consumer																
• Feasibility study																
Charcoal																
• Testing improved steel kilns																
• Capacity building																
• Analysis feasibility of briquetting																
• Monitoring of illegal harvesting & law enforcement																
Wood Chips																
• Solving technical problems with chipper																
• Investigation transport options/costs & production costs																
• Market surveys in Europe, Botswana, Zimbabwe																
Wood Pellets																
• Solving technical problems with pelleting machine																
• Investigation transport options/costs & production costs																
• Market survey regarding large scale overseas consumer																
Action	year 1 (quarters)				year 2 (quarters)				year 3 (quarters)				year 4 (quarters)			

	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12
Bio-refinery																
• Keeping contact with potential European investor																
• Assisting investor in implementation																
Poles																
• Identification of local entrepreneur interested in formal business																
• Capacity building of local entrepreneur																
Wood-Cement Bonded Bricks & Boards																
• Selection of suitable species																
• Property tests with suitable species																
• Identification & mobilization international partner																
• Feasibility study																
•Medium Density Fibre Boards (MDF)																
• Selection of suitable species																
• Property tests with suitable species																
• Market surveys																
• Feasibility study																
• Identification & mobilization of investors																
Wood-plastic Composites (WPC)																
• Verification suitability of mixed invader species																
• Mobilisation of partner from the Namibian plastic industry																
• Cost calculation for limited number of products																
• Identification of specific products & market survey																
• Feasibility study																
Animal Feed																
• Identification of suitable invader species																
• Digestion tests																
• Tests of the whole use of bushes or only smallest branches & leaves																
• Development of feed compositions																
• Development of production processes																
• Feasibility study																
• Identification and mobilization of local investors																
• Training of farmers in small scale production																
Parquet																
• Market survey																
• Selection of suitable species																
• Cost analysis																
• Identification & mobilization of local investor																

Action	year 1 (quarters)				year 2 (quarters)				year 3 (quarters)				year 4 (quarters)			
	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12



Shingles																
• Market survey in Europe																
• Selection of suitable species																
• Simplified feasibility study																
Traditional Medicine																
• Identification of species (parts) used as traditional medicine																
• Determination of available quantities																
• Investigation of possible application & acceptance by foreign health authorities																
• Feasibility study																
• Identification & mobilisation of international partners																
Wood Glue																
• Identification & mobilisation of international partner																
Carving																
• Education of wood carvers																
Frames, Kitchen Boards, Sticks, Handles, Smoking Material																
• Mobilisation of local SMEs																
• Tests of suitable species & production																
• Capacity building of local SMEs																

Legend:

In Namibia

Continuous in Namibia

Abroad

In Namibia and abroad

5.4 Estimation of Development Costs and Benefits

In Tab. 13 the costs for the recommended actions are summarised. The following needs to be considered:

- The estimates are fairly rough due to a number of uncertainties. For example:
 - Costs for tests of wood properties depend on the number of biomass species to be tested. Therefore, a pre-selection of species is required based on the limited local knowledge.
 - It is not sure whether foreign machine suppliers will improve for example the chippers at no costs. However, this can be assumed if they are convinced about the huge market potential in Namibia.
- The following costs are not considered:
 - Actions which could be done by the permanent personnel of the De-Bushing Project or DoF, such as mobilisation of local entrepreneurs or foreign partners⁴⁷⁾, education of entrepreneurs through the De-bushing Advisory Service and keeping contact with international project developers as well as monitoring by DoF and improvement of the institutional regulatory framework.
 - Ongoing consultancies, e.g. regarding harvesting technologies and assessment of the biomass resources.
 - Tests of suitable species for the production of frames, handles, etc. which shall be done by local entrepreneurs.
 - Subsidising of de-bushing.
- The action planning for the end-use opportunities is based on a step-by-step approach, i.e. if for instance the technical problems with pelleting machines cannot be solved or species are not suitable for MDF production, the project development will be terminated at an early stage and thus the costs will be reduced.
- If projects are developed in parallel, costs can be reduced, i.e. for transport of samples.
- Business training for local SMEs is not considered under the different opportunities but separately, because the entrepreneurs from different businesses can be trained together, with the exception of charcoal and feed producers who require special training.

The costs for the required actions to develop the value chains can be covered by different sources already available or to be mobilised. For example:

- International agencies of development cooperation, which could mainly cover research abroad, international market surveys, feasibility studies, etc.
- MTI from their support programmes like the Study Fund and training of SMEs.
- NGOs which are specialised on the development of indigenous products and could assist in the promotion of traditional medicine.
- Government budget from 2016 onwards.

The costs are marginal in light of the following benefits:

- Rangeland management experts estimate an annual loss of N\$1.4-1.6 billion in reduced meat exports caused by bush encroachment.
- The MLR is supporting livestock farmers in years of draught, e.g. by repayment of land tax. Such costs could be avoided by a de-bushing programme that increases the natural livestock carrying capacity and could in addition provide animal feed from invader bush.

⁴⁷⁾ Costs for travelling abroad are included, if deemed necessary.



- De-bushing and in several cases also the following steps of the value chain are labour intensive. Based on estimates of DECOSA (2013), employment in the charcoal industry alone could be increased by 16 000 people in 10 years with an increase of income of workers from N\$120 million to N\$811 million (based on current salaries).
- In addition to the link to livestock farming, value chains based on encroacher bush will have backward and forward linkages to other business sectors including for example
 - environmentally friendly energy generation,
 - construction industry,
 - transport companies,
 - agents and exporters, and
 - producers of equipment.
- Development of the manufacturing sector is a priority of NDP4 with particular focus, besides fishery and mining, on agricultural processing. NDP4 states: “Very little value addition is carried out in Namibia at present with regard to agricultural products. Through suitable support and incentives, agro-processing could also serve as a strategic manufacturing industry for Namibia”. The industry based on de-bushing ideally fulfils the national objective of using local resources and processing them with value addition. Vis-à-vis other sectors the industry has furthermore the advantage that local entrepreneurs – also from communal areas – are promoted.
- Several products are targeting export markets and thus contribute to the national objective of export promotion. The charcoal industry alone could increase its exports from N\$200 million p.a. to N\$900 million p.a. based on constant prices (DECOSA, 2013).
- Also, the fiscal benefits exceed by far the costs for the development of value chains based on de-bushing. Again projections are only available for the charcoal industry. If developed further, the industry would pay N\$211.1 million income tax at constant rates (in total, over 10 years).



Tab. 13: Cost Estimates

Action	Cost Estimate (in N\$)	Remarks
General		
• Training in species identification & harvesting rules	200 000.00	Training of trainers; 500 supervisors in groups of 25
Firewood		
• Education of the rural population	130 000.00	Posters, leaflets; 1 day workshop Traditional Authorities
Compressed Firewood		
• Solving technical problems with extruder	25 000.00	Sending samples abroad; no costs for tests by machine suppliers
• Educational campaign	30 000.00	In Windhoek only
• Research regarding high ash content	150 000.00	Foreign research institute; sending samples
• Investigation transport options/costs & production costs	100 000.00	
• Market surveys private & industrial consumers in Europe & neighbouring countries	250 000.00	
• Feasibility study	250 000.00	
TOTAL	805 000.00	
Charcoal		
• Testing improved steel kilns	150 000.00	Including purchase 1 kiln type; no material costs (provided by producers); no permanent consultancy
• Capacity building	700 000.00	200 supervisors in 10 groups at different locations; 20% cost contribution by participants
• Analysis feasibility of briquetting	200 000.00	
TOTAL	1 050 000.00	



Action	Cost Estimate (in N\$)	Remarks
Wood Chips		
• Solving technical problems with chipper	25 000.00	Sending samples abroad; no costs for tests by machine suppliers
• Investigation transport options/costs & production costs	100 000.00	
• Market surveys in Europe, Botswana, Zimbabwe	250 000.00	
TOTAL	375 000.00	
Wood Pellets		
• Solving technical problems with pelleting machine	25 000.00	Sending samples abroad; no costs for tests by machine suppliers
• Investigation transport options/costs & production costs	100 000.00	
• Market survey regarding large scale overseas consumer	130 000.00	
TOTAL	255 000.00	
Wood-Cement Bonded Bricks & Boards		
• Selection of suitable species	150 000.00	
• Property tests with suitable species	550 000.00	Foreign research institute; sending samples
• Identification & mobilization international partner	100 000.00	Travel abroad
• Feasibility study	350 000.00	With partner
TOTAL	1 150 000.00	
•Medium Density Fibre Boards (MDF)		
• Selection of suitable species	150 000.00	
• Property test with suitable species	700 000.00	Foreign research institute; sending samples
• Market surveys	250 000.00	African countries
• Feasibility study	600 000.00	
• Identification & mobilization of investors	100 000.00	Travel abroad
TOTAL	1 800 000.00	



Action	Cost Estimate (in N\$)	Remarks
Wood-plastic Composites (WPC)		
• Verification suitability of mixed invader species	350 000.00	Sending sample abroad; tests to be paid
• Cost calculation for limited number of products	80 000.00	With local partner
• Identification of specific products & market survey	200 000.00	With local partner
• Feasibility study	250 000.00	With local partner
TOTAL	880 000.00	
Animal Feed		
• Identification of suitable invader species	150 000.00	
• Digestion tests	400 000.00	Foreign research institute; sending samples
• Tests of the whole use of bushes or only smallest branches & leaves	300 000.00	Foreign research institute; sending samples
• Development of feed compositions	300 000.00	Foreign research institute
• Development of production processes	300 000.00	Foreign research institute
• Feasibility study	250 000.00	
• Training of farmers in small scale production	40 000.00	10 farmers for 1 week
TOTAL	1 840 000.00	
Parquet		
• Market survey	40 000.00	Only in Windhoek
• Selection of suitable species	100 000.00	
• Property tests	300 000.00	Foreign research institute; sending samples
• Cost analysis	120 000.00	
TOTAL	560 000.00	



Action	Cost Estimate (in N\$)	Remarks
Shingles		
• Market survey in Europe	180 000.00	
• Selection of suitable species	150 000.00	
• Property tests	200 000.00	
• Simplified feasibility study	100 000.00	
TOTAL	630 000.00	
Traditional Medicine		
• Identification of species (parts) used as traditional medicine	30 000.00	By local people
• Determination of available quantities	200 000.00	Based on on-going biomass inventories
• Investigation of possible application & acceptance by foreign health authorities	2 500 000.00	Depending on number of products
• Feasibility study	200 000.00	
• Identification & mobilisation of international partners	100 000.00	Travel abroad
TOTAL	3030 000.00	
Wood Glue		
• Identification & mobilisation of international partner	100 000.00	Travel abroad
• Capacity Building of Local SMEs	180 000.00	2 groups, 2 weeks each



ANNEXES

ANNEX 1 -Bibliography

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Agriforum

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Agriforum

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Minister launches national rangeland strategy

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Incentives needed to encourage rangeland management

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NAU



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ANNEX 2 — Contacted Persons

<u>Company/Institution</u>	<u>Person</u>
Agra	Kayofa, T.
Agra ProVision	Honsbein, D.
AgriConsult Namibia	Rothauge, A.
Best Braai Pretoria	Ebrahim, A.
Bushman Charcoal Namibia	Konzelewski, R.
Cheetah Conservation Fund	Brewer, B. Dr. Stackmann, H.
Cissonius GmbH	Schiller, M.
Department of Forestry (MAWF)	Hailwa, J. (Director of Forestry)
Deutsches Biomasseforschungszentrum	Schaller, S. Kohlenforschng
Easy Energy	Ndimfitu, W.
Ecolog	Maier, H.
E.L.F Systems sro CZ	Korbelar, M.
Embassy of Finland	Kivimäki, E.
Flamco CC Durban	Naiker, R.
Forklift & Allied Equipment cc	Van Rensburg, J.
F.P. du Toit Transport	Badenhorst, R.
Fachagentur Nachwachsende Rohstoffe e.V	Pelikan , V.
GemGroup AG	Rheinschmidt, K. Dr.
Georg-August-University of Goettingen	Dreber, N.
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)	Gschwender, F. Laufs, J.
Green Goal	Tovin, B.
Global Polymer Industries	Sohrada, G.
Hochschule Ostwestfalen-Lippe	Frühwald, K. Prof.
Isospan	Schilcher, H.
Inventec Otjiwarongo	Theron, J.
JENS GmbH	Klüppel, C.
Jiaozuo Zhoufeng Machinery Co.,Ltd	
Leibnitz Institute for New Materials	Jung, C. Dr.
Maastricht University	Blohmke, J.
Maersk Line	Stander, T. Jalon, A.J.



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 Michael Weinig AG
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 Namibia Development Corporation
 NamChar Cape Town
 Namibia Statistics Agency
 NamPower

 NCPA
 NCT Forest
 Nina Maritz Architects
 Ohorongo Cement
 Okorusu Fluorspar
 Organic Energy Solutions

 Polytechnic of Namibia

 Prosopis Timber Supplier
 Real Consulting
 Rayco Manufacturing
 Ritlee Sales & Services (Pty) Ltd
 SA Braai - Hi-Lite Products Pretoria
 Sunkraft
 Swartboois Traditional Authority
 Technische Universität Dresden

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 Transwold Cargo
 Universität Göttingen
 Universität Hamburg
 University of the Free State

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 Chombo, S.
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 Visser, E.
 Walbaum, B.
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 Hollmann, L.
 Joubert, D.
 Mgohagulema, I.
 Engelbrecht, S.
 Mitchell, D.
 Wooster, L.W.
 Hodgson, J.
 Cromhout, K.
 Krippenstapel, C.
 Luipert, D. (Captain)
 Wagenführ, A. Prof. Dr.
 Cong, N.T. Dr.
 Richter, J.
 Greyling, F.
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ANNEX 3 — Protected Species

Scientific Name	English Name
<i>Acacia erioloba</i>	Camelthorn
<i>Acacia haematoxylon</i>	Grey camelthorn
<i>Acacia montis-usti</i>	Brandberg acacia
<i>Acacia robynsiana</i>	Whip-stick acacia
<i>Acacia sieberana</i>	Paperbark
<i>Adansonia digitata</i>	Baobab
<i>Albizia anthelmintica</i>	Worm cure albizia
<i>Aloe littoralis</i> and all <i>Aloe</i> species	Windhoek aloe
<i>Baikiaea plurijuga</i>	Zambezi teak
<i>Berchemia discolor</i>	Bird plum
<i>Boscia albitrunca</i>	Shepherd's tree
<i>Burkea africana</i>	Omutundungu Burkea
<i>Colophospermum mopane</i>	Mopane
<i>Combretum imberbe</i>	Leadwood
<i>Cyphostemma juttae</i>	Blue kobas
<i>Elaeodendron transvaalense</i> (= <i>Cassine transvaalensis</i>)	Transvaal saffron Bushveld saffron
<i>Entandrophragma spicatum</i>	Owambo wooden-banana
<i>Erythrina decora</i>	South-west coral tree
<i>Euclea pseudobenus</i>	Wild ebony
<i>Euphorbia guerichiana</i>	Paper-bark euphorbia
<i>Faldherbia albida</i>	Ana tree
<i>Ficus burkei</i> (= <i>Ficus thonningii</i>)	Strangler fig
<i>Ficus cordata</i>	Namaqua rock-fig
<i>Ficus sycomorus</i>	Sycamore fig
<i>Guibourtia coleosperma</i>	Ushivi
<i>Gyrocarpus americanus</i>	Propeller tree
<i>Kirkia acuminata</i>	White syringe
<i>Lannea discolor</i>	Live-long
<i>Maerua schinzii</i>	Ringwood tree
<i>Ochna pulchra</i>	Peeling-bark ochna



Scientific Name	English Name
<i>Olea europea subsp. africana</i>	Wild olive
<i>Ozoroa crassinervia</i>	Namibian resin tree
<i>Pachypodium lealii</i>	Bottle tree
<i>Pappea capensis</i>	Jacket-plum
<i>Parkinsonia africana</i>	Green-hair tree
<i>Peltophorum africanum</i>	African wattle Muparara
<i>Philenoptera nelsii</i> (= <i>Lonchocarpus nelsii</i>)	Kalahari omupanda Kalahari apple-leaf
<i>Philenoptera violacea</i> (= <i>Lonchocarpus capassa</i>)	Rain tree
<i>Pterocarpus angolensis</i>	Kiaat Mukwa
<i>Rhus lancea</i>	Willow rhus
<i>Salix capensis</i>	Small-leaved willow
<i>Schinziophyton routanenii</i>	Manketti
<i>Schinziophyton routanenii</i> (= <i>Ricinodendron routanenii</i>)	Manketti
<i>Schotia afra</i>	Karoo schotia
<i>Sclerocarya birrea</i>	Marula
<i>Securidaca longipendunculata</i>	Violet tree
<i>Spirostachys africana</i>	Tamboti
<i>Sterculia africana</i>	Tick tree
<i>Sterculia quinqueloba</i>	Large-leaved sterculia
<i>Strychnos cocculoides</i>	Corky monkey-orange
<i>Strychnos pungens</i>	Spine-leaved monkey-orange
<i>Strychnos spinosa</i>	Spiny monkey-orange
<i>Tamarix usneoides</i>	Wild tamarisk

Source: Dieckmann & Muduva, 2010



ANNEX 4 — Evaluation Matrix

The following table shows the evaluation of the different opportunities, with the following explanations:

- In view of the limitations regarding financial resources and trained personnel, high requirements in terms of skills and financial input are seen as negative, since they may hamper actual implementation. Therefore the lowest of these requirements is rated at 5 points (e.g. low financial requirements) the highest at 1 point. The same applies to the criteria “required other resources” (e.g. water, imported products), “minimum capacities”, “qualitative demand”, “competition” and all required support services.
- The suitability of the invader species with regard to the properties is based on assumptions of timber specialists, since hardly any information is available; research is still required for several potential uses.
- With regard to other resources required, the need for electricity and water is considered and whether required additional resources are available locally (e.g. cement) or need to be imported (e.g. plastics).
- Sophisticated technologies are ranked lower than technologies adapted to the Namibian environment (skills, maintenance etc.).
- Employment (excluding harvesting) is scored as follows:

Number of employees	Score
1-10	1
11-50	2
51-100	3
101-200	4
200+	5

The number of employees is based on one business to be implemented first (later possibly extensions) with the minimal feasible capacity regarding wood-cement bonded bricks and boards, MDF, WPC, parquet and shingles, concerning all other opportunities the national and/or international demand is considered.

- Skills requirements consider only special know-how.
- With regard to the effects on de-bushing further investigations are required for some uses. For instance, there are different opinions whether the whole selected biomass species, or only parts of the bush can be used for animal feed.
- It is not possible to consider the (recommended) combined utilisation of the encroacher bush, e.g. animal feed from younger parts of the bush and chips from the wooden parts. This is also the reason why de-bushing is weighted relatively low.
- Investment needs consider only equipment and tools for one feasible business, but not land and building and vehicles. They are scored as follows:

Initial capital required (N\$)	Score
Up to 10 000	5
11 000-100 000	4
101 000-1 million	3
1-10 million	2
10 million +	1

- With regard to required support services, not only the costs but also the chances that the services are provided have been taken into account.



- The time horizon for implementation assumes that the required support services are provided and is scored as follows:

Time (years)	Score
1	5
2	4
3	3
4	2
5+	1

- The viability, feasibility, sustainability and risks can only be assumed, since several end-use opportunities still require further investigation.

Moreover, the methodology applied considers the following:

- Not all of the selected criteria carry the same weight. Differences are taken into account by allocating different weighting factors (from 1 to 3) to different criteria.
- The matrix comparatively evaluates the different opportunities, i.e. it assesses the comparative advantages / disadvantages in the light of each of the given criteria. The different opportunities are evaluated on a scale 1 to 5 points, 1 being the lowest, 5 denoting the most positive potential. These points are then multiplied by the weighting factors.



Products		Firewood	Compressed Firewood	Charcoal	Wood Chips	Wood Pellets	Poles	Wood-Cement Bonded Bricks/Board	Medium Density Fibre Boards (MDF)	Wood-Plastic Composites (WPC)	Animal Feed	Parquet	Shingles	Traditional Medicine
Criteria	Weight	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C
· Suitability of the resources														
- Properties	(2)	5 2 10	5 2 10	5 2 10	4 2 8	4 2 8	3 2 6	2 2 4	2 2 4	4 2 8	2 2 4	2 2 4	2 2 4	3 2 6
- Availability required quantities	(3)	5 3 15	5 3 15	5 3 15	5 3 15	5 3 15	2 3 6	2 3 6	3 3 9	4 3 12	4 3 12	2 3 6	2 3 6	1 3 3
- Other resources than invader bush	(1)	5 1 5	4 1 4	5 1 5	4 1 4	4 1 4	5 1 5	3 1 3	2 1 2	2 1 2	2 1 2	4 1 4	5 1 5	4 1 4
· Processing technologies														
- Experience in Namibia	(3)	5 3 15	3 3 9	5 3 15	4 3 12	1 3 3	5 3 15	1 3 3	1 3 3	2 3 6	3 3 9	1 3 3	1 3 3	5 3 15
- Sophisticated/adapted technologies	(2)	5 2 10	3 2 6	5 2 10	4 2 8	3 2 6	5 2 10	2 2 4	2 2 4	3 2 6	4 2 8	4 2 8	5 2 10	5 2 10
- Minimum capacities	(3)	5 3 15	5 3 15	5 3 15	4 3 12	4 3 12	5 3 15	3 3 9	3 3 9	3 3 9	5 3 15	4 3 12	5 3 15	5 3 15
· Markets (domestic and foreign)														
- Quantitative demand	(3)	4 3 12	4 3 12	5 3 15	5 3 15	4 3 12	3 3 9	3 3 9	3 3 9	3 3 9	3 3 9	2 3 6	2 3 6	4 3 12
- Qualitative requirements	(3)	5 3 15	4 3 12	5 3 15	4 3 12	3 3 9	3 3 9	2 3 6	2 3 6	2 3 6	3 3 9	2 3 6	3 3 9	1 3 3
- Competition	(2)	4 2 8	2 2 4	5 2 10	4 2 8	3 2 6	1 2 2	2 2 4	2 2 4	2 2 4	1 2 2	3 2 6	1 2 2	3 2 6
- Potential	(3)	4 3 12	3 3 9	5 3 15	4 3 12	3 3 9	3 3 9	3 3 9	3 3 9	3 3 9	4 3 12	3 3 9	2 3 6	5 3 15
· Personnel														
- Employment creation	(2)	3 2 6	3 2 6	5 2 10	4 2 8	3 2 6	2 2 4	3 2 6	3 2 6	3 2 6	4 2 8	2 2 4	1 2 2	5 2 10
- Skills requirements	(2)	5 2 10	3 2 6	5 2 10	4 2 8	3 2 6	5 2 10	2 2 4	2 2 4	2 2 4	4 2 8	3 2 6	4 2 8	4 2 8
- Local availability	(1)	5 1 5	4 1 4	5 1 5	5 1 5	4 1 4	5 1 5	2 1 2	2 1 2	2 1 2	4 1 4	3 1 3	4 1 4	5 1 5
· Effects on de-bushing														
- Whole use or selected species	(2)	5 2 10	5 2 10	5 2 10	5 2 10	5 2 10	3 2 6	2 2 4	2 2 4	4 2 8	2 2 4	2 2 4	2 2 4	1 2 2
- Whole/partial use individual species	(1)	3 1 3	3 1 3	3 1 3	3 1 3	3 1 3	2 1 2	2 1 2	2 1 2	3 1 3	3 1 3	2 1 2	2 1 2	1 1 1
- Size of de-bushed area	(1)	3 1 3	2 1 2	4 1 4	4 1 4	3 1 3	1 1 1	2 1 2	2 1 2	2 1 2	3 1 3	1 1 1	1 1 1	1 1 1
· Financial issues														
- Investment	(2)	5 2 10	2 2 4	5 2 10	4 2 8	3 2 6	5 2 10	1 2 2	1 2 2	1 2 2	4 2 8	4 2 8	5 2 10	2 2 4
- Viability	(3)	5 3 15	3 3 9	5 3 15	4 3 12	2 3 6	4 3 12	3 3 9	2 3 6	3 3 9	3 3 9	4 3 12	4 3 12	4 3 12
- Value addition	(1)	4 1 4	2 1 2	2 1 2	1 1 1	1 1 1	3 1 3	4 1 4	4 1 4	4 1 4	3 1 3	5 1 5	4 1 4	5 1 5
· Required support services														
- Institutional & regulatory support	(2)	4 2 8	4 2 8	1 2 2	4 2 8	4 2 8	4 2 8	4 2 8	4 2 8	4 2 8	4 2 8	4 2 8	4 2 8	3 2 6
- Research	(3)	5 3 15	3 3 9	4 3 12	3 3 9	3 3 9	5 3 15	2 3 6	2 3 6	4 3 12	1 3 3	3 3 9	3 3 9	1 3 3

Products		Firewood	Compressed Firewood	Charcoal	Wood Chips	Wood Pellets	Poles	Wood-Cement Bonded Bricks/Board	Medium Density Fibre Boards (MDF)	Wood-Plasitic Composites (WPC)	Animal Feed	Parquet	Shingles	Traditional Medicine
Criteria	Weight	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C
- Foreign know-how partners	(3)	5 3 15	5 3 15	5 3 15	5 3 15	5 3 15	5 3 15	2 3 6	2 3 6	5 3 15	5 3 15	5 3 15	4 3 12	1 3 3
- Capacity building	(3)	4 3 12	4 3 12	3 3 9	5 3 15	5 3 15	4 3 12	2 3 6	2 3 6	3 3 9	4 3 12	3 3 9	4 3 12	4 3 12
- Strategic documents	(3)	5 3 15	2 3 6	5 3 15	3 3 9	3 3 9	5 3 15	3 3 9	2 3 6	3 3 9	1 3 3	4 3 12	3 3 9	3 3 9
· Time for implementation	(1)	5 1 5	3 1 3	5 1 5	3 1 3	3 1 3	4 1 4	3 1 3	2 1 2	3 1 3	2 1 2	3 1 3	3 1 3	1 1 1
· Feasibility, sustainability & risks	(3)	5 3 15	3 3 9	5 3 15	3 3 9	1 3 3	3 3 9	3 3 9	2 3 6	3 3 9	3 3 9	4 3 12	3 3 9	3 3 9
SCORE		268	204	267	233	191	217	139	131	176	184	177	175	180

Legend:

(A) = Scoring 1 - 5

(B) = Weighting Factor 1 - 3

(A) x (B) = Total Scoring

Value Added End-Use Opportunities for Namibian Encroacher Bush

Specific characteristics distinguish encroacher bush from other industrial wood resources such as the mixture of hardwoods from species with different mechanical and chemical properties and the dimensions of the woody biomass, which are fairly small.

The current economic utilisation of encroacher bush focuses mainly on firewood for local communities, charcoal for exports, and small production of compressed firewood. This study showcases these and further potential products, considering international best practices, traditional uses and emerging opportunities. It explores value chains of wood products for heating and energy, for the agricultural sector and for the construction industry.

The large demand of the energy sector may trigger large scale de-bushing projects. Other value chains use much smaller amounts but may still lead to considerable value addition as well as to the creation of small and medium enterprises and employment.