NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Biomass Utilisation by Sustainable Harvest (BUSH) Project Closure Workshop

Technology Development, Applied Research and Capacity Development in Bush Control and Biomass Utilisation

by

Faculty of Engineering in collaboration with the Faculty of Natural Resources and Spatial Sciences, Faculty of Health and Applied Sciences and the Innovation Design Lab

BUSH
BIOMASS UTILISATION BY SUSTAINABLE HARVEST

german cooperation
DEUTSCHE ZUSAMMENARBEIT

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

2021

Second release, October 2021.

TABLE OF CONTENTS

ABBREVIATIONS

BUSH	Biomass Utilisation by Sustainable Harvest
BCBU	Bush Control and Biomass Utilisation
CBEND	Combating Bush Encroachment for Namibia's Development
CCF	Cheetah Conservation Fund
DAS	De-bushing Advisory Service
DNAS	Department of Natural and Applied Sciences
FE	Faculty of Engineering
FHAS	Faculty of Health and Applied Sciences
FNRSS	Faculty of Natural Resources and Spatial Sciences
IDL	Innovation Design Lab
MAWF	Ministry of Agriculture, Water and Forestry
N-BiG	Namibian Biomass Industry Group
NCA	Namibia Charcoal Association
NFC	Natural Fibre Composites
NSCA	Namibia Small Contractors Association
NUST	Namibia University of Science and Technology
SMEs	Small and Medium Enterprises
WPC	Wood-Plastic Composites
HPP	Harambee Prosperity Plan
NDP-5	5th National Development Plan
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German International Development Agency)
LEU	Lisha Empowerment and Upliftment
HT	Hochland Tractors
BAS	Baufi's Agricultural Services
NGW	NamGreenWood
KTWM	Kleen Tek Waste Management
PSU	Project Services Unit

1. INTRODUCTION AND BACKGROUND

Bush encroachment is one of the key agricultural challenges in Namibia and is causing massive economic and ecological damage. To date, it is estimated that more than half of the country's prime rangelands are affected by this phenomenon that is characterised by the excessive expansion of bush, at the expense of other plant species, especially grasses. This affects 30 to 45 million hectares, which is more than 30 per cent of Namibia's total land mass.

The most significant consequences of bush encroachment are reduced by carrying capacity of affected rangelands, groundwater recharge and biodiversity loss, increased atmospheric carbon dioxide levels and desertification. Over the past two decades, the Namibian government has been implementing activities tailored to combat bush encroachment. These activities are articulated in the Harambee Prosperity Plan (HPP), the 5th National Development Plan (NDP-5), and the National Rangeland Policy and Strategic Plan.

While bush encroachment constitutes an immense challenge, it also opens significant commercial, as well as unprecedented socio-economic and ecological opportunities.

The accumulated biomass resulting from bush thinning can be gainfully used, making it an economically viable resource for value addition opportunities. Against this brief background, NUST with funding from the Bush Control and Biomass Utilisation (BCBU) Project implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), has launched the Biomass Utilisation by Sustainable Harvest (BUSH) Project to advance research and the development of bush-based products, to effect technology transfer as well as conduct applied research on bush control.

1.1 Namibia University of Science and Technology

NUST aims to become the leading university in Africa and a trendsetter in higher education and applied research internationally. The key goals for NUST include 'knowledge-creation' in the applied and multidisciplinary arenas and contribution to economic and social development. The institution aims to

do this through the promotion and facilitation of sustainable innovation, technology development and knowledge-transfer in conjunction with national and international partnerships with other universities, institutions and organisations. In line with this, NUST aims to further develop and expand its research involvement in bush control and biomass utilisation issues in Namibia.

NUST has amassed extensive experience in the project field of Bush Control and Biomass Utilisation (BCBU). Consequently, several projects have been implemented within the scope of rangeland management, biomass harvesting protocols, development of various agricultural tools and machines, while actively engaging with industry and public stakeholders. This project has adopted a multidisciplinary approach to bush control and biomass utilisation issues in Namibia involving the Faculties of Natural Resources, Engineering, Health and Applied Sciences.

Tangible technology development was fostered as well as a pragmatic stakeholders' knowledge-creation pathway. Public stakeholders include the Ministry of Agriculture, Water and Land Reform (MAWLR), Ministry of Environment, Forestry and Tourism (MEFT), De-bushing Advisory Service (DAS) and others. Private stakeholders include the Namibian Biomass Industry Group (N-BiG), the Namibia Charcoal Association (NCA), Lisha Empowerment and Upliftment (LEU), the Cheetah Conservation Fund (CCF) and others.

1.2 Biomass Utilisation by Sustainable Harvest (BUSH) Project

The Biomass Utilisation by Sustainable Harvest (BUSH) is a project that aims to encourage and promote research on the economic use of biomass through controlled bush thinning practices. Through technology dissemination and value chain development, Namibia can create a conducive environment for bush control. The project aims at providing opportunities for the nation to promote the generation and application of knowledge related to the biomass industry. The BUSH project ran for three years and was initiated by the Namibia University of Science and Technology in collaboration with the Bush Control and Biomass Utilisation Project implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit.

1.3 Objectives of the BUSH Project

The overall objective is to develop and test innovative, climate-friendly technologies for bush control, as well as to develop capacities for biomass utilisation in Namibia. The key attributes of this project are

- to position Namibia as a centre of excellence in biomass utilisation
- to support the development of a bio-economy resulting in overall economic benefits
- to develop capacities and knowledge for the emerging biomass sector
- to position NUST as a regional leader in bush control and biomass utilisation research and development

2. PROJECT DESCRIPTION AND ACTIVITIES

Upscaling of the Bush Project requires technologies, applied research and capacity development solutions that

- meet the specific challenges of bush encroachment in Namibia
- respond to the development challenges of the Namibian socio-economic environment, such as employment creation, semi-skilled jobs, labour standards etc.
- ensure that all interventions are environmentally sustainable
- develop innovative, realistic and locally reproduceable technologies

#1: Optimisation of Manual Bush Control Methods and Technologies

This project focused on the methods that are used to optimise bush control, manually and technologically to limit the impact of encroacher bush species. The initial study of this sub-project involved the analysis and comparison between existing manual methods of bush control such as the use of picks, axes and trolley mounted hydraulic cutters to the mechanized methods such as bulldozers. This project hoped to improve manual bush thinning methods, tools and ergonomic conditions towards job creation and poverty alleviation. Several different prototypes were developed during this project.

These manual bush thinning machines are a great potential to Namibia. This is because of the large bush encroachment that the country has, which gives it the potential to continuously improve them until they are perfectly fit for the field for bush thinning. The Namibian country has a great potential in energy production through biomass, and bush thinning would be the primary core of this project.

Several training sessions were conducted with teams from a local community where they were introduced to the new machines being built. The focus was towards the development of contour alley bush harvesting which is towards rangeland restoration.

It is recommended that continuous research and improvement of the manual bush thinning prototypes is enhanced so that Namibia can innovatively have their own locally produced machinery, by their own engineers.

Namibia has abundant biomass which can be harvested and sustain rural communities if locally adapted technology can be developed. We believe the manual bush thinning machines which we are pursuing can still be realised and we will continue with this endeavour.

SP#2: Biochar Production, Processing and Testing

The three kilns were made of the same volume but different shapes to compare their performance in biochar production and the one that produces good quality biochar. After several burns were made, the conical kiln showed to be the best because it retains so much heat within the kiln, which makes it reach the optimum temperature for biochar production. This temperature, which goes to as high as 700 degree Celsius is preferred to be high so that it burns out all the volatile gasses from the biochar, only leaving the char with open pores, which is what is needed for good quality biochar.

The three stoves that were constructed for maximum energy utilization were tested too. In terms of energy utilization, the modified TLUD stove had the highest efficiency because some heat is used to warm water in the outside chamber. The different biochar crushing technologies were analysed and tested in the chapter 2 still. Among the three prototypes, the last one, which is manually operated seemed to have worked the best and can be used by small scale farmers. Moreover, this prototype does not require electricity for operation and it is mobile. Hence it can carry with to different sites.

The smoke that is emitted during biochar production contains valuable substances such as tar. These substances need to be collected and the best way to do this is to re-design the existing stove. For the next design, the chimney pipe may need to be incorporated for the collection and condensation of the substances in the smoke. This way, the air emitted at the end of the day is cleaner than before. These substances are also used for agricultural purposes. This multitasking stove will be able to utilize most if not all the heat energy and residues to a good use.

The trials with soil application of biochar have provided an opportunity for those plots to be observed into the future, to hopefully reveal how long it takes for benefits to manifest. Since no negative effects of biochar were observed in animals, it may be worthwhile for farmers to offer crushed biochar on a free-choice basis. Any consumption of biochar by their animals would likely indicate some benefit, while non-consumption would be of little cost to the farmer.

SP#3: Techno-Economical Assessment of Bio-Gasification Technologies for Off-Grid Electrification

Biomass gasification is an existing technology that has been used since the internal combustion engine was invented. Gasification is a process whereby organic- or fossil fuel-based carbonaceous materials are converted into carbon monoxide, hydrogen and carbon dioxide. During gasification and combustion of the gas, if the gasified compounds were attained from biomass, the energy produced is regarded as renewable energy. Gasifiers can convert approximately 75% of the energy content of the biomass fuel into a combustible gas, and it has found that 1000 kg of wood combustible material could replace 365 litres of petrol.

There have been several gasifiers operational over time in Namibia. This is especially promising for places such as the tourism and hospitality sector or off-grid communities where bush encroachment is a problem. From this background, this study was undertaken to assess the feasibility of gasification for rural electrification in Namibia.

If new installations are to be considered, solar is the cheapest while diesel is the most expensive. For new diesel systems, they are of moderate capital expense, but due to the high cost of diesel fuel the cumulative costs will quickly climb to be the highest of all the evaluated solutions. New gasification units are some of the most expensive systems to install but will overtake diesel in terms of cumulative costs within a couple of years. Retrofitting existing diesel units with new gasifier reactors and filters are the best solution if solar is not applicable. Gasification systems also benefit the community by creating various jobs for bush harvesting, processing, transportation and system operation. Solar systems will generate the least number of jobs, although it is a renewable energy. Diesel is the worst in various aspects in that it burns fossil fuel, relies on fuel and technology importation although it can be seen as most reliable and low tech.

From this analysis, the opportunity is possible for adding gasification to existing diesel systems which can result in a large reduction of electricity production costs. This study is only theoretical and a practical test in field conditions are needed to confirm these numbers. Although we have indications of this result from existing

Namibian gasification systems, the data collected is scarce and thus more actual data collection is needed from running systems.

SP#4: Techno-Economical Assessment of Production Technology of Animal Feedstock from Bush

The core reason and target for this project is to assist farmers in acquiring and purchasing the appropriate bush feeding machine. The work focused on evaluating the correct technology used to produce bush feed and estimate the cost of capital, as well as the cash flows of different bush to feed technology combinations.

The immense potential for improved efficiency and profitability ensures that the introduction of successful bush management systems at national level would at the same time make a significant contribution towards the goals of the land reform system in Namibia. If the issues of encroachment have been resolved, many of the current land units that are uneconomically controlled will provide far higher returns and, as a result, create space for more farmers. In communal areas, more people will make their livelihood from the land, and their livelihoods can benefit from improved income and quality of life.

An empirical research methodology was implemented due to the nature of the project, this was achieved through conducting experiments and observations and a thorough detailed analysis of the results obtained. There is a significant difference between the manufacturer's machine specification data and the experimented data as frequently reported by farmers and industry. Most of the research results were from a thorough study of the desktop and from interviewing local farmers about the results they obtained when using their machines. The results obtained from the research were significantly higher than the specifications of the manufacturer or supplier.

It is important to note that the machine output variables such as the fodder output depend on various parameters, such as the type of bush for example Acacia mellifera, A. reficience, Dichrostachys cinerea, Mopani and Gabba Bush. Acacia mellifera and Dichrostachys cinerea are widespread very thorny species. The productivity also depends on the harvested bush which is readily available. The speed of feeding depends on the thickness of the wood.

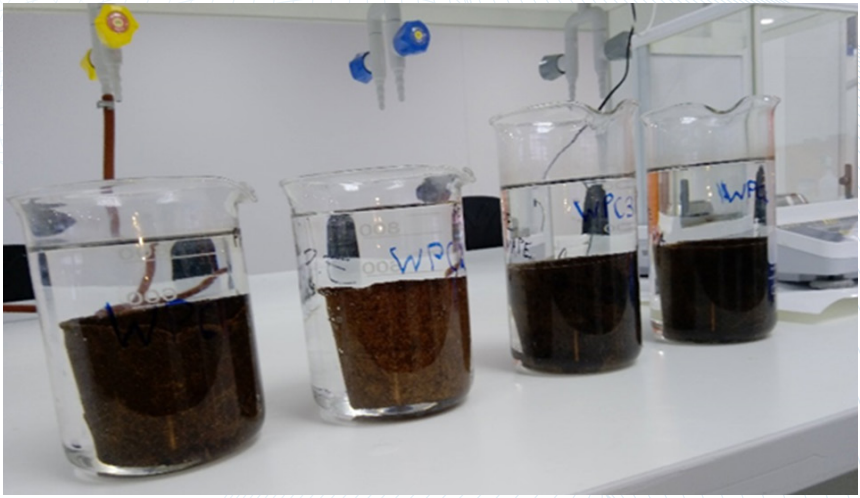
SP#5: Development of Wood Plastic Composite Production Technologies

Wood plastic composites (WPCs) are roughly mixtures of thermoplastic polymers and wood flour. The wood flour and thermoplastics are usually compounded above the melting temperature of the thermoplastic polymers and then further processed to make various WPC products. WPC can be manufactured in a variety of colours, shapes and sizes, and with different surface textures. Depending on the processing method, WPCs can be formed into almost any shape and thus are used for a wide variety of applications, including windows, door frames, interior panels in cars, railings, fences, landscaping timbers, cladding and siding, park benches, molding and furniture.

WPCs were made with wood flour (Acacia mellifera, Acacia reficiens and Dichrostachys cinereal) and virgin polymers, polypropylene (PP) and medium density polyethylene (MDPE) and coupling agents, polypropylene-graft-maleic anhydride (MAPP) and polyethylene-graft-malic anhydride (MAPE). The WPC products were formed via two stages, namely, compounding (melt-blending) and mould-press forming resulting in a cup-shaped product. The resulting product was characterized by density, water absorption, fourier transform infrared spectroscopy (FTIR) and tensile strength measurements. The best formulation ratio for the WPC product was 45% wood flour: 50% polymer: 5% coupling agent.

The availability of raw materials (wood waste and recycled plastics) and minimal competition plays a significant role in the esbtalishmment of profitable WPC enterprise. However, initial investment can be deterrent.

The WPC products produced can be used as flower vases. The formulations tested in this study are also ideal for ceiling boards for low cost houses, school desks and indoor furniture if an extruder is used for processing.



SP#6: Laboratory Analytics Development

The development of laboratory capacity in biomass is of vital socioeconomic and environmental importance to any developing country such as Namibia. The utilisation of biomass (biomass can be biochar, wood powder samples, bush feed, etc.) through value-addition requires specific analyses to render such products to set standards. Currently, few or no analytical services are done for the biomass industry within Namibia and hence the industry relies on outside the country laboratories analytical services which can be costly and time-consuming.

The Department of Natural and Applied Sciences has the expertise and several pieces of equipment for physicochemical characterisation of biomass related products. Similarly, the Department of Mining and Mineral Processing in the Faculty of Engineering also have pieces of equipment needed for biomass analysis such as scanning electron microscope (SEM) for surface morphology and elemental analysis, atomic absorption spectrometer (AAS) for quantitative determination of chemical elements, Rheometer for flow properties, and X-ray fluorescence spectrometer (XRF) for elemental analysis and chemical analysis.

The overall aim of the sub-project with financial assistance and instruments support from the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) was to establish an analytical services centre for the biomass industry. The mission of the laboratory is to support research activities at NUST and provide high quality and timely analysis of environmental and industrial samples from different matrices and, to continuously meet the requirements and expectations of our clients. The analytical service centre is thus aimed at offering affordable, quality, and timely services ranging from environmental monitoring and analysis to raw material and product quality. The sub-project was to offer quality and timely analytical services not only to the BUSH project but also all stakeholders based on standard operating procedures accepted internationally.

SP#7: Scholarships

There is a need to build the capacity of professionals working in bush control and biomass utilisation fields in the Ministry of Environment, Forestry and Tourism. NUST facilitated the financial administration of the scholarships on behalf of GIZ and actively support the students towards a successful completion of the studies. These scholarships were available for staff members to complete their honours or master's degrees as required by MEFT.

Masters:

Helmi Auala: Assessment of soil applied biochar from encroacher bushes on lucerne grown under irrigation at Humulus Farm in Okahandja.

Monika Amutenya: The effect of browsing, fire and plant competition on tree regeneration in northern Namibia.

Agnes Shikomba: Assessment of land cover changes and forest composition in Okongo Community Forest.

Honours:

Jonas Mwiikinghi: Assessment of livelihood activities and diversification among the forest dependent communities in the Linyanti Constituency of the Zambezi Region, Namibia.

Lazarus Gregorius: Identifying and assessing the effectiveness of firebreaks on forest fire prevention in Omusati Region.

Joseph Simataa: Effects of bush encroachment on stocking rate and carrying capacity of livestock.

Josenia Sirongo: The effect of bush thinning on coppicing and regrowth of Dichrostachys cinerea and Acacia reficiens

NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Biomass Utilisation by Sustainable Harvest (BUSH) Project
Technology Development, Applied Research and
Capacity Development in Bush Control and Biomass Utilisation

Faculty of Engineering in collaboration with:
Faculty of Natural Resources and Spatial Sciences
Faculty of Health and Applied Sciences
Innovation Design Lab
Private Bag 13388
Windhoek
NAMIBIA

T: +264 61 207 2340
E: estrydom@nust.na
W: bush.nust.na