A FINANCIAL ANALYSIS OF PRODUCING PELLETS FROM THE ENCROACHER BUSH *SENEGALIA MELLIFERA AS* A POTENTIAL LIVESTOCK FEED: A COST BENEFIT ANALYSIS APPROACH

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ABSTRACT

About 70 million hectares of land in Namibia is suitable for agriculture, of which approximately 71% is utilized by livestock farmers. Namibia’s Livestock Producers are faced by bush encroachment that reduce the carrying capacity of agricultural land due the suppresion of perennial grasses and herbs thus limiting rangeland productivity. Namibia can stand to make about N$734.7 million annually from bush-based feed production which could reduce the current feed cost. Thus, this study assessed whether harvesting of the bush encroacher *Senegalia mellifera* at Neudamm farm to produce animal feed on a commercial basis was viable. The objectives underlying the study were to use a Cost Benefit analysis (CBA) model to determine the viability of the production as well as to use a Willingness To Pay (WTP) method to determine the market availability of the bush-feed pellets. CBA indicators like Net Present Value (NPV) and Benefit Cost Ratio (BCR) were used to determine viability. An online survey and a key informant questionnaire were used to collect data on the WTP of farmers for the bush-based feed. A total sample size of 33 respodents was used. Two methods were compared, a highly mechanized and a manual method of production. Judging from the positive NPV and a BCR greater than 1, the results suggested that both methods were viable. The highly mechanized method was found to have a NPV N$ of 73,965,835.43 and BCR of 2.28 while the manual method had a NPV N$ 62,086,180.39 and BCR of 2.66. The avarage WTP for the bush-based feed was 173.07 per 50 kg bag. The results suggested that the associated costs and benefits of producing bush-based feed pellets using encroacher bush (*Senegalia mellifera*) is viable and investing in the project should be considered. It was recomended in this study that small scale and upcoming farmers consider venturing in the mannual method of production as it was less costly compared to the mechinized method, it was alsorecommended that efforts be put in creating awareness about bush-based feed pellets to increase the WTP for the pellets by farmers. The government should also provide encroacher bush de-bushing programms to help with high de-bushing costs.

Keywords: Bush encroachment, Cost enefit analysis, De-bushing, Willingness To Pay, Farmers, Viability, Costs, Benefits

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DEDICATIONS

I would like to dedicate this thesis to my mother who is always supportive in everything that I do. May the Almighty bless her abundantly. I would also like to dedicate this thesis to my brothers who always put a smile on my face even in times of stress.

DECLARATION

I, Dorthea Kashinasha Shiimi, hereby declare that this study is a true reflection of my own research, and that this work, or part thereof has not been submitted for a degree in any other institution of higher education.

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ADB……………………………………………………. Asian development Bank

BCR……………………...………………………...Benefit Cost Ratio

BoN…………………………………………………. Bank Of Namibia

CBA……………………………………………….…. Cost Benefit Analysis

CEA……………………………………………………Cost Effectiveness Analysis

CV.……………………………………………………. Contingency Valuation

DM……………………………………………………. Dry Matter

ELD……………..…………………………….……Economic of Land Degradation

EIA……………………………………………………. Environmental Impact Assessment

FAO………………………………………………………. Food and Agriculture Organisation

IAP………………………...……………...…………..…Invasive Alien Plants

IRR……………....…………………………………….…. Internal Rate of Return

LSU…………………………………………………...Large-Stock Unit

MAWF…………………………………………………...Ministry of Agriculture Water and Forestry

MCA……………………….……………………...…Multi Criteria Analysis

MITSED…………………………........……………Ministry of Industrialisation, Trade and SME Development

N-BIG………………………………………………Namibian Biomass Industry Group

NDP…………………...……………………………. National Development Plan

NPV……….....……………………………………….Net Present Value

PTO …………………………………………...…. Power Take-Off

PEG…………………………………………………Poly-Ethylene Glycol

PV…………………………………………………...Present Value

SADC ………………..........………………….. Southern Africa Development Community

SAEIA…………………………….……………South Africa Institute of Environmental Assessment

SP…………………………………………………. Stated Preference

SPSS……………………………………………..... Statistical Package for Social Science

WTP…………………….....………………...…. Willingness To Pay

FANRAN…………………………………………Food Agriculture and Natural Resources Policy Analysis Network

VCF………………………………………………. Veterinary Codon-Fence

CHAPTER ONE: INTRODUCTION

1.1 Background

According to Food and Agriculture Organisation (2008) livestock production occupies about 30% of global arable land. In Namibia, where total land is 834 300 km^2, 38% is utilized by cattle farmers and 33% by small stock farmers (Namibian Statistic Agency, 2016). Livestock production accounts for almost 70% of national agricultural output and comes from 52% of the farming/grazing land (Schuler, 2012). The livestock industry plays an important role in growth and job creation in Namibia. The commercial farming sector which is mainly based on livestock farming is the largest source of private employment in the country and thus provides jobs to about 25,000 - 30,000 workers (Schuler, 2012). However, the significant challenge that is faced by Namibia's livestock producers (especially in the central part of the country) is a reduction in the carrying capacity of agricultural land that is encroached by bushes. Bush encroachment is described as an increase in biomass and abundance of undesired species (woody, shrubs) and the suppression of perennial grasses and herbs (Ward, 2005). It is estimated that bush encroachment mounts up to 600 000 km^2 covering about 70% of Namibian arable land (Rothauge, 2017) of which 426 000 km^2 of land is used for livestock production. According to Schuler (2012) Namibia experience livestock productivity losses of over 100% due to a decline in carrying capacity and as a result of bush encroachment, carrying capacity of land is reduced by approximately up to 80%. A reduction in carrying capacity translates into annual economic losses of up to N$2 billion, and this results in high demand for livestock feed importation especially during prolonged dry seasons (importing livestock feed at close to

N$400 million per year) (Gschwender, 2014) as well as the exportation of weaners to South Africa (at a loss of N$1.6 billion).

It is estimated that about 45 million hectares of Namibian land is encroached, South African Institute for Environmental Assessment (SAEIA, 2016). Figure 1 displays the encroached areas in Namibia, the shaded areas shows the extent of bush encroachment. The figure indicates that bush encroachment covers nearly the entire country starting from Opuwo all the way to Keetmanshoop. Only a small area of Namibia is not encroached which includes the northern parts of Namibia namely; Outapi, Oshakato, Eenhana, Nkurenkuru and Rundu.

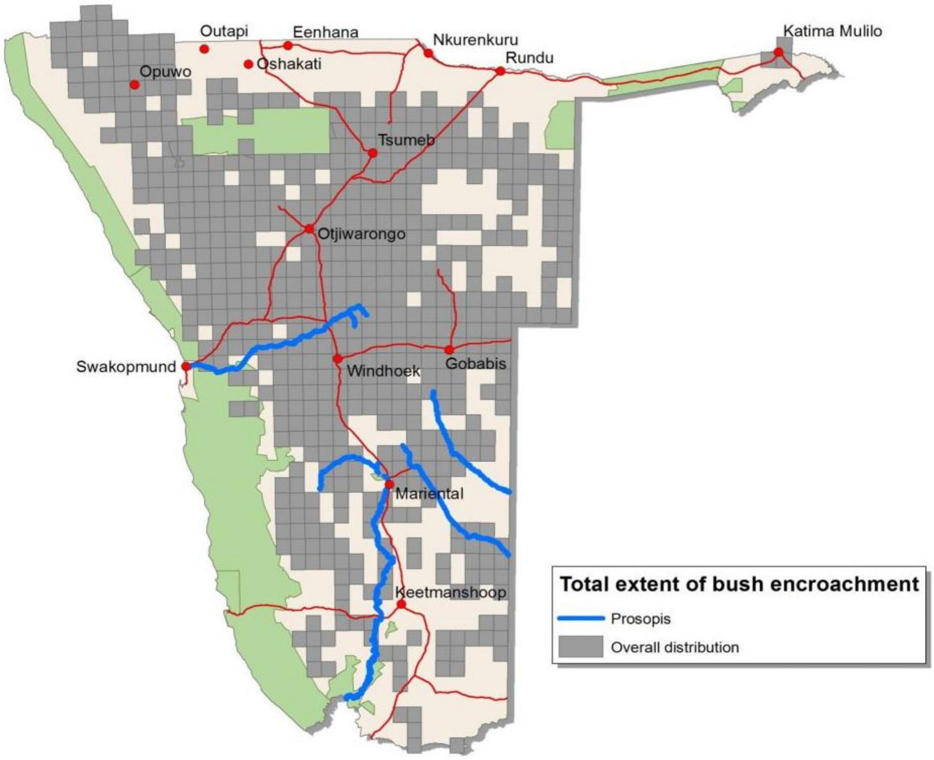

Figure 1: Bush encroached areas and bush density in Namibia

Source: South Africa Institute of Environmental Assessment (SAEIA, 2016).

The most dominant species causing bush encroachment in Namibia and the areas they encroach are presented in (Figure 2). Figure 2 indicates that *Senegalia mellifera* (black thorn) previously known as *Acacia mellifera* is dominating in the following areas; Windhoek, Otjiwarongo and Kalkfeld. *Dichrostachys cinerea* (sickle bush) is dominant in the Tsumeb, Grootfontein, Otavi and Tsintsabis areas, while *Terminalia sericea* (Terminalia) encroach is dominant towards the eastern side of Gobabis. *Terminalia prunioides* (purple pod Terminalia), *Senegalia erubescens* (blue thorn), *Vachellia reficiens* (false umbrella thorn) as well as *Colophospermum mopane* (mopane) are dominating in Oshikoto, Opuwo, Kamanjab and Outjo areas (de Klerk, 2004). *Senegalia mellifera* is the most dominant of the species in Namibia, hence it was chosen for this study.

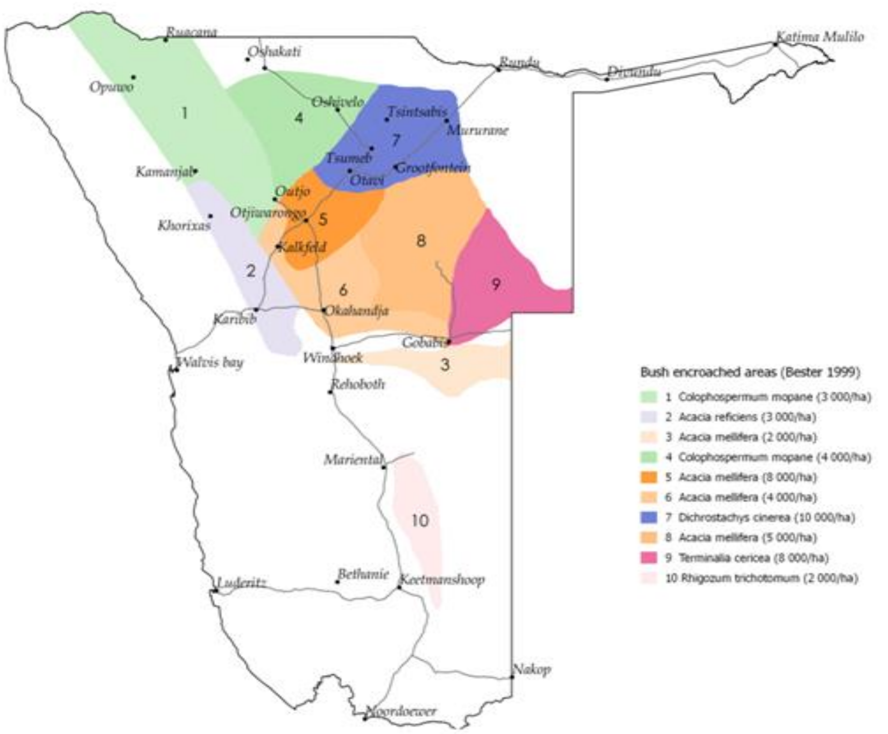

Figure 2: Bush density and encroachment species in Namibia

Source: Honsbein *et. al.*, (2009)

1.2 Problem statement

According to Meat Board of Namibia (2011), Namibia relies heavily on Southern Africa Development Community (SADC) countries (especially South Africa) for livestock feed imports annually, and particularly during prolonged droughts. The high demand for livestock feed imports during prolonged dry seasons is close to N$400 million per year (Gschwender, 2014). According to Birch & Middleton (2017) with the current bush stock (Figure 1), Namibia can stand to make about N$734.7 million annually from bush-feed production alone and this could reduce the current feed cost and at the same time increase the carrying capacity, thus increasing income as a result.

Furthermore, within the challenge of bush encroachment lays enormous social and economic potentials for agriculture and rural livelihoods in general if value is added to the encroacher bush. It is therefore clear that the application of economic principles to assist in the management of bush encroachment and the restoration of invaded sites have become increasingly important. The utilization of encroacher bush to make animal feed has started at a smaller scale. There is a lack of knowledge about the competitiveness of bush-feed production against conversational alternatives. And this study, therefore, sought to fill this gap this study also assessed whether the harvesting of encroacher bush and production of animal feed on a commercial basis will be feasible. This study performed an economic analysis of producing feeds from the encroacher bush for Neudamm farm that would serve as a guide for those who would want to venture into such investments.

1.3 Objectives

1.3.1 Main objective

The main objective of this study was to perform an economic analysis to determine the market viability of producing bush-based feed from *S. mellifera* for Neudamm farm.

1.3.2 Specific objectives

1. To determine economic viability of the bush-to-feed project using cost-benefit model.
2. To determine potential market availability of the bush-based products by farmers, using the Willingness-To-Pay (WTP) model.

1.4 Delimitation of the study

There are several encroacher species that are found in different areas of Namibia, however, this study focused on one species, *S. mellifera* found in the highland savannah.

1.5 Significance of the study

Bush encroachment covers over 70% of Namibian arable land; it reduces carrying capacity for livestock and wildlife farming. With the current bush stock, if value is to be added Namibia can make about N$1.9 billion annually from the available bush. This study can confirm the potential for Namibia to turn economic losses and environmental degradation due to bush encroachment into gains. Determining the viability of commercial value chains that can translate into employment generation, potential for range/ grasslands to recover (from encroachment), increased carrying capacity which in turn will contribute to income and enabling rural sustainable enterprise development in line with the National Development Plan (NDP)5 goal to set-up Rural Productivity Zones. This research can also serve as a baseline study for the bush-feed production value chain system.

1.6 Limitations of the study

A CBA is a forecasting technique that involves predicting the future. Prediction of the future is by any means difficult and there is a risk of a false accuracy attached to the results of detailed CBA models. Since the CBA approach involves identifying all costs and benefits associated with the project and the community**,** it can be quite difficult to identify all costs and benefits which might lead to misleading results. Moreover, to model real-world activities into a model is a difficult task as some activities are dynamic thus used at *ceteris paribus*. A sensitivity analysis was therefore performed to accommodate for any uncertainties associated with the model. Currently, there are no published studies done on processing bush into animal feed and thus there is limited literature which this study can be based on. However, the researcher visited bush-feed producers to ensure that the data used in the study is as accurate as possible and not just based on assumptions. The study was also subjected to time and financial constraints thus some activities could not be done thoroughly. There are other value chains that can be generated from the residual biomass after bush-feed production (i.e. charcoal and biochar production, firewood production, poles production, etc.) however this study only focused on bush-feed production. Since the study focussed on cattle, only the carrying capacity of cattle was computed leaving out that of small stock and wildlife. This study covered a production system that involves pelletizing which is mainly for commercial production purposes thus only a standard feed formulation recipe for commercial ventures was used which includes less than 50% bush, this recipe is accepted by the Ministry of Agriculture Water and Forestry (MAWF). The ingredients costs used in this study are based on the quantities used in the recipe. Due to circumstances beyond the researcher's control, only a sample size of 33 respondents was used to determine the willingness to pay, this is underrepresented and further research in this area is therefore necessary.

1.7 Organisation of the thesis

This section provides an outline of the entire document. The study used a stand-alone chapter method which starts with chapter 1 that provides the background of the study, the problem statement, study objectives, limitations, and delimitation as well as the significance of the study. Chapter 2 offers an overall review of important literature used in the thesis, explaining what bush encroachment is and how it affects livestock production. The chapter further discussed the different value chains that can be produced from bush biomass and their contribution to the Namibian economy. The literature on the theoretical framework of economic analysis of projects was also discussed as well as the literature on the methodology that is used to determine the viability of the project, with specific attention given to the Cost Benefit Analysis (CBA) and Willingness To Pay (WTP) models.

The subsequent chapter, chapter 3 discussed the methodology of CBA that was used in this study to determine the viability, the assumptions put in place for the CBA model was also discussed in this chapter, and finally the discussions of the results for the viability test. In chapter 4 the descriptive results and discussions of the different factors that affect the willingness to pay of farmers for the bush-based feed were discussed. Chapter 5 gave the summary of results as well as the general conclusion and recommendations for the study.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

Bush encroachment is a phenomenon that is widespread affecting not only Africa (Skarpe, 1990; Oba, Post, Syvertsen, & Stenseth, 2000) but also other continents like Australia (Burrows *et al*., 2002) and North American (Scholes & Archer, 2003). de Klerk, (2004) described bush encroachment as the process of "the invasion and/or thickening of aggressive undesired woody and shrubs species, resulting in an imbalance of the grass/bush ratio, a decrease in biodiversity, carrying capacity and concomitant economic losses". According to Morris, Witkowski, & Coetzee (2008), bush encroachment can reduce the grazing capacity of an area due to the canopy cover of the bushes.

Mendelsohn, Jarvis, Roberts & Robertson (2002) explained that there are two ways in which bush encroachment reduces carrying capacity: the first one is due to a loss of grass cover which cannot grow under thick bush; the second one is that high bush densities which make it hard for grazing animals to penetrate the area to get to the grasses. In addition, Lesoli, Gxasheka, Solomon & Moyo (2013) stated that the higher bush density in rangelands reduces the accessibility of land by livestock, and successively negatively affects the utilisation of rangelands. Moreover, a reduction of the grazing capacity has a direct undesirable impact on the livelihoods of societal members who depend on the ecosystem goods and services. In Namibia, bush encroachment covers approximately 600 000 km^2 of land (Rothauge, 2017). Gschwender (2014) further stated that bush encroachment has undesirable impacts on most of the key ecosystem services, such as groundwater recharge, tourism, as well as biodiversity

2.1 Economic impacts of bush encroachment on livestock production

There are a number of ways in which rangelands contribute to the economy of Southern Africa. They provide agricultural commodities such as wool, meat, milk, crops, etc. which can be valued in the market. Rangelands are the major source of fodder for grazing animals which in turn influence animal production (Lesoli *et al*., 2013; Anadon, Sala, Turner & Bennett, 2014). According to Oba *et al*., (2000), the increase in the density of woody plants is a major threat to livestock production and rangeland biodiversity. Furthermore, Mugasi, Sabiiti & Tayebwa (2000) stated that animal productivity in terms of milk yield, body condition, and reproductive performance are reduced due to bush encroachment. It is therefore important to understand the total economic loss that bush encroachment generates on the economy in relation to its agricultural production.

Economic impacts of bush encroachment may be primarily related to a decline in cattle carrying capacity (Elliott, 2012; Lesoli *et al*., 2013), or wildlife carrying capacity and watershed quality (Lesoli *et al*., 2013). Bush encroachment also causes a reduction in cattle grazing which may account for the direct agricultural costs in the purchasing of animal feed (Lesoli *et al*., 2013).

2.2 Empirical literature on different bush clearing methods

Bush control methods reduce woody vegetation from the rangeland and increase habitats for grazers, as well as forage production for herbaceous vegetation (Angassa & Oba, 2009). Birch & Middleton (2017) estimated that de-bushing may possibly result in a net benefit for livestock production, groundwater recharge, tourism, as well as biodiversity.

In a study titled "Effect of Woody-plant Encroachment on Livestock Production in North and South America" Anadon *et al.,* (2014) found that woody plant encroachment in rangelands had a negative impact on livestock production, where an increase of 1% in total cost resulted in an overall decrease in livestock production. Mugasi *et al*., (2000) in their study on economic implications of bush encroachment found that bush encroachment reduced the rangeland's herbage Dry Matter (DM), which in turn reduced the cattle's growth rate, milk yield, body condition score and subsequently reduced farmers' income. In Namibia, bush encroachment causes economic losses that amount up to N$2 billion annually due to a reduction in carrying capacity (Gschwender, 2014). Clearing the invaded areas in a period of approximately six years can improve grazing capacity to about 110 percent. (Morris *et al*., 2008). De-bushing is not aimed at thorough eradication of woody biomass, but instead, it aims at the reduction of bush density to the optimal level.

Mugasi *et al*., (2000) found that cleared farms had higher average herbage dry matter yield of about 2040 kg/ha, compared to a range of 906 kg/ha on encroached farms. Heifers on cleared farms also reached puberty earlier and calved relatively early, between 2 to 3 months as opposed to heifers on encroached farms which only matured at 24 to 36 months. Mogasi further stated that the mean annual gross income on cleared farms were US$49.393 per cow per annum while on encroached farms only US$23.351 was realised which means de-bushing can lead to more than double returns in revenues. Given all economic losses caused by bush encroachment, it is of utmost importance to try and thin out the encroacher species to improve the carrying capacity of land and subsequently income.

There are different bush clearing methods that can be used for bush control in Southern Africa (Elliott, 2012; Lesoli *et al*., 2013). These include; (i) Chemical control, which can involve the use of selective herbicides that aims at selectively killing herbaceous plant species. Species that are not affected by this herbicide gain an advantage and grow (Lesoli *et al.*, 2013); (ii) Mechanical methods such as the use of machines create a competitive space for desired plants, (iii) use of fire to control invasive woody plants is used with the reason that when woody plants are burned they do not recover or they recover slowly which gives the herbaceous species time to grow with minimal or no competition, (iv) biological control method, this is done by using herbivores such as goats to selectively-browse on the encroaching species (Lesoli *et al*., 2013).

2.2.1 Chemical control

There are different chemicals available in the market for controlling bush encroachment. Some of the chemicals are species-specific, some are applied directly to the plant, while others are applied to the soil (Angassa & Oba, 2009). Borrel, Brown, & Slater (2011) explained that chemicals such as arboricides that are used to kill encroacher bushes prevent plant growth by preventing photosynthesis.

Chemical control is a very effective way of controlling bush encroachment in essence that a large track of affected land can easily be treated within a very short period

(Lesoli *et al.*, 2013). However, it is one of the most expensive methods and many farmers are financially unable to use it especially when aerial application is used (Lesoli *et al.*, 2013). A disadvantage with repeated use of chemicals is the accumulation of toxic concentrations with treatments, which is environmentally undesirable. Muroua (2013) stated that there are therefore strict controls on how herbicides are used for both livestock and human safety, and environmental pollution concerns. According to Lesoli *et al.*, (2013), herbicides have some effects on the environment, hence, some plants and animals which are not targeted may also be exposed. In Namibia, chemical control has been one of the most used method for controlling bush encroachment, and this is evident in a study by Rothauge (2014) where 68.5% of de-bushing by farmers was done using chemicals such as arboricides. Even though the application of arboricides was found to be effective in controlling bush encroachment, there were several disadvantages associated with the outcome. Bright blue aboricide pellets were used to target *Dirchorostachys ceneria,* however, pellets were overdosed and ended up killing other trees that were not targeted (Rothauge 2014). The first rains also swept the pellets away from the targeted area sterilising the soil and preventing the growth of grass. Rothauge (2014) also stated that Namibian farmers indicated that incidents are known where soil-applied arboricides still kill non-targeted trees even decades after the last applications.

2.2.2 Semi-mechinized

Semi-mechinized method uses hand-held power tools like hand saws and/or chain saws. This method is highly selective of the bush that is harvested and less costly. The estimated cost for harveting is between N$1500-N$2000 per hectare. Productivity in this method increases about 5 times compared to the manual harvesting method. According to (Rothauge, 2017), about 3 hectares /day can be cleared using this method providing about 1400 tonnes of wood chips per annum, about 4 labourers can harvest the bush.

2.2.3 Highly mechanized method

The method uses advanced machines and minimal manpower. This harvesting method uses bulldozers followed by cutting using rotary saw in skid steer than feeding the biomass into a mobile chipper. The method is costly, with an estimated cost of N$ 4000 per hectare (Rothauge, 2017). Rothauge (2017) added that the method is also fast and can harvest about 4 hectares per day, using about 3-4 labourers to harvest bush and providing about 8000 tonnes of wood chips per annum. It is more suitable for large scale farmers (Elliott, 2012)**.** According to Elliott, 2012; Rothauge, (2017), the disadvantages of the fully mechanized method is that most of the machines are not selective of the type of bush to be harvested and it also causes massive soil disturbances.

2.2.4 Manual method

This is a small scale labour-intensive conventional method of de-bushing. It involves manpower, a person with an appropriate hand tool like a panga or axe to harvest encroacher bush which is then loaded on to the trailer pulled by a tractor and then transported to the warehouse where production will take place. According to Rothauge (2017), a worker can cut out a large *S. mellifera* bush in about 15 minutes using a spade and an axe. The manual approach is very much labour intensive and time consuming compared to other approaches like mechanized and semi-mechanized. A worker harvests 0.05-0.2 hectares per day providing about 800 tonnes of wood chips per annum (Rothauge, 2017).

Table 1: Summary of estimated cost, output and labour for manual, semi-mechanized and mechanized method of production

	Manual	**Semi-mechanized**	**Mechanized**
Estimated cost/ha (N$)	1000-1500	1500-2000	4000+
Estimated wood chips/ annum (Tonnes)	800	1400	8000
Estimated labourers for harversting	6	4	3-4

Sources: (Elliot, 2012; de Wet, 2015; Rothauge, 2017),

According to Elliott (2012), this method is more suitable for small scale farmers and cannot adequately manage the extent of encroacher bush in Namibia. For instance, the manual method is inadequate for halting the spread of encroacher bush, let alone reversing this trend. The farmers used this method which incorporates charcoal making (Elliot, 2012). The method was deemed important by small scale farmers because it is highly cost effective costing about N$ 1000-N$1500 per hectare (Rothauge, 2017).

Apart from it being cost effective this method is also suitable as it is highly selective. It allows for people to select and harvest bush that is favourable to the kind of value addition they require, in this case, bush that is suitable for animal feed production which is mostly young and fresh bush. This method also causes minimal disturbance to the soil as no heavy machinery is used (Rothauge, 2017).

2.2.5 Fire

According to Lesoli *et al.,* (2013), in Southern Africa, fire is regarded as a natural factor of the environment. It is believed to have transpired from time immemorial, and therefore, it is part of the ecosystems. Rangeland burning has proven to be an important ecological management tool in the productivity and maintenance of rangelands in the Southern Africa region (Trollope, 1983). To ensure that fire is used effectively in rangelands, it is of vital importance to understand how it behaves and to develop an insight into the way in which numerous factors influence fire behaviour (Lesoli *et al.*, 2013). The intensity and frequency of burning as well as the season of burning should be well understood, and this is known as fire regime (Trollope & Tainton, 1986). According to Lesoli *et al.*, (2013) the rate of fire is measured in terms of time taken to burn a given unit area.

There are several factors that affect the rate of fire and these include fuel load and moisture. Tree height is also one of the important factors that determine the effect of fire on bushes, therefore, as the bushes become taller, the fire intensity required to cause a top kill of the stems and branches become critical (Trollope & Tainton, 1986). Lesoli *et al.*, (2013) stated that high-intensity fire is vital in controlling coppice growth and bush seedlings or maintaining bush in an acceptable state for browsing animals. It is recommended that when controlling bush encroachment, head fire must be used (Trollope & Tainton, 1986). This is because when burning towards the direction of the wind, head fire mostly occurs in the form of surface fire. However, in more densely wooded areas with more flammable foliage head fire is not recommended. Fire remains the cheapest form of bush encroachment control method available. In Namibia, about 8% of farmers use fire as a bush encroachment control method (Rothauge, 2017). Reduction of bush encroachment with fire enhances biomass production and therefore, forage production increases, which is positive to livestock production. However, where higher frequency of fire is used, for instance burning annually, bush will be controlled but it has an effect on the basal cover of herbaceous plants, the basal cover becomes poor due to effects of fire on plant vigour. That, in turn, renders the soil susceptible to soil erosion.

2.2.6 Biological control

Reinhardt (2000) defined biological control as the use of living organisms to reduce the vigour, reproductive capacity, or effects of weeds. Biological control or better known as Biocontrol aims at controlling encroacher species to a point where the plant is returned to the status of a non-encroacher and naturalized plant species, that is an encroacher plant that is able to survive, and even reproduces, but does not invade aggressively (Richardson & Van Wilgen, 2004). Lesoli *et al.*, (2013) stated that one of the successful examples of using biological control method for de-bushing is the use of *Stenopelmus. rufinasus* on *Azzola*. *filiculoides* insects in Kruger National Park (KNP) of South Africa. It was reported that 100% clearing of the weed was achieved in just a few months after the release of the insects. It was also stated that the insects are able to survive for long periods in the area and re-establish themselves should the area become re-encroached (Lesoli *et al.*, 2013). de Klerk, (2004) stated that goats, at high stocking rates, can also be successfully introduced to reduce bush density to acceptable levels. de Klerk added that the viability of keeping goats at the required stocking rate on a commercial farm of several thousand hectares is however doubtful. According to Rothauge, (2017), trials at Omatjenne Research Station with domestic goats have shown that the browsing intensity required to control bush is too high that it wipes out more palatable fodder bush species before bush encroachment is controlled. The damage is therefore not worth it.

2.3 Empirical literature on different value chains from bush encroachment

According to Birch, Middleton & Harper-Simmonds (2016), de-bushing and biomass utilisation in Namibia has the potential to generate benefits through the utilisation and local value additions to the biomass through charcoal, livestock feed and firewood production, generating electricity and other means like groundwater recharge, tourism as well as employment. The net benefits from ecosystem services was estimated to be around N$ 48 billion of which N$277 million per annum is from de-bushing (Birch, Middleton & Harper-Simmonds, 2016). However, the benefit will only be realised if value is to be added to the de-bushed biomass. De-bushing alone may therefore not be economically viable unless accompanied by value chain additions. There are different value chain additions that encroacher-bush can be turned into in Namibia. These includes charcoal production, firewood production, and animal feed production (Birch, *et al.*, 2016; (Pasiecznik, 2016)

2.3.1 Charcoal production

According to Vos and Vis, (2010), charcoal can be produced from biomass in a process called carbonisation. Carbonisation is the method of burning wood in the absence of air after which it breaks down into liquids, gases and charcoal (Meaai, 2010). In Africa, only a limited number of people consider charcoal production to be their main economic activity. On the other hand, majority only engage in the production occasionally as a means to generate income, particularly in times of financial stress (Vos and Vis, 2010).

Rothauge (2014) stated that even though making charcoal from biomass in Namibia goes back 60 years, it is not until 3 decades ago did the charcoal industry really gain momentum. Rothauge (2014) added that in Namibia about 60,000 to 158,000 tonnes of charcoal is produced annually, using about 240,000-600,000 tonnes of wood biomass per year. Gschwender (2014) stated that although Namibia has a growing charcoal industry, the local demand is insignificant. Out of the 60,000 to 158,000 production, about 60% is exported to South Africa while only 40% to Europe (Rothauge, 2014). The charcoal industry could generate about N$ 612.5 billion per annum by the year 2020 (MITSMED, 2016) via expanding the market share, or consideration for entry into new markets, such as the Middle East.

2.3.2 Firewood production

Firewood is still one of the most important energy sources in developing countries. Trede & Patt (2015) stated that the Food and Agriculture Organisation (FAO) of the

United Nations found that the world firewood production reached 1.8 billion m^3 in 2013 and Africa was producing nearly 650 million m^3 firewood. In Namibia, the use of wood for domestic purposes is enormous. Rothauge, (2014) added that more than 50% of all households in Namibia still depend on wood for cooking while slightly less than half of households depend on wood for heating. According to VO Consulting (2014) as cited by (Rothauge, 2014), about 440,000 tonnes of wood in Namibia is used in the informal firewood sector whilst only 45,000 tonnes of wood per year is used in the formal firewood sector. The discounted potential net benefit for the firewood industry was estimated at N$ 1.2 billion over the 25-year horizon (Birch, *et al.*, 2016).

2.3.3 Bush feed production

The reduction in carrying capacity due to bush encroachment results in a high demand for livestock feed importation. In Namibia, especially during prolonged dry seasons, livestock feed importation can be as high as N$400 million annually (Gschwender, 2014). In order to strengthen drought resilience, a number of Namibian farmers are producing animal feed from encroacher bush. Even though bush feed made from the harvesting and milling of tree and shrub is not a recent technology and it is dated back to the 1960s (Pasiecznik, 2016), the concept is not very well documented. It had proven that bush-based feed works not only as a supplement feed but also as the complete main feed for animal and it has given remarkable results (de la Puerta Fernandez, 2016).

According to de la Puerta Fernandez (2016), the process of bush-based feed production typically is as follows: harvesting of encroacher bush, chipping, milling the biomass, then mixing it with suitable supplements to increase the nutritional content and digestibility of the feed. The producer then has an option of pelletizing the feed and this could increase shelve value, this process is illustrated in Figure 3. According to Birch & Middleton (2017), Namibia can stand to make about N$734.7 million annually from bush-based feed production which could reduce feed cost.

Elaboration on the steps in figure 3: The first step shows a manual bush harvesting method that involves workers harvesting with pangas (machete) and axes. After harvesting the leaves and twigs and small branches of about the size of a broomstick are fed into a wood chipper to reduce the twigs' size. However, chipping the wood alone does not give the desired feed particle size for animal feed. Therefore, the next step in Figure 3 shows chipped materials transferred to a Power Take-Off (PTO) driven hammer mill fixed on a tractor to grind them into smaller particle size which animals can chew easily. The next step involves mixing the bush material with different ingredients in a cement mixer to improve the nutritional content of the bush. The mixed content is then put into a pelletizer and the final product is the feed pellets showed in the last picture.

Figure 3: Illustration of steps in bush-based feed production
Source: De-bushing Advisory Service, (2019)

In order to pursue projects that add value to bush, it is important to know the impacts of such projects on the environment as well as their viability. Thus, it is of vital importance that an economic analysis is conducted. There are different ways to conduct an economic analysis namely: (i) Environmental Impact Assessment, (ii) Strategic Environmental Assessment, (iii) Cost Effectiveness Analysis, (iv) Multi Criteria Analysis, (v) Cost Benefit Analysis. These are discussed below.

2.4 Economic analysis of projects

Economic and financial analysis is a very essential way used to inform decision on whether the project is worth investing in (Vaughan & Ardila, 1993). A project can be assessed in detail using one or more assessment tools. According to Cavatassi (2004) a lot of forestry and environmental values are not automatically reflected in market prices, this is mainly because their public nature involves at least some elements of non-excludability or non-rivalry in use. Different methodologies can be used to measure forest values; this can be methodologies that imply physical approaches, such as Environmental Impact Assessment (EIA), Strategic Environmental Assessment (SEA), or financial and economic methods, such as Cost Benefit Analysis (CBA), and Cost-Effective Analysis (Cavatassi, 2004; ADB, 2013) as well as Multi Criteria Analysis (MCA).

2.4.1 Environmental Impact Assessment

According to the Asian Development Bank (2013), EIA is a systematic procedure for measuring the environmental impacts of a single project or policy and looks for ways that minimize environmental impacts without significantly reducing benefits. Environmental Impact Assessments (EIA) have been widely practiced in both developed and developing countries to help decision makers deliberate the consequences of proposed projects (Noorbakhsh & Ranjan, 1998). However, EIA is not a comprehensive evaluation procedure as it ignores non-environmental impacts and usually does not include costs, the method also has no formal decision rule (ADB, 2013). Other researchers also rejected the use of EIA with the reason that it is not always easy to express the environmental impacts in economic terms, thus it becomes difficult to integrate the EIA findings in the decision making process and the decision is left up to the judgment of the decision makers (Lee & Kirkpatrick, 1996). In addition, The EIA process does not consider the cumulative impacts of projects adequately nor does it give solutions to alternative policy. It does also not anticipate development proposal but rather react to them (Noorbahsh & Ranjan, 1998.). In EIA, the duration of impacts may be indicated but usually the timing of those impacts is not taken into account (Eggenberger & Partidário, 2000). In the realisation of the incapability of using EIA to fully address the range of policy alternatives and cumulative effects in a decision making process, it has led to the identification of strategic environmental assessment (SEA) which is an assessment at more strategic levels (Eggenberger & Partidário, 2000).

2.4.2 Strategic Environmental Assessment

Unlike EIA, SEA is carried out earlier in the decision making process and this ensures that alternatives are adequately considered, cumulative impacts are assessed, and decisions of individual projects are made in a proactive rather than reactive manner (Lee & Kirkpatrick, 1996). However, despite the fact that SEA is considered as a more strategic method compared to EIA, ADB, (2013) stated that similarly to EIA, SEA rarely address non-environmental costs and benefits.

2.4.3 Cost Effectiveness Analysis

Cost−Effectiveness Analysis (CEA) is one of the tools that is used as a second-best option after CBA. When it comes to economic analysis, CEA is superior to the above-mentioned tools (EIA and SEA) in that it explicitly introduces cost efficiency into comparisons (ADB, 2013). CEA and CBA are seen as different monetary assessment tools, with CBA as the most extensive and elaborated option, while CEA is a rather less extensive procedure (Kuik, Scussolini, Mechler, Hunt, & Wellman, 2016). Furthermore (Kuik *et al.*, 2016) concluded that a CEA is commonly used to find the best alternative activity, process, or intervention that minimises the costs of achieving the desired result when benefits cannot easily be monetised (Kuik *et al*., 2016);ADB, 2013). It, therefore, does not ask, nor attempts to answer the question whether a certain project or policy is justified, in the sense that its social benefits exceed its costs.

2.4.4 Multi Criteria Analysis

According to Ackerman (2008a), CBA reduces the different important aspects of value like human health and the natural environment that involve many dimensions of incompatible measurements into a single metric of money. It is unethical to assign a dollar value to aspects like human health. Therefore, the MCA tool can be used to select between alternative projects that taking into account several criteria and the stakeholders' opinions (Beria, Maltese & Mariotti, 2016). However, there are most of the time too many possible criteria, the choice of which one to include in the analysis and the weight given to each criterion lies in the researchers' hands which might create biasness in the final result (Ackerman, 2008;Beria *et al*., 2016). However, given that this project does not involve multiple criteria the MCA does not apply to this study.

2.4.5 Theoretical literature on Cost Benefit Analysis

Cost Benefit Analysis (CBA) is founded in a branch of economics known as welfare economics (Griffin, 1998). Griffin (1998) explained that welfare economics stresses more on public decisions that impact the economic interests of more than one person. According to Kula (1986), CBA origins date back to 1844 when a man named Jules Dupuit began to riddle about the cost and benefit of constructing a bridge. In the 19th century, the theoretical origins of Cost Benefit Analysis was used to solve issues of infrastructure appraisal in France (Pearce, Atkinson & Mourato, 2006). In the late 1930s, CBA was formally used in water-related investments in the USA where costs and benefits were compared (Pearce *et al*., 2006). Pearce *et al*., (2006) stated that after World War II, there was need to ensure that public funds were efficiently utilised in major public investments, this led to the beginning of the combination of the new welfare economics which was essentially cost-benefit analysis. Pearce *et al*., (2006) added that CBA practical became a major decision-making tool for public investments and public policy. Kula (1997) stated that cost benefit analysis is the oldest project appraisal method where costs and benefits of a project can be scrutinized to determine whether they are worthwhile proposals. During a CBA process, the social benefits and costs of an investment project or a programme are identified, measured and compared (Brent, 1997).

Given the above-mentioned tools (EIA, SEA, CEA and MCA) and how they work, this study chose to use CBA to determine the viability of the project. This is because not only does it introduce costs efficiencies in the analysis but it answers the question whether a certain project or policy is justified, in the sense that its social benefits exceed its costs.

There are two commonly used methods for calculating CBA. These are Engineering Estimate and Parametric Modelling (Misuraca, 2014). Engineering Estimates is according to Misuraca (2014) the traditional method for developing cost estimates. It uses a bottom-up approach that calculates costs and benefits at the lowest level of detail. During the engineering method, total products and services are separated into individual components to ensure that each unit is separate and distinct (Misuraca, 2014). Misuraca (2014) went on to say that the unit cost for each part in an engineering architecture is computed in order to arrive at a total material cost. Net Present Value (NPV) of the investment is then determined by calculating its costs and benefits. NPV converts costs and benefits that occur over the program life-cycle to current year values (Misuraca, 2014). The outcomes are then used during proposal preparation and subsequently, for making an investment decision (Misuraca, 2014).

Parametric modelling, on the other hand is a top-down costing approach and it uses statistical relationships that rely on historical data (Misuraca, 2014). In addition, regression analysis is used in building a parametric model that looks for significant cost-estimating relationships. The parametric model gives more insight into the uncertainties and risks associated with a project, each risk has an associated mitigation strategy and an assessment of the probability of its occurrence with program costs and schedules. Given that the data used in this study is not from historical background, the bottom-up approach is used.

The calculated benefits and costs of a project may vary depending on different assumptions about the input data and methodology applied in the cost benefit analysis.

The range of potential outcomes for differing inputs can be evaluated using a sensitivity analysis

2.4.5.1 Sensitivity Analysis

Considering that CBA contains some predictions and estimates, impacts of projects or policies may not be predicted accurately and may be valued incorrectly (Couture *et al*., 2016). Ackerman (2008) added that the controversy regarding the appropriate discount rate to be used is one of the uncertainties of the CBA. It is therefore common, for analysts to test how sensitive their recommendations are to particular assumptions. The process of sensitivity analysis basically involves changing the assumed values of a few key parameters to see how net benefits change.

2.5 The empirical literature on CBA

In a study by Alvarodo (2013), on "Cost-Benefit Analysis of an agricultural project involving a smallholder production system", which used the 9-step methodology by (Boardman, 2011) and (Gittinger, 1982). The researcher proposed a hypothetical project where the farmers would cultivate *Jatropha curcas* instead of simply collecting the fruit from living fences which was the government program at the time. The researcher then evaluated the viability of the proposed alternative project, this accounting results in a stream of net benefits for the status quo and the proposed alternative. Furthermore, the researcher found that the results suggested that the incentives to engage in the government's program are minimal which did not even cover for the opportunity cost of labour. Therefore, it was found that the hypothetical project was feasible. The study by Birch & Middleton (2017), an "assessment of the economics of land degradation related to bush encroachment in Namibia", the study aimed to provide an initial broad basis to incorporate total economic valuation in assessing the costs of bush control and potential benefits that can be obtained from de-bushing comparing to scenario of no de-bushing, found that de-bushing could generate an estimated net benefit of N$48.0 billion over 25 years when compared with a scenario of no de-bushing and this was done on the basis of 2015 prices. A sensitivity and scenario analysis were also carried out which indicate that the net benefit could range from N$24.9 billion for the worst-case scenario to N$111.9 billion for the optimistic scenario. The study also revealed that Namibia could generate about N$734.7 million annually from bush-based feed production.

CBA was also used by FANRPAN (2017) in the study titled "Post-Harvest Management Innovations in Mozambique" where Net present value (NPV) (of the net cash flows); and Benefit-to-cost ratio was used to assess viability of the investments in Post Harvests Loss Management (PHLM) technologies. The study was carried out to assess the viability of using hermetic bags to store the harvested maize as compared to using metallic silos. In undertaking CBA, streams of incremental costs and benefits associated with the adoption of the metallic silo and hermetic bag technologies were constructed in MS Excel. The results of the net present value of the cash-flows (incremental benefits minus incremental costs over a period of 20 years, discounted at a rate of 12% per annum) was positive and the benefit-to-cost ratio was greater than one which suggested that farmers would benefit if they adopt hermetic bags.

2.6 The concept of Willingness To Pay (WTP)

According to Boardman (2015), the important concept for guiding the measurement of benefits is the Willingness To Pay of those affected. The WTP concept gives the analyst an idea of the maximum amounts individuals would be willing to pay for policy impacts that they view as valuable. Mbabazi (2015) defined WTP as the maximum amount of money an individual would be willing to pay rather than to do without an increase in a service or good such as animal feed. The concept of WTP was also described by Gunatilake, Yang Pattanayak & Choe (2007) as the economic value of a good to a person or a household under given conditions.

There has been a development of approaches that value non-marketed outputs that include environmental valuation. Boardman (2015) stipulated that the approaches have considerably extended the scope for Cost Benefit Analysis (CBA). In CBA, benefits of a policy can be valued using the concept of WTP while opportunity cost can be used to guide the valuation of policy costs (Boardman, 2015).

The WTP method have been deemed very important for several reasons. Firstly, they can directly provide information to policy makers about how much people value some goods or services and can thus make informed decisions on the pricing of these goods or services (Hanley, Ryan & Wright 2003). Secondly, WTP methods are important inputs in economic assessments such as cost benefit analyses (ADB, 2013).

2.7 Empirical literature on factors affecting Willingness To Pay (WTP) for a product

There are a number of factors that influence the WTP of a good or service. WTP for food products may be influenced by socio-demographic characteristics such as gender, educational attainment and age of consumers (McGoldrick & Freestone, 2008). McGoldrick & Freestone (2008) found a positive relationship between gender and WTP for products. Other researchers like Krystallis, Fotopoulos, & Zotos (2006) and Basarir, Sayili, & Muhammad (2009) in their studies found education to increase consumers' WTP for food products. Kamaludin & Rahim (1993) used a *probit* model to assess consumers' willingness to pay for improved domestic water services and found that people were willing to pay more than the water market price. Mbabazi (2015) also conducted a study titled "Cost Effectiveness and WTP for vaccination of village free-range poultry against Newcastle disease" and found that that female poultry keepers; farmers with higher level of education as well as income were more likely to pay for vaccination. Additionally, the study also revealed that farmers who own many chickens were willing to pay more to eradicate Newcastle disease. In their study, Chi & Yamada (2002) assessed factors affecting consumers' willingness to pay for animal welfare eggs, the study found that demographic variables such as age and education degree, had a high number of willingness to pay for animal welfare eggs.

Bennett & Blaney (2003) used a contingent valuation method to investigate consumers' willingness to pay for the adoption of specific farm animal welfare legislations including veal and egg taxes. Their results suggested that most respondents would be willing to pay an additional amount on the price of eggs to support the legislation. However, the use of contingent valuation remains controversial.

Boardman, (2015) concluded that if respondents do not understand what is being valued, they cannot be expected to give meaningful responses.

2.8 Conclusion

Bush encroachment is a worldwide phenomenon and have tremendous impacts on rangeland and subsequently on those that depend on it. de Klerk, (2004) described bush encroachment as the process of "the invasion and/or thickening of aggressive undesired woody and shrubs species, resulting in an imbalance of the grass/bush ratio, a decrease in biodiversity, carrying capacity and concomitant economic losses". Even though the mechanisms behind the causes of bush encroachment are not well known. Due to environmental degradation like drought and bush encroachment, farmers and researchers developed ways to turn bush encroachment impacts into benefits. This is by adding value to encroacher-bush through charcoal and animal feed production which will increase income and subsequently their standard of living. Bush feed production projects are gaining momentum in Namibia, it is thus important to determine the viability of the projects in order to make informed decisions of whether they are worth implementing. Cost Benefit Analysis (CBA) is one of the analytic tool to determine the viability of the projects as reviewed in this chapter. This study used the CBA approach to determine the viability of the bush-based animal feed production. In the literature, CBA is described as the process of identifying, measuring and comparing social benefits and costs of an investment project or a programme. During the CBA the Willingness To Pay (WTP) concept can be used to determine the value that the farmer assigns to the bush products.

The main implication of the literature reviewed is that farmers have to stop looking at bush encroachment as just a problem and realised that this problem can actually be turned into economical gains. This can be done by removing encroacher species and adding value to the biomass.

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CHAPTER 3: DETERMINING VIABILITY OF THE BUSH-TO-FEED PROJECT USING A CBA MODEL

3.0 Introduction

A cost benefit analysis relies on estimation of the costs of a proposed project over its useful lifetime as well as the projected time stream of benefits expected to accrue from the project (Couture, Saxe & Miller, 2016). According to Couture *et al*, (2016), analyses can differ for the most part in which cost and benefits are taken into account, how they are quantified, the time period considered as well as the discount factors applied. Though CBA details often vary considerably from place to place and project to project, the basic principles of CBA remain the same across countries (Couture *et al*., 2016). Gabriela, (2015) added that a cost benefit analysis finds, quantifies, and adds all the positive factors which are benefits. Then it identifies, quantifies, and subtracts all the negative factors which are the costs. The difference between the two shows whether the planned action is suitable. The process involves monetary value of initial and ongoing expenses against expected returns (Gabriela, 2015;Boardman, 2015). After all cost and benefits are quantified, a discount rate is chosen, it is then used in the computation of all relevant future costs and benefits in present-value terms (Griffin, 1998; Boardman, 2015; Gabriela, 2015). In most cases, the discount rate used for present value calculations is an interest rate taken from financial markets (Gabriela, 2015). According to Policy (1997); Griffin (1998); Boardman (2011) the selected discount rate can be used to calculate either an Internal Rate of Return (IRR), Net Present Value (NPV) and/or Benefit-Cost Ratio.

This chapter focuses on addressing the objective of determining the viability of the bush-to-feed project. It first gives a description of the study area and explains the methods and the type of data that were collected for this study. CBA methodology comprised of the following procedures: Determination of costs and benefits; explanation of the monetization or quantification of costs and benefits; discounting costs and benefits (costs and benefits were discounted with a nominal discount rate); calculation of economic performance indicators which included Net Present Value (NPV) and the Benefit-Cost Ratio (BCR). The section also presented and discussed the results and a sensitivity analysis was conducted to account for uncertainties of the model used. The last part of this section gives a conclusion and recommendations on the presented results. Excel 2013 was used for data analysis.

3.1 Objective

The objective of this chapter is to determine economic viability of the bush-to-feed project using cost-benefit analysis model. The relevant literature on CBA was discussed in chapter 2

3.2 Methodology

3.2.1 Study area

This study was conducted at the University of Namibia's Neudamm Campus. The Neudamm Campus Farm is situated in Khomas region and it is about 27km east of Windhoek (latitude 22º27'02″ S, longitude 17º21'38″ E and altitude of 1856 m). This farm (Figure 4) occupies 10,177 hectares of rangeland which is used for cattle, goat, and sheep grazing as well as piggery and poultry. The farm is divided into nine (9) blocks and further subdivided into smaller paddocks or grazing camps. The annual rainfall of the farm ranges between 250-350 mm.

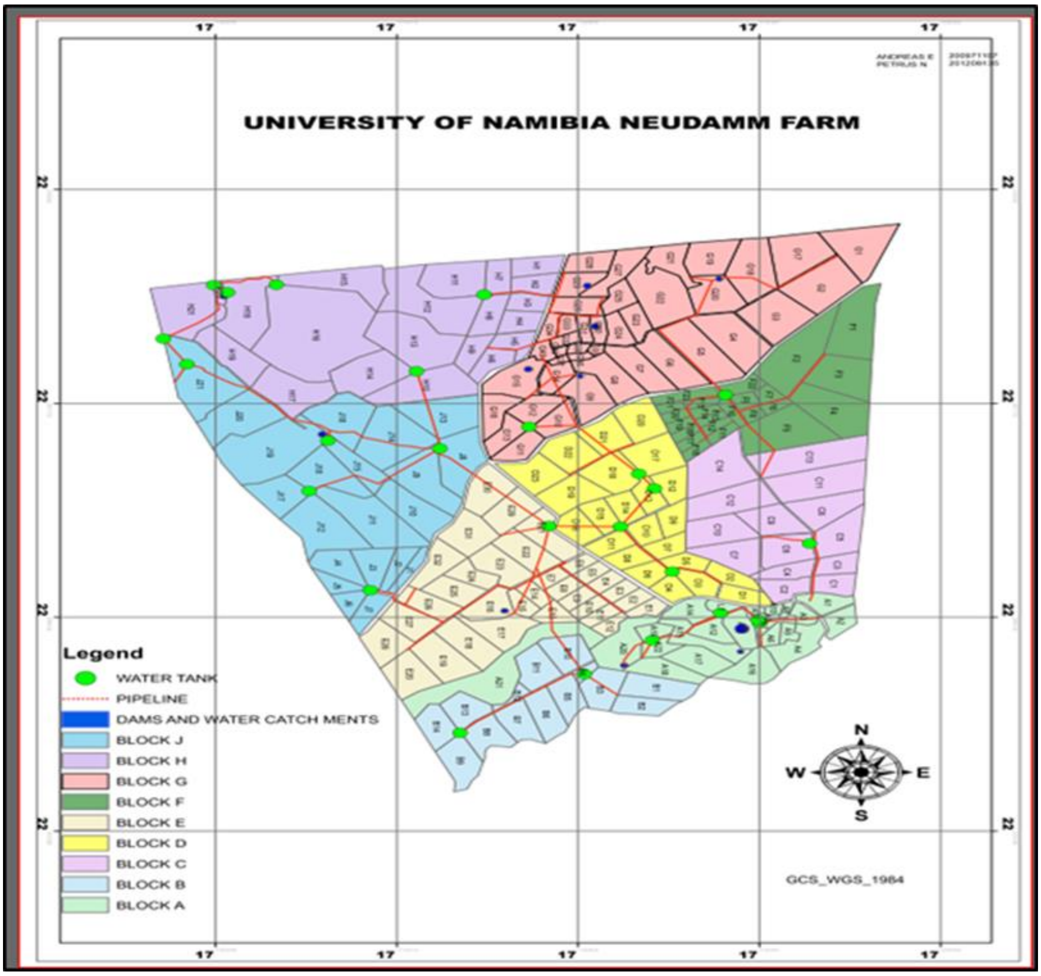

Figure 4: Neudamm campus map

Source: Beukes (2017)

3.2.2 CBA Methodological Framework

Two main methodologies by two researchers were reviewed in this study, one by (Gittinger,1982), and the other by (Boardman, 2015). According to Gittinger (1982), as reviewed by Alvarado (2013), (Gittinger, 1982) developed a methodology to assess agricultural projects both financially and economically, (Gittinger, 1982) displayed the economic analysis in a “project format” which involved a set of required activities, these activities used available resources to obtain a stream of benefits. Gittinger (1982) further calculated Present Value by obtaining a stream of benefits and expenditures for the project’s duration of which he compared to the status quo.

On the other hand, Boardman (2015) identified nine steps to carry out CBA. The 1st step is specifying a set of alternative projects. The 2nd step is to define "standing" which involves identifying the affected parties of the project. The 3rd step is identifying impact categories (costs and benefits) with appropriate indicators to measure them. The 4th step in Boardman's CBA methodology is predicting costs and benefits quantitatively over the project's life, the 5th step is impacts monetization which involves assigning value to costs and benefits; the 6th step is discounting benefits and costs to obtain present values; the 7th step is to compute Net Present Values for each alternative while the 8th step is performing sensitivity analysis, and the 9th step involves making recommendations. In CBA, the policy or project with a positive net benefit is considered economically efficient relative to the status quo, while in cases where many projects or policy alternatives are compared, the decision rule is to choose the policy or project that maximizes the net benefits (Gittinger, 1982; Boardman, 2015).

This study also reviewed the methodology used by Birch & Middleton (2017), the authors followed the 6+1 methodology of the Economics of Land Degradation (ELD), which establishes a common methodological approach for establishing a robust cost-benefit analysis to inform decision-making processes. What the authors did first was delineation and assessment of bush encroachment in Namibia, this includes the first and second step of ELD approach which is to map bush encroached zones out in relation to ecological, social, utilisation, and political parameters using GIS software. Next Birch & Middleton (2017) did the Identification of ecosystem services impacted by bush encroachment which involved step 3 and 5 of the ELD. Step 4 and 5 was done by valuation of ecosystem services impacted by bush encroachment and step 5 was conducting the cost benefit analysis of different scenarios. The final step was to conduct a sensitivity analysis.

The theoretical framework for this study was based on the combination of the 6+1 ELD methodology by (Birch & Middleton, 2017) and the nine-step methodology of (Boardman, 2015), which will only consider step 3 to 9 as steps 1 and 2 are not relevant for this study. The implication of using Boardman's methodology is that it was done on the basis of agricultural project whereas this study is more on forestry aspects. Nonetheless, Boardman's study is in line with the methodology of a study by Cavatassi, (2004) on the "valuation methods for environmental benefits in forestry and watershed investment projects" which aim to examine the full range of costs and benefits associated with forests, distinguishing between how the costs and benefits should be, and actually are included in economic analyses.

3.2.3 Study design

Firstly, the researcher identified all costs and benefits associated with the production. This was done by visiting local bush feed producers to ensure that the right data was collected. Appendix 24 displays the questionnaire used to collect data from bush-feed producers. Only two main producers were registered with The Ministry of Agriculture Water and Forestry (MAWF) at the time of this study and most of the data on the process of bush feed production was obtained from them. Secondly, the data on all costs of machines and ingredients were collected from local outlets while data on wages was collected from the Ministry of Labour and Social Welfare. Thirdly, monetary value was then assigned to benefits that were not quantifiable. Fourthly, all costs and benefits were discounted to determine the Present Value (PV). Net present Value was then calculated by subtracting the total PV of costs from the PV of benefits. Lastly the Internal Rate of Return was determined by dividing the total PV of benefit with the PV of costs.

3.2.4 Data collection and quantification of costs and benefits

The data that was collected for this study was on costs and benefits associated with producing bush-based pellets. The data on benefits was then quantified in order to be assigned dollar value.

3.2.4.1 Capital cost

This data entailed the cost of machines and de-bushing implements. Cost data was collected from local outlets like Hochland Tractors, and Cymot store. The cost of new machineries like the wood chipper, mixer, hammer mill as well as the pelletizer was collected from Hochland Tractor. Data on harvesting implements like chain saw, machete (pangas) and axes were obtained from Cymot store. A declining balance method of depreciation was used to calculate the depreciation cost of the machines over their life time. This method was used because it charges more depreciation early in a machine's life than towards the end of its useful life, with the reason that the assets are usually more productive when they are new and their productivity declines gradually. In addition, in the early years of their life time, assets generate more revenue as compared to the revenue generated in later years of their life. According to the "matching principle" of accounting which was developed by Professors W.A. Paton and A.C. Littleton in the 1940s, assets costs should be depreciated more in early years to match the depreciation expense with the revenue earned from the use of the assets (Zeff, 2005).

3.2.4.2 Operating cost

There were two types of operational costs, which was labour cost for both workers and machinery as well as cost of ingredients used in the bush feed formulation.

3.2.4.2.1 Labour cost data

Labour costs formed part of the operating costs, the information on average labour costs was obtained from the Ministry of Labour and Social welfare. According to article 9 of the Ministry of Labour and Social Welfare, the minimum wage for entry levels of Namibian agricultural employees is N$ 3.70 per hour with an additional N$400 per month (Ministry of Labour and Social Welfare, 2014). This however did not specify as to how much supervisors and general workers are to be paid. The wages to be paid to supervisors were obtain from local bush-feed producers.

Thus, monthly wage bill per labour is given as $400 + 3.7h$, where: h = number of hours worked per month.

3.2.4.2.2 Ingredients used and their cost

According to de la Puerta Fernandez (2016), bush alone without supplements have poor nutritive values, it should therefore not be used alone. Different ingredient supplements should thus be added to the bush-feed to improve digestibility and nutritional content. Bush-feed can make up between 50–85% of animal feed, with the rest of ratio being supplements (Birch & Middleton, 2017). Data on the type of ingredients used in the bush-feed production were collected from local animal bush-feed producing farmers, this was done using a questionnaire which was administered either via market survey as well as self-administered during farm visits. Considering that feed formulation is specific to every bush-feed producer, detailed formulation was considered as trade secret. A standard feed formulation which includes bush-feed was used. Ingredients that were used in the production were; maize, ammonium chloride/ammonium sulphate, salt, molasses meal, sulphur, urea and PEG. The cost of the ingredients was obtained from local outlets (Feed Masters and Agra). Power or fuel utilisation was taken as measured, or as per equipment specifications.

3.2.4.3 Benefits associated with bush-feed production

The benefits recorded in this study were from increased carrying capacity and benefits from sales of pellets. The increase in carrying capacity increases the number of animals the farm can support and therefore increases income.

3.2.4.3.1 Increase in Carrying Capacity

Increased carrying capacity was recorded as part of the benefits that can be used in the CBA. The carrying capacity of the Neudamm farm at the time of this study was 10h/large stock unit or livestock unit (LSU) (Beukes, personal communication, May, 2017). Neudamm farm size is 10177 ha and according to the results from calculations done on the farm, Neudamm has a bush density of 462 750 BE (Bush Equivalent)/ha. The total biomass of the farm was calculated to be 22 138.77 tonnes of bush, of which

76.92% is *S. mellifera*. Only 39% of *S. mellifera* is used for bush feed and the rest is woody material which can be used for other value chains such as biochar production and droppers. There were about 519 cattle at the time of this study with an average live weight of 447 Kg.

According to Birch *et al*., (2016), Namibia Biomass industry Group (N-BIG) recommendation of reducing the density of encroacher species, the environmental management practices states that a reduction in bush density to an optimal rate which is mostly 33% would at least double carrying capacity at the end of year four. Therefore, this study adopted the same methodology and assumed that the number of cattle will double in the de-bushed area by the end of the year 2022.

In order to estimate the cost or benefit of the change in livestock production a two-step process was undertaken. Firstly, the actual stocking rate of Neudamm farm was determined by dividing the total farm size by the number of large stock unit (cattle) which was 519, resulting in 19.60 ha/LSU. It was then assumed that at 19.60 ha/ LSU the stocking rate is 100% and in year four the rate will be 9.8 ha/LSU which is assumed to be at 200%, indicating that the carrying capacity/stocking rate doubled. Secondly, to get the benefits from increased livestock number, the increase in the farm's annual off-take (the number of cattle sold or consumed per year) was determined, and multiplied with the cattle market prices. The average market live weight price paid by MeatCo for cattle in 2018 was N$36.63/kg (MeatCo is a meat processing company in Namibia and the largest exporter of prime beef in Namibia).

The return period following cutting takes about 2-3 years for the bush to regrow up to the height of 0.5 mm, it may however vary widely depending on a number of parameters such as soils, rainfall cycles, and plant species. This was according to a personal communication with experienced farmer, Larry Bassy. Joubert Rothauge & Smit (2008) added that high annual rainfall in consecutive years promotes an increase in woody vegetation cover, especially in encroacher plants like *S. mellifera* which requires at least 3 years of successive good rainfall to recruit successfully. Although there is no enough reliable data available on regrowth rates, based on the literature by Christian (2010), it will take about 10-15 years before the same amount of biomass is available again.

3.2.4.3.2 Benefit from sales

Revenues from sales of the pellets was determined by multiplying the quantity that was produced per year with the market pellet price (price/kg). The market price that was used was the average market prices from the two main large bush feed producers in Namibia (Larry Bussy and Anton Dresselhaus); the average market price was N$ 4.95 per kg. The Neudamm increase in annual off-take for cattle due to increased carrying capacity was used and multiplied with the cattle live weight market price (N$36.63) offered by MeatCo to determine benefit from sales. Once the revenues were determined, the figures were then fed in the CBA model which contributed to the determination of the viability of the project. Microsoft Excel 2013 was used for data analysis.

3.2.5 Model specification

After costs and benefits were identified and valued, the final step in the CBA model is to calculate Net Present Value (NPV) and the Benefit-Cost Ratio (BCR) in order to determine the viability of the project. The formulas of discounted NPV and BCR are as follows:

NPV adopts the formula, NPV = PV (B) – PV(C); ……………………….. (i)

Where PV (B) = $\sum_{t=0}^{n} \frac{B_t}{(1+r)^t}$ ………………………………………… (ii)

And PV(C) = $\sum_{t=0}^{n} \frac{C_t}{(1+r)^t}$ …………………………………………… (iii)

BCR adopts the formula, BCR $= \frac{\sum_{t=0}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+r)^t}}$………................................. (iv)

Where, B_t = the project's benefits in year t, where t = 0 to some future planning horizon.

C_t = the project's costs in year t, where t = 0 to some future planning horizon.

r = the discount rate

NPV= Net Present Value

Decision rule: Adopt project if NPV >0. If the discounted Present Value of the benefits exceeds the discounted Present Value of the costs then the project is worthwhile (Gabriela, 2015; Boardman, 2015; Couture, Saxe & Miller, 2016). This is comparable to the condition that the net benefit must be positive. Another corresponding condition is that the ratio of the present value of the benefits to the present value of the costs must be greater than one. If there are more than one mutually exclusive projects that have positive Net Present Value then there has to be further analyses (Gabriela, 2015; Boardman, 2015; Couture *et al.*, 2016).

3.2.6 Assumptions used in the study

This section explains the assumptions for both costs and benefits that were fed into the CBA model. This study analysed two methods of bush feed production, a highly mechanized scale for bush harvesting as well as a manual scale. The two methods are different in the sense that the first uses a harvesting strategy that is more machinery oriented with minimal manpower while the latter uses more manpower with hand tools. The mechanized method is costly compared to the manual method, with an estimated cost of N$ 4000+ per hectare while the manual cost is about N$1000-1500 per hectare (Rothauge, 2017). Rothauge (2017) added that the mechanized method is also fast and can harvest about 4 hectares per day and can provide about 85,000 -150 000 tonnes of woodchips per annum. While manual on the other hand is time consuming, harvesting about 0.05-0.2 hectares per person per day and providing only about 800 tonnes per annum. According to Elliott (2012) and Rothauge (2017), the disadvantages of the fully mechanized method is that some machines are not selective on the type of bush to be harvested and it also cause massive soil disturbances.

3.2.6.1 Assumptions for the CBA model

This study discounted the costs and benefits over a period of 15 years which reflects the lifespan of the machines. Gittinger (1982) specified that the suitable discount rate for financial analysis should reflect the marginal cost of money to the farm, which would efficiently be the rate at which the farmer is able to contract a loan. A nominal interest rate of 10. 50% (BoN, 2018) was therefore used for discounting the costs and benefits. Nominal interest rate was also preferable because it is not altered or adjusted to include inflation as opposed to real interest rate (Gittinger, 1982). In addition, since nominal prices were used in this study a nominal interest rate was also suitable, in the study by (Birch & Middleton, 2017) a real interest rate was used with the reason that real prices were used in the study. According to the Office of Management and Budget (1972), the proper discount rate to use depends on whether the benefits and costs are measured in real or nominal terms. A nominal discount rate that reflects expected inflation should be used to discount nominal benefits and costs. Market interest rates are nominal interest rates in this sense. A declining balance of depreciation method was used at 6.6% of depreciation rate. The 6.6% depreciation rate was determined by dividing 100 by 15 years (the life span of the machines), this assumption holds for both mechanized and manual scale of production. The depreciation calculation is presented in (Appendix 3).

3.2.6.2 Harvesting to pelletizing assumptions

This study presented results from two scenarios with two different harvesting strategies. The first scenario is that of a highly mechanized harvesting strategy and the latter is that of manual harvesting.

3.2.6.2.1 Highly mechanized method assumptions

These assumptions are based on information collected from bush-feed producers, Larry Bussy and Anton Dresselhaus as well as bush control publication by Rothauge, (2017).

- This study assumes 3 workers harvest the bush using chainsaws as well as a front-end cutter machine.
- Three workers chip and feed the bush into the hammer mill
- Three workers work at the mixer and pelletiser as well as bagging
- One worker supervises the production
- Harvesting 14, 91 tonnes of bush per day and covering 3 hectares. According to personal communication with a bush-feed producer Larry Bussy, one can harvest approximately as much as 1 tonne of bush per hour when using a front-end cutter to harvest while machines like chainsaws can harvest about 6 tonnes of bush per day. Only 47.39 % of the harvested bush is used for bush feed which is leaves and twigs (7, 06 tonnes/day).
- The pelletizer run for about 6 hours per day.
- Maximum capacity of the pelletizer is 1 ton per hour.
- One batch is 0, 76 tonnes and 9 batches are produced per day.
- Total production was assumed to be 1097.22 tonnes annually.
- A total number of 10 workers are employed for the production; 3 to harvest, 3 to chip and hammer mill, 3 to mix and pelletize and 1 supervisor.

3.2.6.2.2 Manual harvesting method assumptions

- The study assumes that 10 workers harvest bush using axes (one worker harvests about 500 Kg of bush leaves and twigs per day hence it takes 10 workers to harvest 5000 Kg of bush per day). See appendix 18 for labour productivity calculation.
- Harvesting 5 tonnes of bush per day (leaves and twigs) covering 1 ha.
- Pelletizer run for 5 hours/ day.
- Maximum capacity of the pelletizer is 1 tonne per hour.
- One batch is 0,5 tonne and 10 batches are produced per day.
- Total production was assumed to be at 600 tonnes annually.
- The production was assumed to employ a total number of 14 workers; 10 to harvest and chip, 3 for mixing and pelletize and 1 as a supervisor.

3.2.6.2.3 The following assumptions hold for both methods

- Working days are assumed to be 5 days a week.
- Biomass is chipped then dried for 4 days and the excess is stored.
- Only 3 workers feed the harvested bush into the wood chipper.
- Harvesting and chipping is done 8 hours per day.
- Harvesting, chipping and milling is done only for 9 months in a year (November-July) with November- January being the peak season.
- Mixing and pelletizing was assumed to be done for 12 months.

3.2.6.2.4 Power consumption (costs)

This information was collected either as measured or as per producer's description

- Power or fuel utilisation was as measured for each machine.
- Wood chipper running on PTO uses 5 litres of diesel/hour.
- Hammer mill uses 1KW of electricity/hour.
- Mixer uses 0, 44 kW of electricity/hour.
- Pelletiser on PTO uses 8 litres of diesel/ hour.
- Chain saws and front-end cutter use 8 litres/ day.
- Costs were assumed to increase with 4.6% based on the 2018 inflation rate.

3.2.6.2.5 Increased carrying capacity

- The total biomass of the farm was calculated to be 22 138.49 tonnes of bush (2,19 tonnes/ha) of which 76.92% is *S. mellifera*. Only 47, 39% of *S. mellifera* is used for bush feed and the rest is woody material which can be used for other value chains like biochar production (Shilume, personal communication, September, 2018).
- This study assumed that de-bushing 33% of the total area of Neudamm farm will double the carrying capacity at the end of year 4 (Birch *et al*., 2016).
- Neudamm stocking rate of 19.60 LSU (10177ha /519 cattle) was used to determine and value the benefits from the increased carrying capacity per year. This was used as opposed to the current carrying capacity of 10 ha/LSU with the reason that it is the value of the animals that needed to be determined and the recorded 10 ha/LSU could not do that, had it been used.
- This study used 2018 MeatCo prices per live weight of cattle, which was at N$36.60. Live weight prices were used over carcass weight prices. This was

because using carcass weight could bring some complication as the carcass weight is divided in portion which fetch different market prices.

- Carrying capacity was assumed to double at the end of the 4th year after de-bushing 33% of the land (Birch *et al*., 2016).

- This study also assumed that an annual linear increase in carrying capacity of 33%. This was based on the assumption that carrying capacity doubles at the end of the fourth year as it was found that carrying capacity will only be doubled if it increases by 33%

3.2.6.3 Benefits from sales of pellets

- Benefits from sales were determined by multiplying the total annual production with the current bush feed market price.
- The average market price for bush was N$ 4.95 per kg (Bussy & Dresselhaus, 2018) and this was used to value the total production of pellets.
- Given the fact that efficiency increases with time which in turn increase productivity, this study assumed that there is an annual incremental benefit of 10%

3.2.6.4 Sensitivity analysis assumptions

- The average market price for the worst- and best-case scenarios were assumed to be 25% below and above the actual market price respectively.

- The nominal interest rate was assumed to be at 11,50% for the worst-case scenario and 9,50% for the best-case scenario
- The market price for cattle were assumed to be N$27.3/kg for the worst case (2015 Meatco prices during severe drought) and N$45.96/kg for the best-case scenario
- The annual incremental benefits are assumed to be increasing by 17% annually for the best-case scenario while the costs remain the same at 4.6% and the annual incremental benefits are assumed to stay the same at 10% while the incremental cost increase by 17% annually for the worst case, 17% was used because it was the incremental cost at which the project lost viability.

3.3 Results and discussions

This section presents and discuss the results from the findings of the Cost Benefit Analysis (CBA) model for both highly mechanized and manual scenarios. This study used the CBA model to determine the viability of producing bush-based pellets from *S. mellifera.* Firstly, the costs of the production were presented, followed by the benefits. The discounted total costs were then subtracted from the series of discounted total benefits to determine the discounted NPV of producing feed from *S. mellifera*. A Net Present Value (NPV) was calculated at 10.50% nominal interest rate over the period of 15 years. A Benefit Cost Ratio (BCR) was also determined by dividing the discounted PV of cost into the PV of benefits. The results of the sensitivity analysis was also discussed in this section of the chapter where some variables were varied to account for uncertainties of the model and the economy. This section also gave results on the sensitivity analysis. Key indicators that were varied for sensitivity analysis were the market prices of cattle, the interest rate as well as the estimated annual incremental costs and benefits.

3.3.1 The results of the analysis of costs for both mechanized and manual methods

A highly mechanized bush-based feed production scenario which is capital intensive indicates the total investment costs (Table 2) to be N$4,391,566.00, with 74% being from harvesting equipment namely chain saws and front-end cutter. The remaining amount is for production machines. Investment costs are fixed one-time expenses that are associated with a project. They can be from purchasing land machinery and equipment needed to begin a project. One could say that the investment cost is very high, however, farmers indicated that it is a one-time cost and it is, therefore, worth the investment because production rate is increased which eventually increases income for the farmer (Rothauge, 2017). It is worth mentioning that the cost presented in Table 2 is suitable for large scale farmers. Small scale farmers can use the manual method which is more labour intensive, less capital intensive and less costly. For this study, large scale farmers are regarded as farmers that produce 922 tonnes of bush-feed or more per annum while small scale farmers are those that produce 614 tonnes or less per annum. Rothauge (2017) stated that the highly mechanized method of production is preferred by some farmers as opposed to the manual with the reason that it is fast and can harvest about 4 hectares per day providing about 85,000 -150,000 tonnes of woodchips per annum.

Table 2: Investment cost for a highly mechanized production system

Machines and equipment	**Cost (N$)**
Tractor	262,600
Trailer	72,000
Chainsaw x 3	22,266
front end cutter	3,247,000
Wood chipper	278,100
Hammer mill	36,000
Mixer	95,000
Pelletizer	378,600
Total investment cost	4,391,566

Source: Own source

A manual method of production uses more workers to harvest bush, reducing the high cost that may be encountered from de-bushing machines. The total investment cost for a manual harvesting method of production was N$1,128,360.00; 54% of the cost is from harvesting equipment and the rest is from production machines such as hammer mill, wood chipper and pelletizer (Table 3). Besides it being less costly, the manual method is time consuming, covering only about 0.05-0.2 hectares per person per day (Rothauge, 2017). Results obtained from interviews conducted by Honsbein (2009) with farmers highlighted that labour intensive methods may not be accepted by farmers when done on a commercial basis, the idea of large teams of bush harvesters entering a farm under external control is not favoured as it may increase chances of theft.

Table 3: Total investment cost for a manual production system

Machines and equipment	**Cost (N$)**
Tractor	262,600
Trailer	72,000
Axes x 12	6060
Wood chipper	278,100
Hammer mill	36,000
Mixer	95,000
Pelletiser	378,600
Total Investment cost	1,128,360

Source: Own source

Investment cost for a highly mechanized production system which is more capital intensive is high as evident in figure 5, It is however suitable for large scale farmers and can provide more biomass for the production. Even though the manual method of production benefits small scale farmers as it is not financially draining, it is reported to not be desirable by the general (unskilled) labourers (Rothauge, 2017). The work is deemed as very physically demanding and difficult.

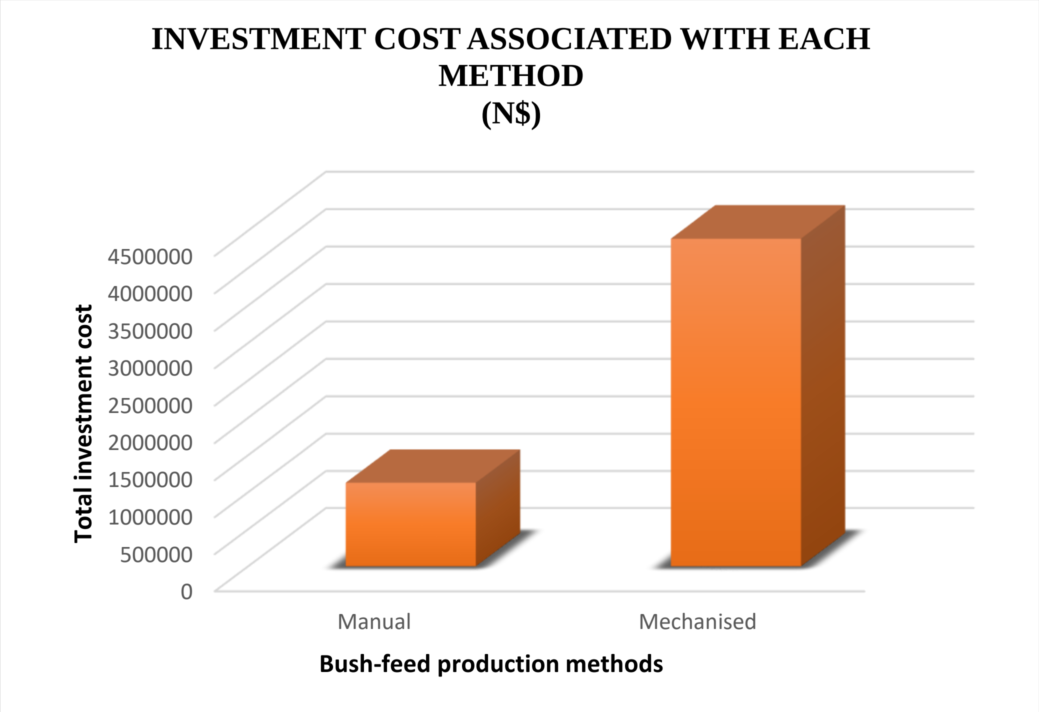

Figure 5: Manual and highly mechanized investment cost

3.3.1.1 Annual production/operating cost

The production cost associated with bush feed pellets production was separated into two categories i.e. the total labour cost and the cost of the total ingredients. Production cost is referred to as cost incurred by a business or a project when a product is manufactured or produced. The type of labour by both machinery and human was presented. The manpower and machines power consumption were given in wages, kilowatts and diesel consumption respectively. The figures on machinery power consumption were given as measured or as per equipment specification. Activities were done in 8 hours per day and 5 days a week as per Namibia labour regulations. Due to factors like rain and change in season/weather conditions, harvesting, chipping and milling were only done for 9 months. One of the experienced bush-feed producer Larry Bussy indicated in a personal communication that moisture content of less than 13% is favourable for producing pellets and moisture content higher than that will result in the production of low-quality pellets. Hence, wood chips are sun-dried for 2-3 days depending on the weather. Drying is difficult during the rainy season and a spacious shelter may be needed. Harvesting starts in November when the bushes are sprouting and November to March is deemed as the peak season for harvesting. According to personal communication with an experienced bush-feed producer Anton Dresselhaus, it is also not favourable to harvest during the late dry season (August-October) as the bushes do not have leaves and they lack nutrients. Abusuwar & Ahmed (2010) highlighted that in the early dry season of arid and semi-arid rangelands, bushes have a higher crude protein per cent, as high as 9% compared to the late dry season where protein level drops and there is an increase in lignin content. Harvesting can also continue to the early dry season and this is because early dry season immediately follows the end of the rainy season, therefore the vegetation is still nutritious compared to the late dry season.

The monthly wage bill per labour is given as $400 + 3.7h$, where: h = number of hours worked per month. Labourers were assumed to work for 8 h/day as per the Namibian government regulations (Ministry of Labour and Social Welfare, 2014). This suggested that the total wage per month was N$ 1288. Since wages for agricultural skilled labour was not specified by the government, a fixed wage of N$ 7.4 per hour was used which was derived from farmers that are already producing bush feed. The wages were multiplied by the number of working days in a year. Only 180 days for harvesting, chipping and milling as it is done only for 9 months and 240 days for mixing and pelletizing. Wage is a very important factor in agricultural projects. Schmitz & Moss (2015) highlighted that the demand for hired agricultural labour is affected by factors such as minimum wage rates. Low wages do not motivate labourers and hence reduce the supply for agricultural labour.

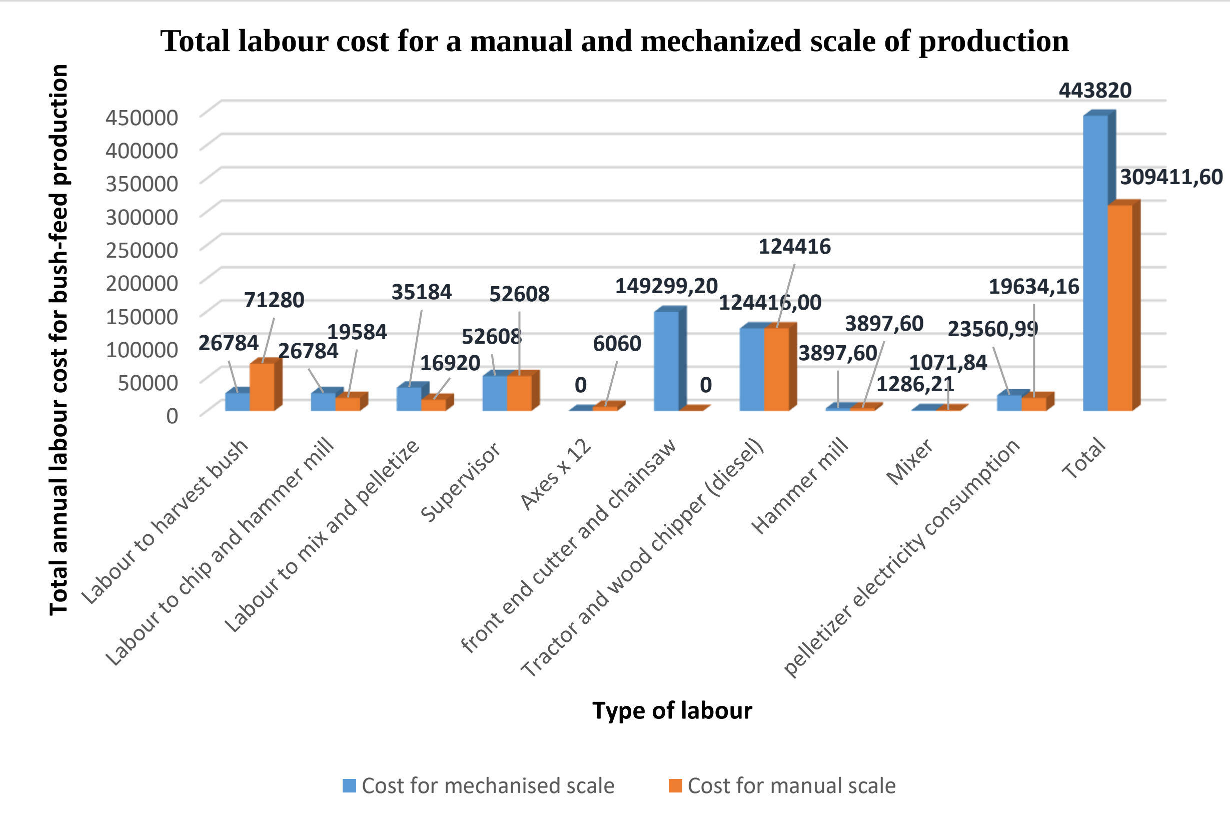

Figure 6: Annual labour cost for a manual and mechanized scale of production

Due to the fact that the diesel price keeps fluctuating, an average price of N$ 12.96 (July 2018 price) was applied, it was more reasonable to use one price rather than change the price in the model every time the price changed. To measure cost of electricity consumption, the 2018 NamPower price of N$2.03 per kilowatt was used. NamPower is the national power utility company of Namibia. The diesel price was way higher than the price of electricity, the results therefore suggests that it is cheaper to use electricity to run the machines for the production as compared to diesel (Figure 6). The total annual cost of labour for the highly mechanized production system was at N$ 443,820.00 with an annual pellet production of 1 097 222, 4 kg (Appendix 4). This suggest that the cost of labour is N$0, 25 per kg, this low cost of labour may be due the efficiency of machines. The annual bush-feed production for the manual scale was found to be 600 000.00 kg (Appendix 5) and the total labour cost was N$ 309,411.60 (Figure 6). This concluded that the cost of labour for the manual production system is N$2.66 per kg of production. Rothauge (2017) emphasised that harvesting using a manual method is more labour intensive as it demands more labour that use implements such as axes and pangas (machetes) and this may increase the labour cost.

3.3.1.2 Ingredient costs

According to de la Puerta Fernandez (2016), bush-feed alone without supplements have poor nutritive values, it should therefore not be used alone. Bush-feed is said to have anti-nutritive factors that affect the digestibility and use of nutrients in bush-feed by the animal (Pasiecznik, 2016). The reasons for the ingredients used in the bush-feed pellet production (Figure 7) was to increase palatability, decrease the effects of tannins and improve digestibility as well as to improve the nutritional content of the feed (Pasiecznik, 2016). Pasiecznik (2016) stated that molasses is used to improve the palatability of the feed, Polyethylene Glycol (PEG) is a tannin binding agent that is used to improve the digestibility of proteins in the feed, urea is added to improve the protein content whilst maize improves energy content. Other ingredients such as wood ash or activated charcoal can also be used in place of PEG to improve digestibility. According to Makkar (2003) as reviewed by de la Puerta Fernandez (2016), wood ash in a solid state fermentation with white rot fungi which gives the best results in binding tannins. However, the treatment is only suitable for small scale production. The recipe used in this study is that of a standard feed formulation which includes bush-feed. The recipe may vary with each producer, each producer has their own specific recipe. For the recipe used in this study, encroacher-bush makes up 44% of the feed, molasses takes up 22% of the total feed followed by maize at 14% and the least is sulphur that is at 0.43% (Figure 7).

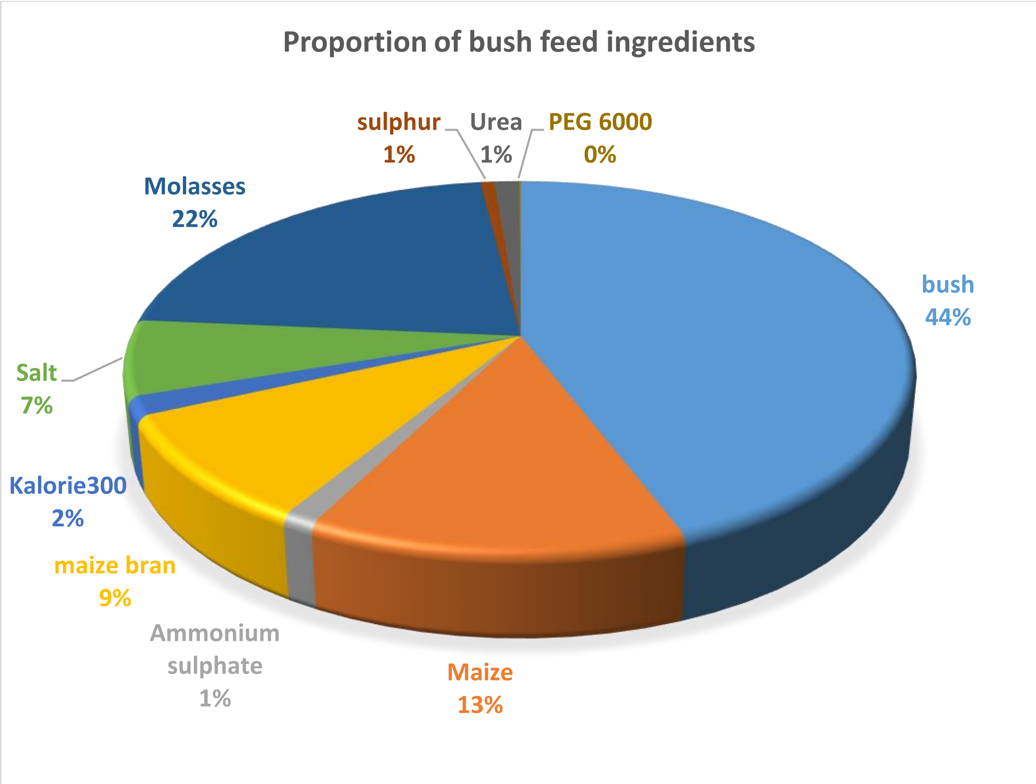

Figure 7: Proportion of bush feed pellets

The total annual ingredient cost for both highly mechanized (Table 4) and manual (Table 5) method of production were N$ 5,275,748.59 and N$ 3,470,928.00 respectively. Sulphur was the most expensive ingredient, costing N$28,69 per kg while the least expensive ingredient was salt. Sulphur is needed in the diet to support microbial growth in the rumen (Van Saun, 2014), while salt is important in maintaining osmotic balance and pH in every living cell as well as to improve appetite. Salt also helps to buffer acid during ruminal fermentation (Smith, 2008). Smith (2008) further added that salt toxicity can be a real danger to cattle that do not have access to sufficient drinking water. However, studies have shown that diets containing as much as 10% salt have not hindered digestion, as long as sufficient drinking water was accessible (Berger & Rasby, 2011).

Table 4: Ingredients used in the study for a highly mechanized scale of production and their cost

Ingredients	**Kg**	**cost/kg (N$)**	**cost/batch (N$)**	**Cost/year (N$)**
Maize	102	3.7	395,15	853,519.68
Ammonium sulphate	9	5.21	46.91	101,317.39
Maize bran	72.12	2.08	150.01	324,025.23
Salt	50	1.21	60.4	130,464.00
Molasses	165	7.50	1237.50	2,673,000,00
Calorie 300	12.5	7.3	91.25	197,100.00
Sulphur	5	28.69	143.44	309,830.40
Urea	50	6.27	313.7	677,592.00
PEG 6000	0.59	6.96	4.12	8899.89
Total ingredient cost	466.21	69.10	2442.48	**5,275,748.59**

Source: Own source

Table 5: Ingredients used in the study for a manual scale of production and their cost

Ingredients	kg	cost/kg (N$)	cost/batch (N$)	Cost/year (N$)
Maize	65	3.87	251,81	604,344
Ammonium sulphate	5	5.21	26.06	62,541.60
Maize bran	45	2.08	93.60	224,640
Salt	35	1.21	42.28	101,472
Molasses	110	7.50	825.00	1,980,000
Calorie 300	10	7.30	73.00	175,200
Sulphur	3.3	28.69	94.67	227,208.96
Urea	5.9	6.27	37.02	88,839.84
PEG 6000	0.4	6.96	2.78	6681.60
Total ingredient cost	279.6	69.10	19319.19	3470928

Source: Own source

Local by-products like marula peels, marula oil cake may also be used as supplementation for protein. Camelthorn pods have also been used by farmers for years as a protein supplementation (de la Puerta Fernandez, 2016).

3.3.1.3 Annual incremental cost and benefits

The total costs of the production were determined. A study by Agustini (2015) found that an increase in the inflation rate will lead to an increase in cost of capital, hence this study assumed that cost will be increasing by 4.6% annually (4.6 % was the annual inflation rate for 2018 according to the Economic Association of Namibia (2018)).

Due to economies of scale and efficiency that comes with time, benefits are assumed to increase by 10% annually.

Feed production from encroacher bush is relatively new, and there are no projects that determined the feasibility of the bush feed production and its nutritional content. This analysis is very general and some assumptions are informed by circumstantial evidence and data from individual producers.

The total annual production cost for both manual and highly mechanized methods of production was estimated to be at N$ 3,775,011.6 and N$ 5,719,568.59 respectively while the benefits were estimated to be N$ 5,950,070.28 and N$ 8,411,321.16 respectively (Appendices 4 and 5). These figures are associated with the scale of production, the larger the scale of production the more costs and benefits one will acquire.

In year 2 the annual incremental costs and benefit of bush feed production of the highly mechanized method were estimated to be N$ 5,982,668.75 and N$ 9,937,869.44 respectively. In year 15 the amounts were at N$ 10,735,118.83 and N$ 37,492,363.96 respectively (Figure 8). The high incremental costs and benefits associated with the highly mechanized method of production can be due to the mechanized method which was assumed to be used for a large scale production and thus results in high input cost. (Monk, 2015) stated that using more machines results in increased total production which may explain high benefits.

For the manual method, the incremental costs and benefits were estimated to be N$ 3,948,662.13 and N$ 7,230,493.47 respectively in year 2 and N$ 7,085,359.23 and N$ 28,145,767.84 respectively in year 15 (Figure 8).

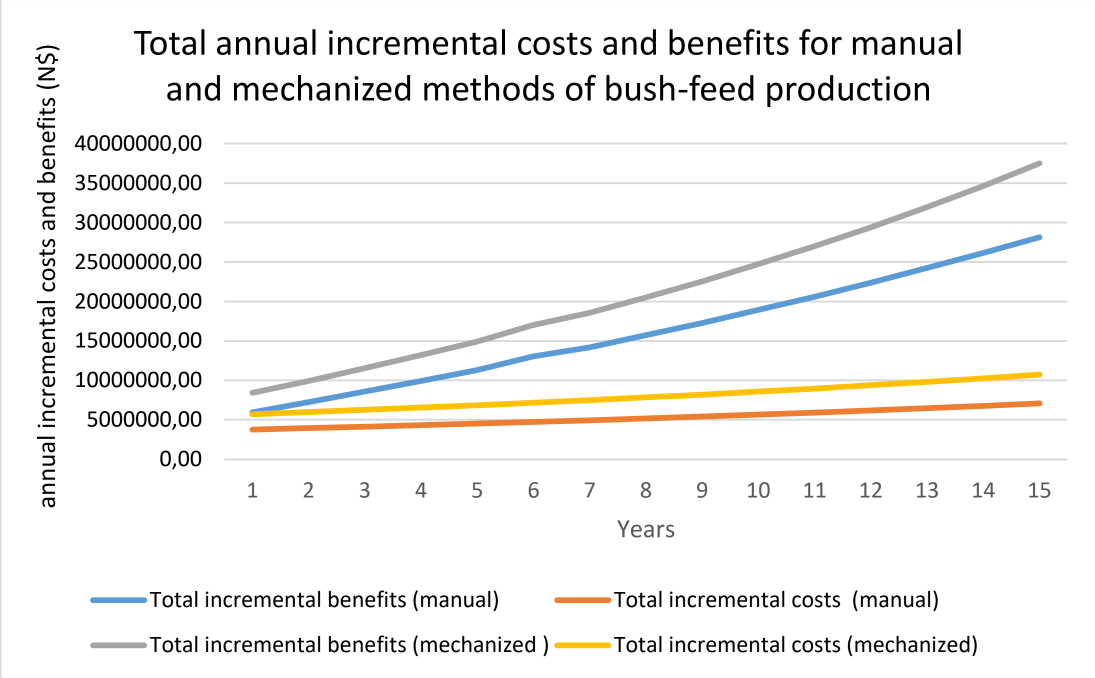

Figure 8: Total incremental cost and benefit for the manual and highly mechanized scales of production.

3.3.1.4 Present value of costs

The total cost was discounted over the period of 15 years to determine the discounted Present Value (PV) of costs. To determine PV, a discount rate is chosen, and it is then used in the computation of all relevant future costs and/or benefits in present-value terms (Griffin, 1998; Boardman, 2015; Gabriella, 2015). Gabriella (2015) added that in most cases, the discount rate used for present value calculations is an interest rate taken from financial markets. A nominal interest rate of 10.50% (BoN, 2018) was therefore used to discount the costs and benefits for this study. Nominal interest rate was chosen because it includes inflation (Gittinger, 1982), given the fact that nominal prices were used in this study, it is only reasonable that a nominal interest rate was used.

The discounted total Present Value (PV) of cost was determined from the total Investment cost, production cost and depreciation cost which was discounted over the period of 15 years (2018 prices). The results for the PV of cost was estimated to be at N$57,851,232.55 for a highly mechanized method (Table 6) and N$ 37,358,026.67 for manual method (Table 7). In a similar study by (Birch & Middleton, 2017) a present value of N$217.7 million (2015 prices) was estimated over a 25-year horizon.

Table 6: Present Value of cost calculation of a highly mechanized method

Year	**Depreciation**	**Production + Investment**	**Total**	**PVC**
	cost	cost	cost	
0	0.00	4,391,566.00	4,391,566.00	4,391,566.00
1	281,547.40	5,719,568.59	6,001,115.99	5,430,874.20
2	262,683.72	5,982,668.75	6,245,352.47	5,114,844.06
3	245,083.91	6,257,871.51	6,502,955.42	4,819,743.69
4	228,663.29	6,545,733.60	6,774,396.89	4,543,824.25
5	213,342.85	6,846,837.34	7,060,180.20	4,285,528.58
6	199,048.88	7,161,791.86	7,360,840.74	4,043,465.61
7	185,712.61	7,491,234.29	7,676,946.89	3,816,388.60
8	173,269.86	7,835,831.07	8,009,100.30	3,603,176.55
9	161,660.78	8,196,279.29	8,357,940.07	3,402,818.23
10	150,829.51	8,573,308.14	8,724,137.65	3,214,398.59
11	140,723.93	8,967,680.32	9,108,404.25	3,037,087.04
12	131,295.43	9,380,193.61	9,511,489.04	2,870,127.40
13	122,498.63	9,811,682.52	9,934,181.15	2,712,829.26
14	114,291.23	10,263,019.91	10,377,311.14	2,564,560.48
15	106,633.71	10,735,118.83	10,841,752.54	2,424,740.80
				57,851,232.55

Source: Own source

*Present value of cost $=\sum_{t=0}^{n} \frac{C_t}{(1+r)^t}$

C_t = total costs in year t, where t = 0 to some 5 years

r = the discount rate

Table 7: Present value of cost for a manual method of production

	Depreciation	Production + Investment	Total	PVC
Year	**cost**	**cost**	**cost**	
0	0	1,125,700.00	1,125,700.00	1,125,700.00
1	63,998.40	3,775,011.60	3,839,010.00	3,474,217.19
2	59,710.51	3,948,662.13	4,008,372.64	3,282.793.26
3	55,709.90	4,130,300.59	4,186,010.49	3,102,512.06
4	51,977.34	4,320,294.42	4,372,271.76	2,932,635.15
5	48,494.86	4,519,027.96	4,567,522.82	2,772,485.83
6	45,245.70	4,726,903.25	4,772,148.95	2,621,442.42
7	42,214.24	4,944,340.80	4,986,555.04	2,478,932.33
8	39,385.89	5,171,780.47	5,211,166.36	2,344,427.00
9	36,747.03	5,409,682.38	5,446,429.41	2,217,437.44
10	34,284.98	5,658,527.77	5,692,812.75	2,097,510.38
11	31,987.89	5,918,820.04	5,950,807.93	1,984,224.81
12	29,844.70	6,191,085.76	6,220,930.46	1,877,189.04
13	27,845.10	6,475,875.71	6,503,720.81	1,776,038.09
14	25,979.48	6,773,765.99	6,799,745.47	1,680,431.31
15	24,238.86	7,085,359.23	7,109,598.09	1,590,050.36
				3,735,8026.67

Source: Own source

*Present value of cost =$\sum_{t=0}^{n} \frac{C_t}{(1+r)^t}$

C_t = total costs in year t, where t = 0 to some 5 years

r = the discount rate

3.3.2 The results of analysis of benefits in both methods

The benefit for this study was derived from the sales of bush-feed pellets produced as well as from increased carrying capacity due to de-bushing. The 2018 average market price for bush-based feed was N$ 4.95 per kg and this was multiplied with the total annual production to value the total benefit from sales of pellets. Based on personal communication with Larry Bussy, one of the largest bush-feed producers in Namibia, prices of bush-feed vary according to individual producer's recipe. The annual benefits was discounted over a period of 15 years (2018 prices) and a nominal interest rate of 10.50% (BoN, 2018) was used to determine the discounted present value of benefits. The market price of N$36.63 per kg of cattle live weight was used to value the benefit from sales of increased cattle due to increased carrying capacity.

3.3.2.1 Benefits from sales of pellets

The total estimated annual production for the highly mechanized method was 1,097,222.40 kilograms of pellets (Appendix 4). A batch was 761.96 kg and 9 batches were assumed to be produced per day; this assumption was based on the observation made by the researcher during visits to the bush-feed producers. It was further observed that the large-scale producers produced about 700-800 kg per batch, because despite the pelletizers having a capacity of 1000 kg (similar to that found at Neudamm farm), it could only take about 700-800kg of bush in order for it to run efficiently. The pelletizer was assumed to run for 6 hours per day. In addition, it was observed that small scale producers produce a batch that is 500 kg, mainly because the harvesting process is slow and provides only about 500 kg of biomass per day. Hence, the batch for the manual method was assumed to only be 500 kg and 10 batches were being produced per day with the pelletizer running for 5 hours per day. The total estimated annual production for the manual production system was 600,000.00 kg (Appendix 5).

The highly mechanized method which uses machines to harvest bush supplies more biomass to the production by providing about 7000 kg of bush per day and increasing output as a result. The manual method on the other hand is estimated to provide about 5000 kg of biomass per day when 10 workers are used to harvest. Ten workers were assumed to harvest bush for the manual method because based on the results from a study done at Neudamm farm, only about 5000 kg of biomass is harvestable per hectare and it was estimated that 10 workers harvest 5000 kg of bush per day. Rothauge (2017) indicated that 1 man can harvest about 0,05 - 0,2 hectare per day. Anton Dresselhaus, an experinced bush feed producer, indicated that on his farm 1 man harversts about 0,34 hectares in a day. At the end of the day, the number of hectares harversted per day is site specific.

The annual productions for both methods were multiplied with the average market price of N$ 4.95 to get benefits of N$ 5,431,250.88 for the highly mechanized and N$ 2,970,000.00 for the manual method. Due to specialization of which may lead to efficiency over the years it was assumed that the benefits will increase by 10% annually. The annual incremental benefits from sales of pellets for the highly mechanized of production system was estimated to be N$ 5,974,375.97 in year 2 and N$ 20,625,166.18 in year 15 (Appendix 6). While for the manual scale of production, the incremental benefit from sales of pellets was assumed to be N$ 3,267,000.00 in year 2 and N$ 11,278,570.06 in year 15 (Appendix 7). In the study titled “Specialization and diversification of agricultural production”, (Czyżewski, 2015) noted that specialization of production leads to higher economic performance. It was however also highlighted by other researchers that bush-feed production in combination with other productions like charcoal production will bring more income and reduce harvesting cost for the producer (Gschwender, 2017; Birch *et al*., 2016). This is because the whole harvested bush including wood is utilized.

3.3.2.2 Benefits from increased cattle offtake due to increased carrying capacity

Though animal feed is an input into cattle production, this study assumed that in de-bushed areas, increased grass production would be adequate and animal feed would not be required. The benefit from increased carrying capacity is assumed to be the monetary value of the additional number of cattle that the farmer is willing to sell per year due to increased carrying capacity. According to Birch *et al.,* (2016), using Namibia Biomass Industry Group's (N-BiG) recommendation of reducing the density of encroacher species by the environmental management practices, a reduction in bush density to an optimal rate which is mostly 33% of the total bush coverage would at least double carrying capacity at the end of year 4. The carrying capacity was therefore assumed to double in year 4. Honsbein, Shiningavamwe, Iikela, & de la Puerta Fernandez (2018) stated that according to the farm assessment conducted farm Langbeen, the rangeland carrying capacity in the farm areas that were thinned improved by 75% in five years. It is implicitly assumed that the current carrying capacity is being fully utilised. The Neudamm carrying capacity was at 19ha/LSU. Thus, in year one 19 ha were assumed to be equivalent to 100% carrying capacity while year 4 the increased in carrying capacity was assumed to be at 9.5ha/LSU which is equivalent to 200% indicating that it doubled (Table 8). Appendix 6 displays the complete table that shows results until year 15.

The annual offtake rate of Neudamm farm was 172 cattle, average live weight was 473 kg and the average market price was N$36.63/kg. The carrying capacity was assumed to have a linear increase of 0.33%. This is based on N-BIG's recommendations that states that de-bushing 33% will double the carrying capacity at the end of the fourth year, the calculations show that this will happened when you have a linear increase. The results indicated that there will be an additional increase of N$ 983 423.19 per year. In year 1, the undiscounted benefit from increased carrying capacity was assumed to be N$2,980,070.30 (2018 prices) which doubled in the fourth year to N$5,960,140.60 (Table 8). This suggests that not only will de-bushing generate benefit from sales of pellets, it will also generate income from the sales of additional animals that the land would support after it had been freed from the encroacher species. In a similar study by Birch & Middleton (2017) titled "An Economic of Land Degradation related to Bush Encroachment in Otjozondjupa, Namibia," it was estimated that the net benefit for additional cattle production was at N$ 146 million per annum. Honsbein (2009) indicated that livestock, including game farming enterprise also benefit from increased grazing due to de-bushing.

Table 8: Benefits from increased carrying capacity due to de-bushing

	year 1	year 2	year 3	year 4	year 5
Increased carrying capacity	100%	133%	167%	200%	233%
Offtake per year	172	229	287	344	401
Benefits from carrying capacity	2,980,070.28	3,963,493.47	4,976,717.4	5,960,140.56	6,943,563.75

Source: Own source

The benefit from sale of animals is seen to be increasing for the de-bushing scenario while it was assumed to remain constant for the no de-bushing scenario. The cost for de-bushing was found to be lower than that of the benefit from increased carrying capacity (Figure 9). Labour cost to de-bush that was compared in Figure 9 was very low (less than N$ 1 million), however if the investment cost for the de-bushing machines was to be added the cost of bush control will increase.

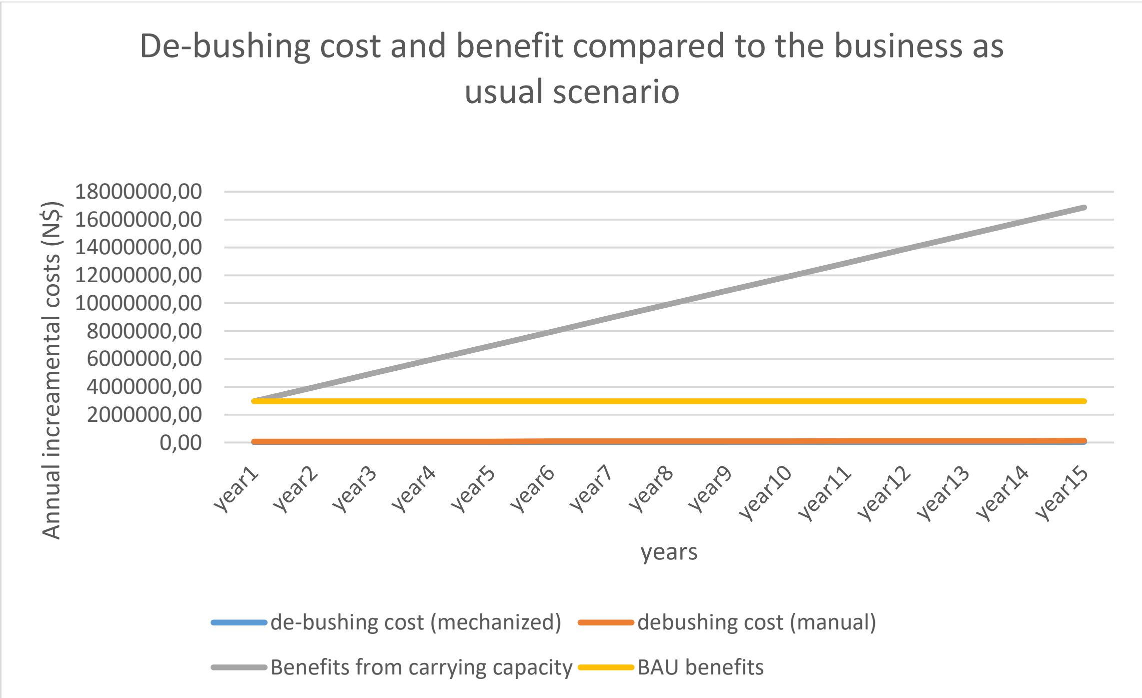

Figure 9: De-bushing cost and benefit compared to the business as usual scenario

The total benefit was also summed up and discounted over the period of 15 years using a nominal interest rate of 10.50% (as discussed in previous sections) to obtain a Present Value (PV). The PV provide a valuation in today’s money, this following the principle that money spent today is more valuable than money spent in the future (Gittinger, 1982). It was assumed that there will be a 10% increase in benefits due to specialization which may lead to efficiency.

Using 2018 price, the results of the present value of the total discounted benefit from a highly mechanized production system was estimated to be N$ 131,817,067.97 (Table 9) while that of the manual scale was estimated to be N$ 99,444,207.06 (Table 10). There was no benefits received in year 0 for both methods as the production was assumed to have started in year 1. Rothauge (2017) stated that machines are fast and can provide more biomass to the production compare to the manual production that uses man power with hand implements to harverst bush. More biomass means more output and consequently more benefit. Farmers should therefore make a choice on which method they would like to choose depending on the resources they have. In their study, (Birch & Middleton, 2017) estimated the total benefit from animal feed production of N$952.3 million (2015 prices) over a 25-year horizon. It was however unclear whether a manual or mechanized system was used.

Table 9: Present Value of benefits for a highly mechanized method

Year	Total benefits	PVB*
0	0,00	0,00
1	8,411,321.16	7,612,055.35
2	9,937,869.44	8,138,956.57
3	11,548,530.93	8,559,332.70
4	13,189,135.48	8,846,413.13
5	14,895,458.17	9,041,541.42
6	17,001,878.53	9,339,491.71
7	18,562,003.08	9,227,602.84
8	20,507,605.50	9,226,069.68
9	22,549,425.84	9,180,682.87
10	24,726,886.59	9,110,593.23
11	26,990,970.33	8,999,812.04
12	29,383,120.13	8,866,466.44
13	31,945,943.28	8,723,808.07
14	34,633,925.66	8,559,134.05
15	37,492,363.96	8,385,107.87
PV		**131,817,067.97**

Source: Own source

Table 10: Present Value of benefits for a manual method

Year	Total benefits	PVB*
0	0.00	0.00
1	5950070,28	5,384,678.99
2	7230493,47	5,921,658.83
3	8570417,37	6,352,067.99
4	9913210,56	6,649,136.04
5	11291940,75	6,854,206.76
6	13038009,38	7,162,054.49
7	14201747,01	7,060,018.28
8	15711323,82	7,068,293.19
9	17273515,99	7,032,670.08
10	18923385,76	6,972,299.95
11	20607119,42	6,871,194.30
12	22360884,12	6,747,480.45
13	24221483,68	6,614,410.25
14	26137020,10	6,459,281.02
15	28145767,84	6,294,756.44
PV		**99,444,207.06**

Source: Own source

*Present value of cost $=\sum_{t=0}^{n} \frac{C_t}{(1+r)^t}$

C_t = total costs in year t, where t = 0 to some 5 years

r = the discount rate

3.3.3 Cost of production

The cost of production was determined by dividing the total cost by the total production. The results from this study suggested that the cost of production for a highly mechanized production system was N$ 1.05 per kg. The mechanized method of production is associated with machine efficiency which may increase output therefore reducing the cost of production. According to (Subramaniam, Yusop, & Hamidon, 2008) since the investment in machineries is high, industries try to increase machine efficiency by maximize their usage in the shortest time possible. The results of this study goes hand in hand with (Monk, 2015), who in his study titled "An economic analysis of a Mechanized systems approach to cassava production in sub-Saharan Africa," concluded that a mechanized systems approach to cassava farming was beneficial to reducing cost of production and increasing yield.

The cost of production for a manual production system was N$ 1.27 per kg. Based on the survey results run for this project. The cost of production associated with the manual method may be high because of low production and which may increase cost of production.

According to the results of the survey, lucerne was the main feed bought by farmers in Namibia. The cost of a 40 kg bale of lucerne can fluctuate from N$80 to N$200 depending on the season of the year, with the dry season associated with the highest prices. This means the cost of lucerne ranges between N$2-N$5 per kg, making it way expensive compared to bush-feed production results from this study. Farmers also buy supplements such as salt licks which cost approximately N$ 60 per 50 kg bag. The total cost spent by farmers on feed are therefore high. Birch & Middleton (2017) also stated that based on interviews with farmers, the capex and opex for animal feed production was at N$1.2 and N$1.8 per kilogram respectively. Given the fact that the cost of production for this study is lower than buying feed in the market, it is therefore clear that producing animal feed is more beneficial to the farm as it is produced at a low cost. Not only will the production reduce the feed cost for Neudamm farm by increasing grazing, it can also increase income from sales of pellets and from increased carrying capacity which in turn increases cattle herd.

3.3.4 Results of Cost Benefit Analysis of producing bush-based animal feed from *Senegalia mellifera*

Alvarado, (2013) stated that indicators of Cost Benefit Analysis such as Net Present Value (NPV) and Benefit Cost Ratio (BCR) measures projects' worth. As discussed in previous sections an interest rate of 10.50% was applied to discount a series of benefits and costs for this study.

The decision rule to accept the project is when it has a positive NPV and a BCR that is greater than 1 (Gabriella, 2015; Boardman, 2015; Couture *et al.*, 2016). The results from the cost benefit analysis for both the highly mechanized and the manual methods showed a positive NPV, a BCR that is greater than 1 (Table 11).

The NPV was determined by getting the difference between the total discounted present value of benefits and costs (Gittinger, 1982). The NPV calculations for the highly mechanized production gave the results of N$ 73,965,835.43 (N$ 131,817,067.97- N$57,851,232.55), while that of the manual method was N$ 62,086,180.39 (Table 11). This results implies that the proposed projects are both recommendable as the NPV is positive (Gabriella, 2015; Boardman, 2015; Couture, *et al.*, 2016). Boardman (2015) mentioned that in situations where not just one project has a positive NPV, the rule of thumb will be to choose the project with the higher net present value. In this case however, the choice of which method to use depends on whether the farmer is a large- or small-scale producer. It is wise for small scale producers to choose the manual method as it is more cost effective compared to the mechanized method of production. The BCR is obtained by dividing the present value of the benefit stream from the present value of the cost stream (Gittinger, 1982).

Table 11: Net Present value and Benefit Cost Ratio

	Highly mechanized scale		Manual scale	
Year	**NPV**	**BCR**	**NPV**	**BCR**
0	-4,391,566.00	0.00	-1,125,700.00	0.00
1	2,181,181.15	1.40	1,910,461.79	1.55
2	3,024,112.50	1.59	2,638,865.57	1.80
3	3,739,589.02	1.78	3,249,555.93	2.05
4	4,302,588.88	1.95	3,716,500.89	2.27
5	4,756,012.84	2.11	4,081,720.92	2.47
6	5,296,026.10	2.31	4,540,612.07	2.73
7	5,411,214.24	2.42	4,581,085.96	2.85
8	5,622,893.13	2.56	4,723,866.19	3.01
9	5,777,864.64	2.70	4,815,232.64	3.17
10	5,896,194.64	2.83	4,874,789.57	3.32
11	5,962,725.00	2.96	4,886,969.50	3.46
12	5,996,339.03	3.09	4,870,291.40	3.59
13	6,010,978.81	3.22	4,838,372.16	3.72
14	5,994,573.57	3.34	4,778,849.71	3.84
15	5,960,367.07	3.46	4,704,706.08	3.96
	73,965,835.43	**2.28**	**62,086,180.39**	**2.66**

Source: Own source

When the total present value of benefit was divided by the total present value of cost it gave a BCR of 2.28 for the highly mechanized method and 2.66 for the manual method. The results of the BCR suggest that if the projects are to be implemented, for every dollar invested in the projects, the projects deem to get N$ 2.28 and N$ 2.66 in benefits for every N$1 of investment in the two methods respectively. This also show that the projects are capable of covering the investment and operating cost.

2.1.1 Sensitivity analysis

The parameter values and assumptions of any model are subject to change and error, the investigation of these potential changes and errors as well as their impacts on conclusions to be drawn from the model is known as sensitivity analysis (Baird, 1989). It is therefore important to consider how variations of some key indicators affect the

NPV and the BCR of the project. The key indicators that were varied for the sensitivity analysis were the market price for the sales of cattle, the nominal interest rate and the annual incremental percentages. The 2018 actual cattle market price was N$36.63 per kg and this was used for the base case scenario. For the worst-case scenario, the market price was assumed to be N$27.3 per kg (2015 MeatCo prices during severe drought) while for the best-case scenario, the price of N$45.96 per kg was assumed.

The nominal interest rate for the base case scenario was 10.50%. Interest rate for the worst-case scenario was assumed to be 9.5% while for the best-case scenario was increased to 11.5%. The calculations for the sensitivity analysis scenarios for both mechanized and manual production system are presented in (Appendix 8-15)

The results from the sensitivity analysis show that the worst-case scenario of producing bush-based feed from *S. mellifera,* assuming a 17% increase in cost was not viable for the mechanized method of production. The interest rate was also assumed to be at 11.5% while the market price for selling cattle was assumed to be N$27, 30/kg (about 25% below the market price). The NPV was recorded to be N$ -7,581,806.71 which was associated with a BCR of 0.93 (Table 12).

Looking at the negative NPV, it means that the investor will not make enough money to cover the cost, the BCR of 0.93 also means that the project will be making less than a dollar from the investments which is a loss. Thus, the investment is not worthwhile, (Gabriella, 2015; Boardman, 2015; Couture et al., 2016) stated that the projects should only be implemented if the NPV is positive and the BCR is greater than 1, which is not the case for this result. (Appendix 9) show the CBA calculations for the worst-case scenario for the mechanized. The results for the worst-case scenario for the manual production system showed that the project was viable. The indicators varied were the same as those in the worst-case scenario of the mechanized method of production. The results showed that the NPV was N$ 4,072,285.62 and the BCR was 1.05 which suggests viability. The best-case scenario for both methods were proved to be viable, with the mechanized method having a high NPV of N$ 140,951,593.52 while the manual had an NPV of N$ 83,960,557.11. In cases where two or more mutually exclusive projects are compared, literature suggest that it will be wise to invest in the project with the higher NPV (Boardman, 2015). However, one should take into consideration different aspects of projects such as sizes of the projects being compared. A large project may have a low NPV and BCR compared to smaller project which doesn't necessarily mean the smaller project is better.

Table 12: Sensitivity analysis results for the mechanized and manual production systems

Highly mechanized scale			**Manual method**	
	NPV (N$)	BCR	NPV (N$)	BCR
Worst case	-7,581,806.71	0.93	4,072,285.62	1.05
Base case	73,965,835.43	2.28	62,086,180.39	2.66
Best case	140,951,593.52	3.20	83,960,557.11	3.11

Source: Own source

3.3.5 Conclusion and recommendations

This chapter discussed viability of producing animal feed from *S. mellifera* encroacher bush using a CBA model. Two methods were discussed in this chapter, a highly mechanized method as a fast method that can harvest about 4 hectares per day and can provide about 8000 tonnes of wood chips annually. The method is however more capital intensive and costly, it was found in this study that the highly mechanized method had high estimated investment cost of N$ 4,391,566.00. Another method observed in this study was the manual method which is labour intensive and time consuming. The manual method clears only about 1 hectare per day and provide about 800 tonnes annually. The investment cost for this method was about N$ 1,128,360.00. Both investment cost from the two methods included the costs for production machines (wood chipper, hammer mill and pelletizer).

The operating cost for both methods was divided into two categories, labour and ingredient costs. The mechanized method was assumed to produce 9 batches per day and a batch was assumed to be about 700 kg. The ingredient cost for the mechanized method was at N$ 5,275,748.59. For the manual method, it was assumed that the batch was 500 kg and 10 batches were produced per day, the ingredient cost in the manual method was estimated to be N$3,470,928.00 annually. The ingredients that were used in the production systems were Maize, Ammonium sulphate, Maize bran, Salt, Molasses, Calorie 300, Sulphur, Urea and PEG 6000 which were used to improve digestibility and nutrition content of the bush feed. Given inflation, the costs were assumed to increase by 4.6% annually (BoN, 2018).

Income from sales of pellets and the increased carrying capacity were the benefits determined for this study. The production for the mechanized system was assumed to be 1,097,222.40 kg of pellets annually with the cost of production at N$ 1.05. The manual method was assumed to have a production of about 600 000 kg annually and the cost of production at N$ 1.27. The cost of production for both methods was seen to be lower than the cost of feed in the market, specifically lucerne which costs between N$ 2-N$ 5 per kg concluding that bush feed production is cheaper than purchasing feed in the market.

After all costs and benefits were identified, they were discounted over the period of 15 years using a nominal interest rate of 10.50%. A nominal interest rate was used because it is not altered for inflation and because nominal prices were used in the study.

The discounted Net Present Value (NPV) and Benefit Cost Ratio (BCR) were the indicators of viability for the projects. The decision rule said to adopt the project with a positive NPV and a BCR greater than 1. The choice of which system to choose is also based on the resources the producer have. Both projects were seen to be viable with the mechanized method having a NPV of N$ 73,965,835.43 and the manual had an NPV of N$ 62,086,180.39.

To accommodate the uncertainty of the model, a sensitivity analysis was conducted. Key indicators of the model varied to see the effect they have on the viability of the project. The indicators varied were; cattle market price, the interest rate, as well as annual incremental percentage in costs and benefits. In the worst case scenario the price of cattle was reduced by 25% below the current market price (2018 prices), the interest rate increased by approximately 0.5%, while the annual increase in cost was 17%. The results showed that the manual method was still viable while the worst case scenario for the mechanized method was seen to be inviable with the NPV of -7581806, 71 and a CBR of 0, 93.

For the best-case scenario, the market price of cattle was also increased by 25% above the current market price (2018 prices), the interest rate was reduced by approximately 0,5 % and the annual increase in benefit was assumed to be 17%. The NPV for the mechanized scale increased to N$140951593.52 recording an increase of approximately N$ 50 million. The NPV from the manual scale increased to N$ 83,960,557.11 which increased by N$ 38 million. The BCR for both methods also increased.

Based on the results of the study, it is recommended for farmers to venture in bush feed production because not only will the production generate income from the sales of bush feed, but it will also reduce bush encroachment which subsequently increases carrying capacity and grazing for the rangeland. The production of bush feed is also vital to the Namibian livestock feed market that is monopolized, and it is good for competition as it could reduce the current feed cost. Increased income for the producer also improves their livelihood. The production also creates job opportunities thus tackling unemployment in the country.

It was determined in the study that even though the mechanized scale of production had high benefits, it is also associated with very high investment cost which most farmers may not be able to endure. This method is therefore recommended for large scale farmers with an annual production of 922 000 kg of bush feed or more. Farmers with a high production will be able to afford to cover the high costs.

The manual scale of production is labour intensive with low investment cost. This method is recommended for small scale farmers with an annual production of 614 000 kg or less. Both methods are recommended for commercial farmers, whereas for communal farmers that are unable to cover costs, pelletizing is not recommended. It is also recommended that the government steps in and subsides the farmers, especially communal farmers to help with the high investment costs by offering free de-bushing programs.

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CHAPTER 4: DETERMINING THE POTENTIAL MARKET AVAILABILITY FOR THE BUSH-BASED PRODUCTS USING THE WILLINGNESS-TO-PAY (WTP) MODEL

4.0 Introduction

This chapter discusses the methodology used to determine the farmers' willingness to pay (WTP) for bush-based pellets as well as the results from the analysis. The chapter also drew conclusions and recommendations from the results. Willingness to pay is the maximum amount of money an individual would be willing to pay rather than to do without an increase in a service or good such as animal feed (Mbabazi, 2015).

According to (ADB 2013), WTP techniques go back to the 1940s, in the proposal of Ciriacy-Wantrup (1947) who wanted to use Stated Preference (SP) method to value natural resources and the environment. In addition, Hotelling (1949) used Travel Costs (TC) to value economic benefits of national parks. Since then WTP studies have advanced and been adapted to application in many different settings and sectors around the world. WTP studies have been used in sectors such as health for valuation of mortality risk reduction (Mahmud, 2009). In the urban agricultural sector (Henn, 2001) used a Contingency Valuation (CV) Method.

Contingency valuation is a valuation method that directly elicits the WTP of people for a good whose benefit does not have a market price. This is done using survey methods (Boardman, 2015; ADB, 2013). Under the CV method, consumers are directly asked for their WTP value of a good or service. To elicit consumers' WTP values for non-marketed goods, the researcher needs to formulate a hypothetical market scenario of which should be described to the survey respondents (as in this study). Hence, "the elicited WTP values of a good are "contingent upon" the hypothetical market prescribed in the survey instrument" (ADB, 2013, Pg. 79). According to Whitehead (2001), an open ended choice method of CV can be adopted where respondents are asked to state their maximum WTP with no value being suggested to them. Furthermore, the advantages of this method are that it is straightforward, that the maximum WTP can be identified for each respondent, the results may also be assessed using simple statistical techniques such as Ordinary Least Squares regression (OLS) method. This study therefore used an open-ended CV to collect data on WTP.

The relevant literature review about WTP is discussed in chapter 2. Please see the detailed literature on WTP model in section 2.6.

4.1 Objective of the chapter

The objective of this chapter is to determine potential market interest and availability of the bush-based products by farmers, using the Willingness-To-Pay (WTP) model.

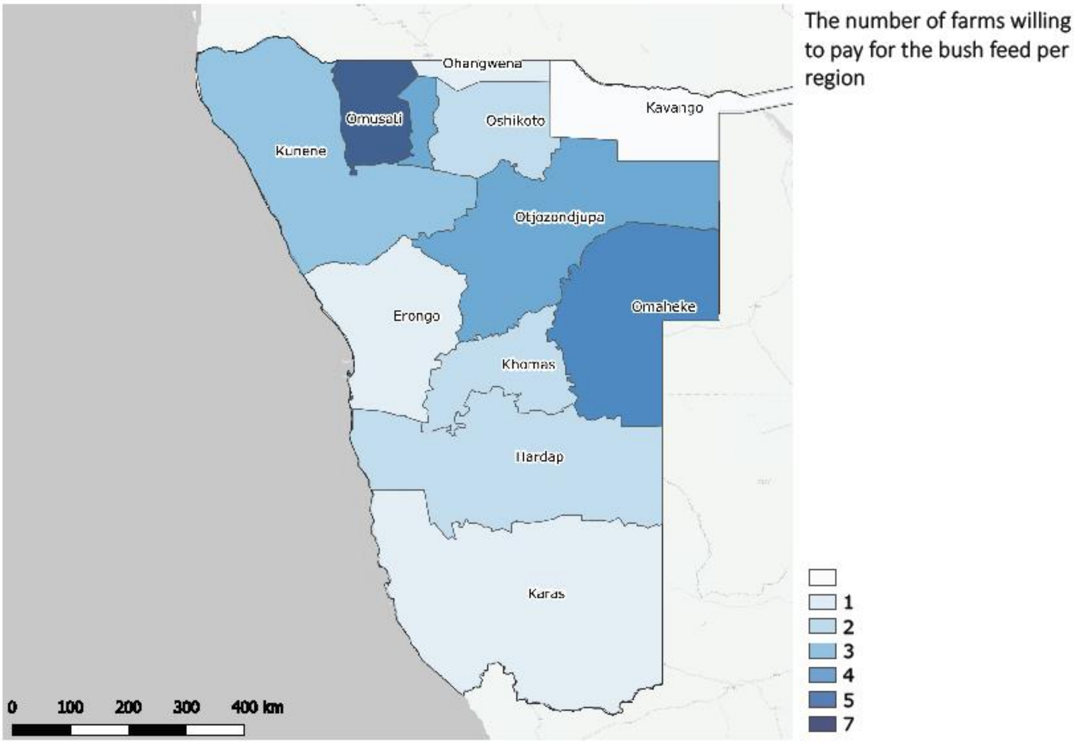
4.2 Methodology

4.2.1 Data collection and study design

Firstly, a questionnaire was designed to collect data on the Farmers' Willingness To Pay (WTP). Survey monkey was used to disseminate the questionnaire to different farmers around Namibia. Survey monkey is a faster, simpler, and cheaper online survey method that is used to collect information from individuals in a systematic way. An online survey was used because it was seen as the method that could reach a wide range of farmers. This study was also subjected to time constraint and given the fact that the exact locations of the farms were not known, there was no time to identify the location of farmers and meet them. Thus, an on line survey was seen to be a better way to reach all farmers. However, the implications of this method are that farmers that do not have access to internet may not access the survey and therefore will not be included in the survey. The information about the survey was advertised in different communication media such as farmers' blogs and farmers' groups on Facebook. The link to the survey was also directly emailed to individually known farmers, in order to attract as many respondents as possible. The survey ran for a period of 5 months. Due to financial constraint subjected to the study, constant advertisement of the survey could not be done. Unfortunately, there was a low rate of response on the survey. A key informant questionnaire was then administered to farmers that the researcher deemed knowledgeable about animal feed and what the new bush-feed could mean to their animals.

A Contingence Valuation (CV) method was used where the researcher formulated a hypothetical market scenario which was described to the survey respondents, a sample of the bush-feed was also displayed to the farmers and all ingredients in the feed was given and explained. The farmers were then asked if they are willing to pay for the bush-feed, and how much they were willing to pay if the product was to be made available on the market. There are over 6000 livestock farms in Namibia (Namibia Statistic Agency, 2015) revised in 2019, due to financial constraints, the study could only get a total sample size of 33 respondents from both the online survey and key informant interviews of which 18 were from the online survey while 15 were from the key informant questionnaires administered by the researcher. The key informant questionnaire was made up of 16 questions; the first question was on the demographic information followed by questions about the number of animals the farmer owns; the type of animal feed they bought and at what price, transportation cost and most importantly, the willingness to pay for the bush-feed pellets. Appendices 19 and 20 display the online survey and key informant questionnaires respectively.

Out of the total 14 regions in Namibia, 11 regions were represented in the study. Figure 10 indicate that 1 represent the regions with the least number of respondents and 7 being the most represented regions. The different regions represented by respondents in the study are: Kunene, Omusati, Oshana, Ohangwena, Omaheke, Otjozondjupa, Karas, Khomas, Erongo, Hardap and Otjozondjupa (Figure 10). Kavango region had the least number of respondents while Omusati had the greatest number of respondents



Source: own source

Figure 10: The survey respondents by regions

The completed survey data was printed out and farmers that omitted some questions were called and the questions were explained to them and asked to answer again.

4.2.2 Data cleaning and removing outliers

Both the survey and the key informant questionnaire data was cleaned to iron out any errors or inconsistencies. The data was then carefully entered into SPSS version 21. Outliers were identified using a box plot. The outliers were then removed before analyses were done. Appendices 21 and 22 indicate the box plot before and after deleting the outliers.

4.2.3 Data analyses

To determine the market interest of bush-based feed pellets, farmers' willingness to pay was determined. The economic value of a good to a person or a household under given conditions is known as WTP (Gunatilake, Yang, Pattanayak & Choe, 2007). Descriptive statistics (percentages and mean), were used to analyse the data in the Statistical Package for the Social Sciences (SPSS) version 21.

WTP was illustrated using a demand curve (Figure 11). A demand curve represents all the different potential quantities of a good available and the WTP of consumers for each quantity. Willingness to pay can vary for individual consumers, depending on their personal assessment of the value of a product or service. The total willingness to pay for quantities of goods is the area under the demand curve (grid plus the shaded area). The total amount actually paid for, for a certain quantity in a competitive market however is the shaded area. The difference between the two areas is known as the consumer surplus which is grid area.

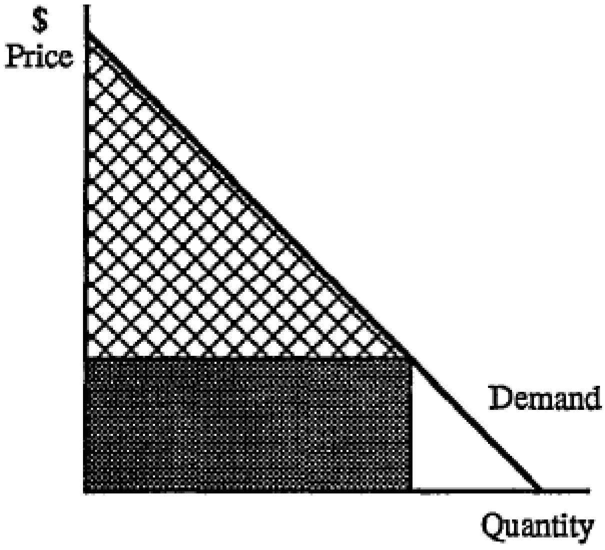


Figure 11: Willingness to pay and the demand curve
Source: Hoffman & Matthew (1993)

The next section gives an account of the study findings and their detailed discussion. A descriptive summary of what the farmers are willing to pay for the bush-based pellets compared to the market price will be thoroughly explained.

4.3 Results and discussion

4.3.1 Descriptive statistic results

For each variable there are two tables, the first table indicates the average value that farmers are willing to pay which is provided by the mean. The second table displays the frequency distribution of the number of farmers that are willing to pay for the market price of the bush-feed, which is N$247.50 per 50 kg bag. It is based on the dummy dependent variable which takes a value of 0 when the farmer is not willing to pay the market price or above and 1 when the farmer is willing to pay the market price or greater than.

4.3.1.1 Farmers willingness to pay for the bush feed

After the outliers were removed, a sample size of 30 respondents was left which was used in the analysis. The current average market price for bush-feed is around N$4.95 per kg (2018 price). The descriptive statistic results of the study indicate that farmers were willing to pay an average price of N$173.07 per 50 kg bag, which is N$3.46 per kg (Table 14). The average WTP result seem to suggest that farmers are willing to pay less than the market price for bush-feed. The individuals' lowest and highest WTP amounts of N$ 75 and N$ 302 were recorded. To get the lowest and highest amount that the farmers were collectively willing to pay the standard deviation was subtracted and added to the mean respectively. Hence, the minimum amount that the farmers were willing to pay was N$108.55 and the maximum N$237.54. The low standard deviation suggest that more farmers are willing to pay the prices around the mean which range from N$108.55 to N$237.54 gives the 95 percent confidence interval for the WTP.

During the study, it was established that the farmers felt like the current feed market price is too high, especially lucerne which costs about N$2.30 per kg for a 40 kg bale, these prices were based on Agra 2018 prices (Agra Limited is Namibia's leading agricultural industry player, providing agricultural and industry related products and services to Namibian producers and major industry players). Farmers have to buy hundreds of these to be able to have enough for the animals. In addition, lucerne bales have to be bought with other feed supplements such as salt, protein and phosphorus depending on the time of the year. Farmers indicated that during the dry seasons, feed prices increase drastically with lucerne costing about N$5 per kg for a 40 kg bag (Agra, 2018). During this time, the range have a deficient forage supply due to low rainfall, thus farmers depend on purchased livestock feed. Farmers lose a lot of cattle to drought due to the fact that they can't afford the feed for their animals. The bush-feed on the other hand is a complete feed which may not need to be fed with supplements or supplementation will be minimal because supplement nutrients are already incorporated in the feed. Thus, the farmers feed cost may be reduced. However, farmers are sceptical about the bush-based feed hence the low WTP. Farmers indicated that they will only pay the market price when they test the feed themselves and are certain of its effectiveness to their animals.

Table 13: Descriptive statistic results for the depended variable Willingness to pay for bush-feed

Descriptive Statistics

	N	Minimum (N$)	Maximum (N$)	Mean (N$)	Std. Deviation
WTP BUSH	30	75	302	173.07	64.472

The frequency distribution of the willingness to pay indicate that only 20% of the respondents were willing to pay above the market price of N$ 247.5 per 50 kg bag of bush-feed while a high percentage of 80% were willing to pay below the market price (Table 15). Considering that bush-based feed is relatively a new concept in Namibia, this result could be due to the lack of knowledge about bush-feed. Many farmers have not tried the product yet hence they are sceptical about it, this subsequently creates doubt for the farmers about the effectiveness of the bush-feed to the animals. During the interviews conducted, farmers mentioned that they will only pay the market price when they are sure about the product.

Table 14: F**requency distribution of the farmers and their willingness to pay for the bush-feed**

Willingness to pay

		Frequency	Percent (%)
1= WTP market price or grater 0= otherwise	0	24	80.0
	1	6	20.0
	Total	30	100.0

4.3.1.2 Willingness to pay and age

The results of descriptive statistical analysis of the willingness to pay with regards to age shows that out of the total number of farmers, 80% of the respondents were young farmers that were less than the age of 50, while farmers that were older than 50 years were only 20% (Table 16). The mean for farmers less than 50 years old was 173.84 while that of older farmers was 170. This result was expected and it suggests that younger farmers are willing to pay more for the bush-feed compared to older farmers.

Considering the fact that an online survey was used for part of the data for this study, it could be that the outcome for these results was due to the fact that the older farmers did not have access to the survey because they are not so keen about using new technology very much. Younger farmers are more open minded to adopting new innovations compared to older farmers who most of the time believe in their life time experience instead of new ideas. In a study by Chi & Yamada (2002), on factors affecting farmers adoption to innovation, it was found that farmers older than 40 years do not adopt new innovations as they did not believe in new technology and only believe in their own experience.

The results for this study suggested that the average price that all the age groups were willing to pay was less than the market price. The highest and lowest mean for WTP was recorded in the farmers that were over the age of 50, with the lowest mean of 123.33 recorded in the age group 50-59, while the highest mean of 216.67 was recorded for the farmers over the age of 60. The results for the age group 50-59 which had the lowest mean was expected as older farmers are known to pay less for new innovations as compared to younger farmers. However, other studies also suggested that due to older farmers' accumulated experience, it helps them to make early willing to pay decisions in order to save their animals (Gonfa, 2015), which explains the high mean for the age group 60+. John *et al.,* (2017) also found that there was a positive relationship between WTP and age, the older the farmers, the more they were willing to pay for extra pellet fertilizer.

Table 15: The WTP with respect to age of farmer

Descriptive Statistics

Age		N	Minimum (N$)	Maximum (N$)	Mean (N$)	Std. Deviation
30-39	WTPBUSH	12	100	302	164.75	64.750
40-49	WTPBUSH	12	100	300	182.92	62.902
50-59	WTPBUSH	3	75	165	123.33	45.369
60+	WTPBUSH	3	150	300	216.67	76.376

The frequency distribution indicates that out of the total 80% of the younger farmers (less than 50 years old) that were willing to pay for the bush feed, 41.7% were willing to pay above the market price (N$247.5 per 50 kg bag). Only 33% of older farmers were willing to pay above the market price with all of them being above the age of 60 (Table 17)

Table 16*: The distribution of farmers that are willing to pay above the market price with respect to their age*

		Willingness to pay		
Age			Frequency	Percent
30-39		0	10	83.3
		1	2	16.7
		Total	12	100.0
40-49		0	9	75.0
		1	3	25.0
		Total	12	100.0
50-59		0	3	100.0
60+		0	2	66.7
		1	1	33.3
		Total	3	100.0

1= WTP market price or greater

0= otherwise

4.3.1.3 Willingness to pay and education level

The descriptive statistics results for the willingness to pay with respect to education level indicated that only 16.66% of the farmers had secondary education and 83% of the farmers received tertiary education (Table 18). The results indicated that the recorded means for both levels of education were below the average market price of bush feed (N$ 247.5 per 50 kg bag). It was found that farmers with tertiary education were willing to pay more for the bush-feed compared to the farmers with only secondary education. Farmers with tertiary education had a mean of N$ 182.68 while those with secondary education had a mean of N$ 125. This was expected because considering the fact that an on line survey was used, most farmers who would have access to the survey or those that are literate enough to use the internet were those with high level of education. The more educated farmers are also expected to have better access to information because education enables farmers to have access to new information and idea. Chi & Yamada (2002) found that level of education was positively related to farmers' adoption to technologies in agriculture. In their study, Makdisi & Marggraf (2011) also found that university education level had a positive significant effect on consumer willingness to pay for farm animal welfare. The low standard deviation associated with secondary educated farmers implies that most farmers in this category were willing to pay close to the mean price of the bush feed.

Table 17: The effect of education level on the willingness to pay of farmers for the bush feed

Descriptive Statistics

Education Level		N	Minimum (N$)	Maximum (N$)	Mean (N$)	Std. Deviation
Secondary	WTPBUSH	5	100	175	125.00	35.355
Tertiary	WTPBUSH	25	75	302	182.68	65.090

The frequency distribution of farmers that were willing to pay for the market price or above showed that only tertiary educated farmers were willing to pay the market price and above. This could be due to the reason mentioned above, that the more educated farmers may have better access to information and new ideas. Out of the total tertiary educated farmers only 24% were willing to pay above the market price (Table 19). This could be because the bush-feed product is relatively new and farmers are sceptical about its effectiveness. During the interviews, some farmers raised concerns that it is hard to pay a lot of money for a product that they have not tested out yet. Researchers such as Rajiv (2010) concluded that WTP of farmers for livestock feed depends on the fulfilment of the feed requirements or better yet on the productivity of the livestock feed which is determined by the animal's productivity. Awareness about bush-based feed need to be created, this can be done by hosting seminars and excursions to producers that have done feeding trials. Seeing the animals that are fed with the product may convince farmers to increase their willingness to pay for the bush-based feed.

Table 18: Frequency distribution of farmers that are willing to pay the market price or above for the bush feed with respect to their level of education

Willingness to pay				
Education Level			Frequency	Percent
Secondary		0	5	100.0
Tertiary		0	19	76.0
		1	6	24.0

1= WTP market price or greater

0= otherwise

4.3.1.4 Farmers willingness to pay and number of cattle they own

The total number of cattle that a farmer owns was expected to increase the farmers' WTP (Gonfa, 2015). Research result reported by Tesfaye & Alemu (2001) confirmed that livestock holding has a positive influence on adoption of new innovations. This literature goes hand in hand with the descriptive findings of this study which indicated that the mean of the willingness to pay for the bush-based feed increased with the number of cattle a farmer owned, with the lowest mean of N$152.78 recorded in farmers that had cattle in the range of 1-50 while the highest mean was associated with the farmers that owned cattle in the range of 251-300 (Table 20). The results imply that farmers with more cattle were willing to pay the most. This is logical because these farmers have more to lose and are able to risk paying more for the feed to avoid losing their animals which may reduce their income.

The descriptive results on the willingness to pay and the number of cattle a farmer owns (Table 21) indicate that out of 30 farmers, the majority of farmers (18) (60% of the total respondents) had number of cattle in the range of 1-50, followed by the farmers (8) with 51-100 number of cattle who took up 26.66% of the total farmers. While farmers (2) that had cattle that ranged from 101-200 and 251-300 both covered 6.66% each.

Table 19: The mean WTP associated with the number of cattle owned by farmers

Descriptive Statistics

Number of cattle		N	Minimum (N$)	Maximum (N$)	Mean (N$)	Std. Deviation
1-50	WTPBUSH	18	75	300	152.78	60.591
51-100	WTPBUSH	8	125	250	186.25	46.809
101-150	WTPBUSH	2	200	300	250.00	70.711
251-300	WTPBUSH	2	150	302	226.00	107.480

The frequency distribution on the other hand indicate that the majority of farmer that are willing to pay the market price or above are those with fewer cattle (Table 20). It should however be noted that even though the majority of farmers with fewer cattle are willing to pay the market price or above, they still did not pay a price higher than those with more cattle (Table 21).

Table 20: The frequency distribution of the number of farmers that are willing to pay the market price or above with respect to the number of cattle they own

Willingness to pay				
Number of cattle			Frequency	Percent
1-50		0	16	88.9
		1	2	11.1
		Total	18	100.0
51-100		0	6	75.0
		1	2	25.0
		Total	8	100.0
101-150		0	1	50.0
		1	1	50.0
		Total	2	100.0
251-300		0	1	50.0
		1	1	50.0
		Total	2	100.0

4.3.1.5 Willingness to pay and location of the farm

This variable was segregated in terms of the Namibian Veterinary Codon Fence (VCF), also known as the red line. For the purpose of this study, it is believed that the market of cattle north and south of the VCF differs, and this may affect the farmer's willingness to pay for the bush feed or animal feed in general. The VCF was established to attain animal disease free status. However, it divides the country into 2 regions, benefiting farmers south of the VCF. The farmers south of the VCF are allowed to export directly to the lucrative European Union market.

The result of the study shows that both farmers north and south of the VCF had the mean WTP less than the market price, indicating that they were willing to pay less than the market price for the bush-based feed. The results also show that 60% of the respondents were from the north of the VCF while only 40% were from the south of the VCF. As expected, farmers north of the VCF are willing to pay less compared to the farmers south of the VCF. This is evident in the results that show the mean of N$170.39 for the NVCF farmers while the SVCF farmers had a mean of N$177.08 (Table 22). During the interview that was conducted by the researcher with farmers north of the VCF, farmers expressed frustrations that they do not have direct access to the lucrative beef market. The animals from the northern VCF are quarantined for 21 day only to be sold to regional destination, these farmers are not motivated enough to invest in their cattle as there is no access to the market for their cattle hence the low mean. The farmers north of the VCF further engage more into crop farming compared to livestock farming. Given the reasons above, it is surprising that the minimum WTP price was recorded by the farmers south of the VCF while the maximum WTP prices was recorded north of the VCF. This could be because of the small sample size, if more farmers were to be included in the study the results might have been the opposite.

Table 21: results for the effect of the location of farmers on their WTP

Descriptive Statistics

Location of farm		N	Minimum (N$)	Maximum (N$)	Mean (N$)	Std. Deviation
North VCF	WTPBUSH	18	100	302	170.39	66.817
South VCF	WTPBUSH	12	75	300	177.08	63.477

Out of the total respondents from north of the VCF, only 22.2% were willing to pay the market price of N$ 247.50 per 50 kg bag and above. Those from the south of the VCF, 16.7% of the total were willing to pay the market price and above (Table 23). Similar to the number of cattle variables, the majority of the farmers willing to pay the market price of the bush feed and above farm north of the VCF. Farmers south of the VCF were willing to pay a higher price as indicated by the mean WTP in (Table 22).

Table 22: The frequency distribution of the farmers that are willing to pay the market price or above with regard to their location

Willingness to pay

Location of farm			Frequency	Percent
North VCF	Valid	0	14	77.8
		1	4	22.2
		Total	18	100.0
South VCF	Valid	0	10	83.3
		1	2	16.7
		Total	12	100.0

4.3.1.6 Farmers engagement in off farm activities

The descriptive statistic results indicate that 90% of the farmers were engaged in off farm activity while only 10% were full time farmers (Table 23). Off-farm activities such as university lecturing and government employment were indicated. The high percentage of response from farmers who engage in off farm activities could be attributed to the fact that they have access to internet and computers at the work place and hence, access to the online survey compared to the full time farmers who most of the time live on the farm where there could be no reception for internet. The assumption of this variable was that farmers who are engaged in off farm activities were expected to pay more for the bush feed. Pender & Kerr (1998); Holden & Shiferaw (2002) stated that off-farm income is expected to have a positive influence on WTP for new technology, given the assumption that diversification out of agriculture would enable households to earn income, thereby easing the liquidity constraint needed to invest in new technology. Olaleye (2010) also stated that off farm activity was one of the coping mechanisms to reduce the dependency of farmers on farm income.

In this study however, the mean for the farmers that are not engaged in off farm activities was seen to be higher than those that are full time farmers. The farmers who did not engage in off farm activities had a WTP mean of N$217.33 while those who engaged in off farm activities was N$168.18 (Table 24). This suggested that farmers that were engaged in off farm activities were willing to pay less compared to those with off-farm activities. This result contradicts with findings from literature. The results for this outcome could be because full time farmers are more involved in farming as farming is the main part of their income and hence sacrifice more money for the survival of their animals, and therefore they will pay more compared to part time farmers.

Table 23: The effects of being engaged in off farm activities to generate income on the willingness to pay

Descriptive Statistics

OFF-FARM INCOME		N	Minimum (N$)	Maximum (N$)	Mean (N$)	Std. Deviation
No	WTPBUSH	3	150	302	217.33	77.468
Yes	WTPBUSH	27	75	300	168.15	62.637

The frequency distribution indicates that majority of the farmers that are willing to pay the market price or above are those that engage in off-farm activities. This could be because they are the majority of the respondents as only 10% of the farmers were not engaged in off farm activities.

Table 24: The frequency distribution of the willingness to pay of farmers for the market price or above with respect to whether they engage in off farm activities or not

			Willingness to pay	
OFFINCO			Frequency	Percent
No		0	2	66.7
		1	1	33.3
		Total	3	100.0
Yes		0	22	81.5
		1	5	18.5
		Total	27	100.0

4.3.1.7 Willingness to pay and type of farmer

The results indicated that the commercial farmers were willing to pay more for the bush feed compared to the communal farmers. This was evident from the mean WTP of N$226 for the commercial farmers and N$169.29 for the communal farmers (Table 26). The lowest price that the farmers are willing to pay was recorded for communal farmers while the highest was from the commercial farmers.

Commercial farmers farm for profit, it is therefore logical that they are willing to pay more for the bush-based feed to ensure the well-being of their animals. According to Masika (1994) animals in commercial farmers are fed more compared to communal farmers, this explains the results. The reason for communal farmers having a low WTP mean could be that communal farmers let their animals graze on the range and they don't spend so much into raring high-quality animals because they don't farm to make profit. However, considering that only 6.66% of the total respondents were commercial farmers, the result could be biased.

Table 25: The effects of the type of farmer to their willingness to pay for the bush feed

Descriptive Statistics

Type of farmers		N	Minimum (N$)	Maximum (N$)	Mean (N$)	Std. Deviation
Commercial	WTPBUSH	2	150	302	226.00	107.480
Communal	WTPBUSH	28	75	300	169.29	61.760

The communal farmers were the majority in this study; hence the majority are the ones willing to pay for the bush feed. Out of the total number of communal farmers that are willing to pay for the bush feed, only 17% are willing to pay the market price (Table 27).

Table 26: The frequency distribution for the farmers willing to pay the market price and above with respect to the type of farming they are into

Willingness to pay

Type of farmers			Frequency	Percent
Commercial		0	1	50.0
		1	1	50.0
		Total	2	100.0
Communal		0	23	82.1
		1	5	17.9
		Total	28	100.0

4.4 Conclusion and recommendation

The second objective for this study was to determine the market availability of the bush-based feed pellets by conducting a willingness to pay (WTP) assessment of farmers for the proposed bush-based feed. This study had a sample size of 33 respondents of which 18 were from an online survey while 15 were from a key informant questionnaire administered by the researcher. After outliers were removed from the data, only the 30 remaining respondents were used in the analyses.

The results suggest that the farmers were interested in the bush-based pellets as all respondents were willing to pay for the pellets. However, farmers were willing to pay N$173.03 per 50 kg bag which was below the bush-based market price of N$247.50 per 50 kg bag. The frequency distribution table revealed that only 20% of the total farmers were willing to pay above the market price. This suggests a low off take for the bush-based pellets. The reasons for farmers paying lower than the market price was according to farmers, that they would like to test the effectiveness of the feed first, for them to determine whether or not the feed works for their animals, then only will they pay more than the market price. The farmers also seemed not to be aware of the bush-based feed.

The descriptive results indicated that younger farmers were willing to pay more for the bush-based feed compared to older farmers. The results further seem to suggest that formally educated farmers with a tertiary education were willing to pay more compared to the less educated farmers with just a secondary education. The survey did not capture any farmers who had less than a secondary education. Farmers who had a large herd of cattle were also found to pay more for the bush-based pellets compared to those with less cattle. Farmers that are located south of the veterinary cordoned fence also seemed to pay less compare to those north of the veterinary cordoned fence.

This study recommends that: there should be programs put in place to create awareness about the bush-based feed. The researcher is of the belief that if awareness is created, it will increase the market interest and availability of the bush-based pellets. Namibia receive most of its agriculture-based national income from beef exportation hence, investment in the bush-based feed production is required. Locally produced animal feed may help reduce the current high feed market price that beef producers are suffering from. Funding is also required in order to have a more detailed research on the WTP of the bush-based feed as due to financial constraint for this study, an appropriate sample size could not be achieved.

Chapter 5: General summary, conclusion and recommendation

5.1 Viability of bush-based feed production and market availability of bush-based pellets

The main objective for this study was to conduct a financial analysis for the production of bush-based pellets from an encroacher *Senegalia mellifera* bush. The two specific objectives were to conduct a cost benefit analysis that will determine the viability of the production and to determine the market interest of the bush-based feed by using a willingness to pay model. The study observed two methods of producing bush-based pellets, a highly mechanized and a manual production system.

A Cost Benefit Analysis (CBA) model was used to determine the viability of the two scenarios of the production of encroacher bush-based feed, components of CBA used in this study are Net Present Value (NPV) and Benefit Cost Ratio (BCR). The results for this study showed a positive discounted NPV of N$ 73,965,835.43 and a BCR of 2.28 for the highly mechanized method while the manual method had a NPV of N$62,086,180.39, and a BCR of 2.66. This results are consistent with the rule of viability by different researchers such as, (Commonwealth of Australia, 2006; Gabriella, 2015; Boardman, 2015; Couture *et al*, 2016), which states that for a project to be considered viable, it should have a positive NPV, and a BCR that is greater than 1.

A project that met the above-mentioned requirements generally indicate efficient use of the resources. Research also indicated that in cases were two projects are compared, one should adopt the project with the highest NPV (Gabriella, 2015). For this study the choice of which method to adopt depends on the farmer and the resources at hand. The manual method is more suitable for small scale farmers while the highly mechanized is suitable for large scale farmers thus they are not comparable.

Since the bush-based feed production was a relatively new practice, it was important to determine the farmers' Willingness To Pay (WTP) for the bush-based feed which will determine the market availability and interest of the product. The results suggested that the market availability of the bush-based feed exist, with the farmers WTP of about N$173.07 for a 50 kg bag, it was however revealed that most farmers are not willing to pay the market price which was N$247.50 per 50 kg bag (Dresselhaus, 2018; Bussy, 2018). The reason behind the low WTP could be that the product is fairly new and most farmers are still sceptical about its effectiveness. Farmers indicated that they will only be able to pay more once they are more familiar with the product. Another reason could be because of the small sample size for a cross-sectional data. A sample size of 32 was used for this study.

A positive discounted Net Present Value and a Benefit Cost Ratio that was greater than 1 in both methods proved that the production was viable and is worth investing in. the result indicated however that the worst-case scenario for the mechanise method of production was not viable. The cost of producing bush-based pellets was calculated to be N$ 1.05 and N$ 1.27 for the mechanized and manual production system respectively, this was found to be lower than the cost of feed in the market which range from N$2-N$5 per kg. This implies that it is more economical for farmers including Neudamm farm to venture into bush-based feed production in order to reduce the cost of buying feed.

Due to high investment cost of the highly mechanized production, the researcher recommends that upcoming and small-scale producers adopt the manual method of production. The study also found that there are farmers who are interested in bush-based pellets, however awareness about the benefits of the pellets need to be created for them, only then will they be more willing to pay the market price for the pellets and this will increase the market uptake of the bush-based pellets.

In the case of this study, it could not be said for certain that all the respondents from the online survey understood the value of bush-based feed. The researcher was however confident that the respondents from the key informant questionnaire understood as they were deemed expert farmers and understood the importance of the feed to their animals. Producing bush-based feed will combat the problem of bush encroachment in Namibia while reducing the animal feed market price. A reduction in animal feed cost could boost the beef market thus increasing national income. Therefore, investment in the bush-based feed production is highly recommended. It is also recommended for government to provide encroacher-bush harvesting programs which may help farmers with the high investment cost that are associated with de-bushing equipment.

5.2 Farmers willing to pay for the bush-based pellets

It was determined in this study that there is a direct relationship between the number of cattle a farmer owned and the famer's WTP decision. This was evident in the descriptive statistic results in which farmers with more cattle were willing to pay more for the bush-based feed compared to those with less cattle. It is therefore recommended that it will make economically sense for bush-based feed producers and investors to target the farmers with large numbers of cattle when selling the feed as they have more to lose in the situation of animal feed scarcity.

The results also showed that farmers situated South of the Veterinary Cordoned Fence (SVCF) were willing to pay more for the bush-based feed as compared to those North of the Veterinary Cordoned Fence (NVCF). The results also showed that the farmers SVCF had more of cattle compared to those NVCF. Hence, this study recommend that bush-based feed investors set up production SVCF as they are more sensitive to animal feed scarcity and this will make business sense.

The descriptive statistic results also suggested that commercial farmers were willing to pay more for the bush-based feed compared to the communal farmers. Commercial farmers' main interest is to make a profit thus it makes business sense for them to invest more into their animals to reduce the risk of losing them. This study recommend that bush feed producers target the commercial farmers.

Further research is needed on the standard recipe formulation, considering that the sample size for this study was small, a detailed study is needed on the Willingness To Pay for the bush feed. Documentation on success stories about bush feed is also need, this may increase farmer's adoption to bush-feed.

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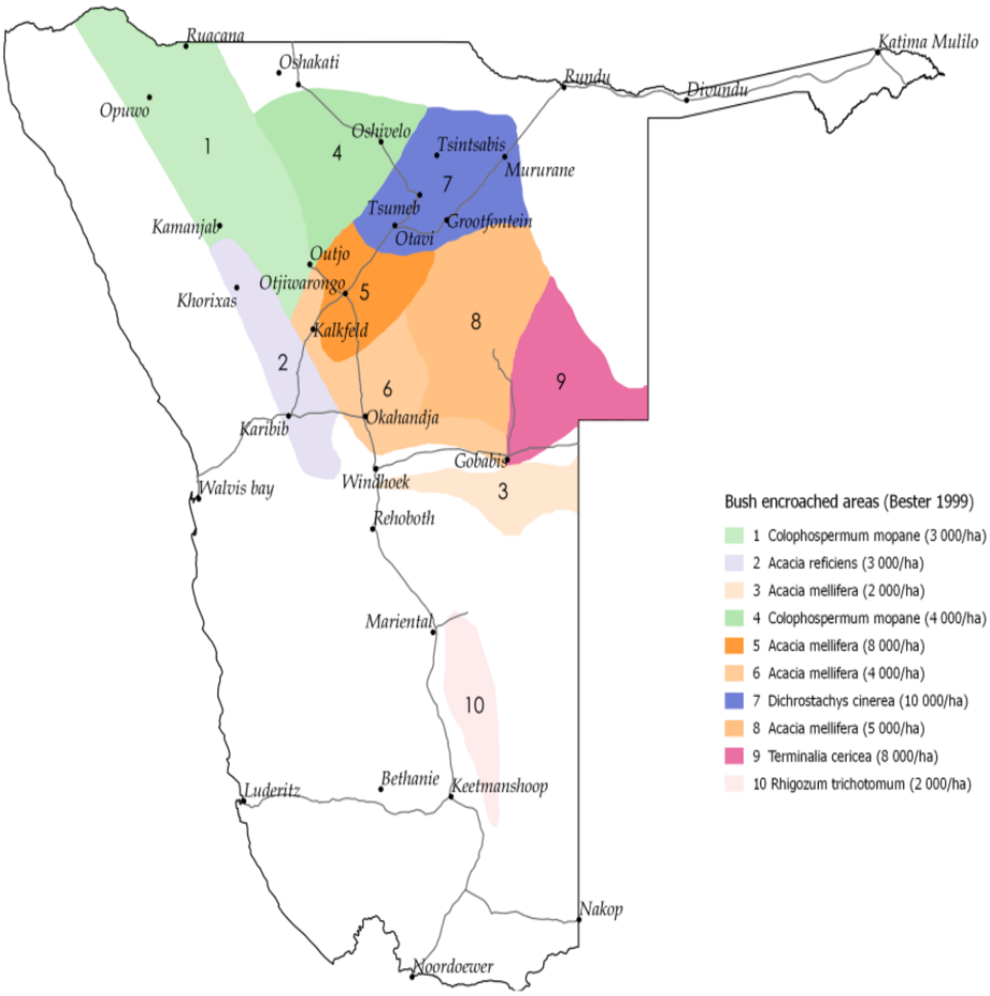
Appendices

Appendix 1: Bush encroached areas and bush density in Namibia



Source: Bester (1999) and Honsbein *et. al*., (2009)

Appendix 2: Declining balance method of depreciation calculations.

		Depreciation calculation using a declining balance method									
		DB(Cost,Salvage,life,period [month])									
Assumption; all machines were bought the first day of january											
Pelletising machine		Hammer Mill		Wood Chipper		Tractor		front end cutter			
slavage value	sv=(cost(1-l)^life										
Depreciation rate	6,666666667										
Cost	378 600	36 000		278 000		262 600		3247000			
Salvage value	134647,27	12803,23		98869,36		93392,43		1154779,96			
Life period	15	15		15		15		15			
Year	Depreciation expense	Year	Depreciationexpense	Year	Depreciation expense	Year	Depreciation expense	Year	Depreciation expense	Total annual dp mechanized	Total annual dp Manual
1	25366,20	1	2412,00	1	18626,00	1	17594,20	1	217549,00	281547,40	63998,40
2	23666,66	2	2250,40	2	17378,06	2	16415,39	2	287789,64	347500,15	59710,51
3	22081,00	3	2099,62	3	16213,73	3	15315,56	3	189374,01	245083,91	55709,90
4	20601,57	4	1958,94	4	15127,41	4	14289,42	4	176685,95	228663,29	51977,34
5	19221,27	5	1827,70	5	14113,87	5	13332,02	5	164847,99	213342,85	48494,86
6	17933,44	6	1705,24	6	13168,24	6	12438,78	6	153803,18	199048,88	45245,70
7	16731,90	7	1590,99	7	12285,97	7	11605,38	7	143498,37	185712,61	42214,24
8	15610,86	8	1484,39	8	11462,81	8	10827,82	8	133883,97	173269,86	39385,89
9	14564,94	9	1384,94	9	10694,80	9	10102,36	9	124913,75	161660,78	36747,03
10	13589,08	10	1292,15	10	9978,25	10	9425,50	10	116544,53	150829,51	34284,98
11	12678,62	11	1205,57	11	9309,71	11	8793,99	11	108736,04	140723,93	31987,89
12	11829,15	12	1124,80	12	8685,96	12	8204,79	12	101450,73	131295,43	29844,70
13	11036,60	13	1049,44	13	8104,00	13	7655,07	13	94653,53	122498,63	27845,10
14	10297,14	14	979,13	14	7561,03	14	7142,18	14	88311,74	114291,23	25979,48
15	9607,24	15	913,52	15	7054,44	15	6663,66	15	82394,86	106633,71	24238,86
	244815,66		23278,83		179764,28		169806,11		2184437,30	2802102,18	617664,88

Appendix 3: Bush feed recipe feed proportion

MECHANIZED SCALE

Ingredients	Kg	percentage
bush	336,65	44%
Maize	102	13%
Ammonium sulphate	9	1%
maize bran	72,121	9%
Kalorie300	12,5	2%
Salt	50	7%
Molasses	165	22%
Sulphur	5	1%
Urea	9,1	1%
PEG 6000	0,59	0%
	761,96	100%

MANNUAL SCALE

Ingredients	Kg	Percentage
bush	220,40	44%
Maize	65,00	13%
Ammonium sulphate	5,00	1%
Maize bran	45,00	9%
Salt	35,00	7%
Molasses	110,00	22%
Calorie 300	10,00	2%
Sulphur	3,30	1%
Urea	5,90	1%
PEG 6000	0,40	0%
Total PC	500,00	100%

Bush feed alone does not have value. To improve the nutritional content and palatability, ingredients are added. Above is a standard feed formulation for bush feed for a highly mechanized and manual scale used in this study.

Appendix 4: The annual pellets production for a mechanized scale

Assumption					
Current Carrying capacity(h/LSU)	10				
Total number of animals on the farm	519				
Average LW	473				
Total farm hectares	10177				
BENEFITS					
sales of pellets	kg/month	kg/year(12 months)	ave. price /kg(N$)	off take /year	total benefit/year
production	91435,2	1097222,4	4,95		5431250,88
increased carrying capacity (after 33% de-bushing) double after the 4th year			36,63	172	2980070,28
total Benefits					8411321,16

The monthly production was 91435.2 kg and when it was multiplied by 12 moths it gave a total annual pellets production of 1, 097, 222, 40 kg. The benefits from pellets production when it was multiplied with the market price (N$ 4, 95) was N$ 5,431,250.88 while the actual benefit before increased carrying capacity (off take x cattle live weight price N$36.63) was 2,980,070.28.

Appendix 5: Benefits calculations for a manual production system

BENEFITS					
sales of pellets	kg/month	kg/year(12 months)	ave. price /kg	off take /year	total benefit/year
production	50000	600000	4,95		2970000
increased carrying capacity (after 33% de-bushing) double after the 4th year		36,63		172	2980070,28
total					5950070,28

The monthly production was 50 000 kg and when it was multiplied by 12 moths it gave a total annual pellets production of 600 000 kg. The benefits from pellets production when it was multiplied with the market price (N$ 4, 95) was N$ 2,970,000 while the actual benefit before increased carrying capacity (off take x cattle live weight price N$36.63) was 2,980,070.28.

Appendix 6: Incremental benefits from sales of pellets for a mechanized scale

	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	year 11	year 12	year 13	year 14	year 15
Increased carrying capacity	**100%**	**133%**	**167%**	**200%**	**233%**	**277%**	**300%**	**333%**	**366%**	**400%**	**433%**	**466%**	**500%**	**533%**	**566%**
Offtake per year	**172**	**229**	**287**	**344**	**401**	**476**	**516**	**573**	**630**	**688**	**745**	**802**	**860**	**917**	**974**
Benefits from carrying capacity	**2980070,28**	**3963493,47**	**4976717,37**	**5960140,56**	**6943563,752**	**8254794,68**	**8940210,84**	**9923634,032**	**10907057,2**	**11920281,12**	**12903704,31**	**13887127,5**	**14900351,4**	**15883774,6**	**16867197,8**
benefits from pellet sales	**5431250,88**	**5974375,97**	**6571813,56**	**7228994,921**	**7951894,413**	**8747083,85**	**9621792,24**	**10583971,46**	**11642368,6**	**12806605,47**	**14087266,02**	**15495992,6**	**17045591,9**	**18750151,1**	**20625166,2**
total incremental benefits	**8411321,16**	**9937869,44**	**11548530,93**	**13189135,48**	**14895458,17**	**17001878,53**	**18562003,08**	**20507605,50**	**22549425,84**	**24726886,59**	**26990970,33**	**29383120,13**	**31945943,28**	**34633925,66**	**37492363,96**

The sales of pellets were assumed to increase by 10% annually. This is due to efficiency from specialization and potential economies of scale.

Appendix 7: Incremental benefits for pellet sales for a manual method of production

	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	year 11	year 12	year 13	year 14	year 15
Increased carrying capacity	100%	133%	167%	200%	233%	277%	300%	333%	366%	400%	433%	466%	500%	533%	566%
Offtake per year	172	229	287	344	401	476	516	573	630	688	745	802	860	917	974
Benefits from carrying capacity	2980070,3	3963493,5	4976717,368	5960140,56	6943563,752	8254794,68	8940210,84	9923634,032	10907057,2	11920281,12	12903704,31	13887127,5	14900351,4	15883774,59	16867197,78
benefits from pellet sales	2970000	3267000	3593700	3953070	4348377	4783214,7	5261536,17	5787689,787	6366458,77	7003104,642	7703415,106	8473756,617	9321132,279	10253245,51	11278570,06
total incremen tal **benefit**	5950070,3	7230493,5	8570417,368	9913210,56	11291940,75	13038009,4	14201747,01	15711323,82	17273516	18923385,76	20607119,42	22360884,12	24221483,68	26137020,1	28145767,84
total incremen tal **cost**	3775011,60	3948662,13	4130300,59	4320294,42	4519027,96	4726903,25	4944340,80	5171780,47	5409682,38	5658527,77	5918820,04	6191085,76	6475875,71	6773765,99	7085359,23

The sales of pellets were assumed to increase by 10% annually. This is due to efficiency from specialization and potential economies of scale

Appendix 8: Annual incremental cost and benefit for the worst case scenario (mechanized scale)

Mechanized method worst case scenario	
Avarage live weight	473
Avarage carcass weight	245,35
price/kg (N$)	27,3
annual increase on sales	10%
cost increases with	17%

	year 1	year2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	year 11	year 12	year 13	year 14	year 15
Increased carrying capacity	100%	133%	167%	200%	233%	277%	300%	333%	366%	400%	433%	466%	500%	533%	566%
Offtake per year	172	229	287	344	401	476	516	573	630	688	745	802	860	917	974
Benefits from carrying capacity	2221018,80	2953955,00	3709101,40	4442037,60	5174973,80	6152222,08	6663056,40	7395992,60	8128928,81	8884075,20	9617011,40	10349947,61	11105094,00	11838030,20	12570966,41
benefits from pellet sales	5431250,88	5974375,97	6571813,56	7228994,921	7951894,413	8747083,85	9621792,24	10583971,46	11642368,6	12806605,47	14087266,02	15495992,6	17045591,9	18750151,1	20625166,2
total increamental benefits	7652269,68	8928330,97	10280914,96	11671032,52	13126868,22	14899305,93	16284848,64	17979964,07	19771297,42	21690680,67	23704277,42	25845940,23	28150685,88	30588181,28	33196132,59
total increamental costs	5719568,59	6691895,25	7829517,45	9160535,41	10717826,43	12539856,92	14671632,60	17165810,14	20083997,87	23498277,51	27492984,68	32166792,08	37635146,73	44033121,68	51518752,36

Appendix 9: Feasibility calculations for the worst case scenario of the mechanized scale of production

Mechanized Worst case scenario								
Assumptions								
Nominal interest rate	11,5%							
Production starts in year one								
year	Depreciation	production + Investment	Total	PVC	Total	PVB	NPV	BCR
	cost	cost	cost		benefits			
0	0,00	4391566,00	4391566,00	4391566,00	0,00	0,00	-4391566,00	0,00
1	281547,40	5719568,59	6001115,99	5382166,81	7652269,68	6863022,13	1480855,33	1,28
2	262683,72	6691895,25	6954578,98	5593982,57	8928330,97	7181588,99	1587606,42	1,28
3	245083,91	7829517,45	8074601,36	5825007,49	10280914,96	7416639,41	1591631,92	1,27
4	228663,29	9160535,41	9389198,70	6074759,10	11671032,52	7551092,84	1476333,73	1,24
5	213342,85	10717826,43	10931169,28	6342964,53	13126868,22	7617049,68	1274085,15	1,20

6	199048,88	12539856,92	12738905,81	6629532,78	14899305,93	7753839,97	1124307,19	1,17
7	185712,61	14671632,60	14857345,21	6934531,78	16284848,64	7600806,12	666274,34	1,10
8	173269,86	17165810,14	17339080,01	7258169,59	17979964,07	7526444,79	268275,20	1,04
9	161660,78	20083997,87	20245658,65	7600778,97	19771297,42	7422690,68	-178088,30	0,98
10	150829,51	23498277,51	23649107,01	7962804,86	21690680,67	7303390,24	-659414,61	0,92
11	140723,93	27492984,68	27633708,61	8344794,24	23704277,42	7158189,31	-1186604,93	0,86
12	131295,43	32166792,08	32298087,51	8747388,15	25845940,23	6999933,71	-1747454,45	0,80
13	122498,63	37635146,73	37757645,37	9171315,36	28150685,88	6837789,15	-2333526,21	0,75
14	114291,23	44033121,68	44147412,90	9617387,50	30588181,28	6663547,72	-2953839,79	0,69
15	106633,71	51518752,36	51625386,07	10086495,56	33196132,59	6485813,85	-3600681,71	0,64
				115963645,30		108381838,59	-7581806,71	0,93

NPV and BCR for the worst-case scenario of the highly mechanized scale of production is barely showing viability The NPV is too low given the cost that is invested in the project. The BCR is also really low.

Appendix 10: Annual incremental cost and benefit for the best case scenario (highly mechanized scale)

SENSITIVITY ANALYSIS	
Mechanized method best case scenario	
Average live weight	473
Average carcass weight	245,35
price/kg	45,96
annual increase on sales	15%
cost increases with	4,6%

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Increased carrying capacity	100%	133%	167%	200%	233%	277%	300%	333%	366%	400%	433%	466%	500%	533%	566%
Offtake per year	172	229	287	344	401	476	516	573	630	688	745	802	860	917	974
Benefits from carrying capacity	3739121,76	4973031,94	6244333,34	7478243,52	8712153,701	10357367,3	11217365,28	12451275,46	13685185,6	14956487,04	16190397,22	17424307,4	18695608,8	19929519	21163429,2
benefits from pellet sales	5431250,88	6245938,51	7182829,29	8260253,68	9499291,73	10924185,49	12562813,32	14447235,32	16614320,61	19106468,71	21972439,01	25268304,86	29058550,59	33417333,18	38429933,16
total incremental benefits	9170372,64	11218970,5	13427162,6	15738497,2	18211445,44	21281552,8	23780178,6	26898510,78	30299506,3	34062955,75	38162836,23	42692612,3	47754159,4	53346852,2	59593362,3
total incremental costs	5719568,59	5982668,75	6257871,51	6545733,60	6846837,34	7161791,86	7491234,29	7835831,07	8196279,29	8573308,14	8967680,32	9380193,61	9811682,52	10263019,91	10735118,83

Cost were assumed to increase by 4.6% due to inflation

Appendix 11: Feasibility calculations for the best case scenario of the mechanized scale of production

Mechanized best case scenario								
Assumptions								
nominal interest rate	9,5%							
Production starts in year one								
year	Depreciation	Production + Investment	Total	PVC	Total	PVB	NPV	BCR
	cost	cost	cost		benefits			
0	0,00	4391566,00	4391566,00	4391566,00	0,00	0,00	-4391566,00	0,00
1	281547,40	5719568,59	6001115,99	5480471,23	9170372,64	8374769,53	2894298,31	1,53
2	262683,72	5982668,75	6245352,47	5208692,46	11218970,45	9356744,40	4148052.662.66	1,80
3	245083,91	6257871,51	6502955,42	4953001,04	13427162,63	10226850,13	5273849,08	2,06
4	228663,29	6545733,60	6774396,89	4712096,33	15738497,20	10947294,07	6235197,74	2,32
5	213342,85	6846837,34	7060180,20	4484821,78	18211445,44	11568413,97	7083592,18	2,58
6	199048,88	7161791,86	7360840,74	4270145,83	21281552,77	12345781,81	8075635,98	2,89
7	185712,61	7491234,29	7676946,89	4067145,43	23780178,60	12598425,66	8531280,23	3,10
8	173269,86	7835831,07	8009100,93	3874992,03	26898510,78	13014134,26	9139142,23	3,36
9	161660,78	8196279,29	8357940,07	3692939,39	30299506,26	13387777,28	9694837,89	3,63
10	150829,51	8573308,14	8724137,65	3520313,31	34062955,75	13744885,89	10224572,58	3,90
11	140723,93	8967680,32	9108404,25	3356502,59	38162836,23	14063238,20	10706735,61	4,19
12	131295,43	9380193,61	9511489,04	3200951,41	42692612,27	14367569,25	11166617,84	4,49
13	122498,63	9811682,52	9934181,15	3053152,70	47754159,39	14676674,26	11623521,56	4,81
14	114291,23	10263019,91	10377311,14	2912642,42	53346852,16	14973079,47	12060437,05	5,14
15	106633,71	10735118,83	10841752,54	2778994,60	59593362,32	15275171,74	12496177,14	5,50
				63958428,54		**188920809,92**	**124962381,38**	**2,95**

This shows a feasible project that is worth the investment

Appendix 12: Annual incremental cost and benefit for the best case scenario (manual scale)

SENSITIVITY ANALYSIS	
Mannual Best case scenario	
Avarage live weight	473
Avarage carcass weight	245,35
price/kg	45,96
annual increase on sales	15%
cost increases with	4,6%

	year 1	year2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	year 11	year 12	year 13	year 14	year 15
Increased carrying capacity	100%	133%	167%	200%	233%	277%	300%	333%	366%	400%	433%	466%	500%	533%	566%
Offtake per year	172	229	287	344	401	476	516	573	630	688	745	802	860	917	974
Benefits from carrying capacity	3739121,76	4973031,94	6244333,34	7478243,52	8712153,70	10357367,28	11217365,28	12451275,46	13685185,64	14956487,04	16190397,22	17424307,40	18695608,80	19929518,98	21163429,16
benefits from pellet sales	2970000	3415500,00	3927825,00	4516998,75	5194548,56	5973730,85	6869790,47	7900259,04	9085297,90	10448092,59	12015306,48	13817602,45	15890242,81	18273779,24	21014846,12
total increamental benefit	6709121,76	8388531,94	10172158,34	11995242,27	13906702,26	16331098,12	18087155,75	20351534,51	22770483,54	25404579,63	28205703,70	31241909,85	34585851,61	38203298,22	42178275,28
total increamental cost	3775011,60	3948662,13	4130300,59	4320294,42	4519027,96	4726903,25	4944340,80	5171780,47	5409682,38	5658527,77	5918820,04	6191085,76	6475875,71	6773765,99	7085359,23

Appendix 13: Feasibility calculation for the best case scenario (manual scale)

Manual method best case scenario								
Assumptions								
Nominal interest rate	9,5%							
Production starts in year one								
	Depreciation	Production + Investment	Total	PVC	Total	PVB	NPV	IRR
Year	cost	cost	cost		benefits			
0	0	1125700,00	1125700	1125700	0,00	0,00	-1125700,00	0,00
1	63998,40	3775011,60	3839010	3505945,205	6709121,76	6127051,84	2621106,63	1,75
2	59710,51	3948662,13	4008372,641	3343026,743	8388532.662.66	6996127,64	3653100,89	2,09
3	55709,90	4130300,59	4186010,495	3188291,015	10172158,34	7747663,58	4559372,56	2,43
4	51977,34	4320294,42	4372271,759	3041239,839	11995242,27	8343582,17	5302342,33	2,74
5	48494,86	4519027,96	4567522,82	2901416,857	13906702,26	8833922,01	5932505,15	3,04
6	45245,70	4726903,25	4772148,951	2768402,773	16331098,12	9473940,94	6705538,17	3,42
7	42214,24	4944340,80	4986555,038	2641811,234	18087155,75	9582337,08	6940525,85	3,63
8	39385,89	5171780,47	5211166,361	2521285,257	20351534,51	9846552,64	7325267,39	3,91
9	36747,03	5409682,38	5446429,408	2406494,129	22770483,54	10061093,40	7654599,27	4,18
10	34284,98	5658527,77	5692812,747	2297130,706	25404579,63	10251108,29	7953977,58	4,46
11	31987,89	5918820,04	5950807,93	2192909,062	28205703,70	10393974,05	8201064,99	4,74
12	29844,70	6191085,76	6220930,464	2093562,433	31241909,85	10514004,17	8420441,73	5,02
13	27845,10	6475875,71	6503720,814	1998841,422	34585851,61	10629551,11	8630709,69	5,32
14	25979,48	6773765,99	6799745,475	1908512,41	38203298,22	10722676,17	8814163,76	5,62
15	24238,86	7085359,23	7109598,085	1822356,174	42178275,28	10811277,86	8988921,69	5,93
				39756925,26		**140334862,94**	**100577937,68**	**3,53**

Appendix 14: Sensitivity analysis for the annual increamental benefits for the worst case scenario (Manual method)

Worst case scenario manual method	
Avarage live weight	473
Avarage carcass weight	245,35
price/kg	27,3
annual increase on sales	10%
cost increases with	17%

	year1	year2	year3	year4	year5	year6	year7	year8	year9	year10	year11	year12	year13	year14	year15
Increased carrying capacity	100%	133%	167%	200%	233%	277%	300%	333%	366%	400%	433%	466%	500%	533%	566%
Offtake per year	172	229	287	344	401	476	516	573	630	688	745	802	860	917	974
Benefits from carrying capacity	2221018,80	2953955,00	3709101,40	4442037,60	5174973,80	6152222,08	6663056,40	7395992,60	8128928,81	8884075,20	9617011,40	10349947,61	11105094,00	11838030,20	12570966,41
benefits from pellet sales	2970000,00	3267000,00	3593700,00	3953070,00	4348377,00	4783214,70	5261536,17	5787689,79	6366458,77	7003104,64	7703415,11	8473756,62	9321132,28	10253245,51	11278570,06
total increamental benefit	5191018,80	6220955,00	7302801,40	8395107,60	9523350,80	10935436,78	11924592,57	13183682,39	14495387,57	15887179,84	17320426,51	18823704,23	20426226,28	22091275,71	23849536,47
total increamental cost	3775011,6	4416763,57	5167613,38	6046107,65	7073945,95	8276516,77	9683524,62	11329723,80	13255776,85	15509258,91	18145832,93	21230624,53	24839830,70	29062601,91	34003244,24

Appendix 15: Feasibility calculation for the worst case scenario (manual method)

Manual method worst case scenario								
Assumptions								
Nominal interest rate	11,5%							
Production starts in year one								
	Depreciation	Production + Investment	Total	PVC	Total	PVB	NPV	BCR
Year	cost	cost	cost		benefits			
0	0	1125700,00	1125700,00	1125700,00	0	0	-1125700,00	0,00
1	63998,40	3775011,6	3839010,00	3443058,30	5191018,80	4655622,242	1212563,95	1,35
2	59710,51	4416763,57	4476474,08	3600695,03	6220955,00	5003885,06	1403190,03	1,39
3	55709,90	5167613,38	5223323,28	3768098,99	7302801,40	5268231,949	1500132,95	1,40
4	51977,34	6046107,65	6098084,99	3945426,92	8395107,60	5431587,714	1486160,79	1,38
5	48494,86	7073945,95	7122440,81	4132896,33	9523350,80	5526058,084	1393161,75	1,34
6	45245,70	8276516,77	8321762,47	4330779,89	10935436,78	5690978,301	1360198,41	1,31
7	42214,24	9683524,62	9725738,86	4539400,83	11924592,57	5565695,953	1026295,12	1,23
8	39385,89	11329723,80	11369109,69	4759129,45	13183682,39	5518712,791	759583,35	1,16
9	36747,03	13255776,85	13292523,88	4990380,30	14495387,57	5441968,523	451588,23	1,09
10	34284,98	15509258,91	15543543,89	5233610,16	15887179,84	5349314,574	115704,41	1,02
11	31987,89	18145832,93	18177820,82	5489316,56	17320426,51	5230401,659	-258914,91	0,95
12	29844,70	21230624,53	21260469,23	5758036,81	18823704,23	5098080,415	-659956,39	0,89
13	27845,10	24839830,70	24867675,80	6040347,45	20426226,28	4961521,329	-1078826,12	0,82
14	25979,48	29062601,91	29088581,40	6336864,18	22091275,71	4812521,165	-1524343,01	0,76
15	24238,86	34003244,24	34027483,10	6648241,95	23849536,47	4659689,002	-1988552,94	0,70
				74141983,14		78214268,76	4072285,62	1,05

Appendix 16: Labour cost calculations (mechanized scale)

LABOUR COSTS (mechanized method)					
Type of Labour cost	Number of workers & l or kw/h	cost/hour/l/kW	hours/day	days/year	annual cost
Labour to harvest bush	3	3,7	8	180	26784
Labour to chip and hammer mill	3	3,7	8	180	26784
Labour to mix and pelletize	3	3,7	6	240	35184
Supervisor	1	7,4	8	240	52608
Machines					
front end cutter and chainsaw	8	12,96	8	180	149299,2
Tractor and wood chipper (diesel)	5	12,96	8	240	124416
Hammer mill	1	2,03	8	240	3897,6
Mixer	0,44	2,03	6	240	1286,208
pelletizer electricity consumption	8,06	2,03	6	240	23560,992
Total					443820

Appendix 17: labour cost calculations (manual scale)

LABOUR COST (manual method)					
Type of Labour cost	**Number of workers & l or kw/h**	**cost/hour/l/kW**	**hours/day**	**days/year**	**annual cost**
Labour to harvest bush	**10**	**3,7**	**8**	**180**	**71280**
Labour to chip and hammer	**3**	**3,7**	**8**	**180**	**19584**
Labour to mix and pelletize	**3**	**3,7**	**5**	**240**	**16920**
Supervisor	**1**	**7,4**	**8**	**240**	**52608**
machines					
Tractor and wood chipper (diesel)	**5**	**12,96**	**8**	**240**	**124416**
Hammer mill	**1**	**2,03**	**8**	**240**	**3897,6**
Mixer	**0,44**	**2,03**	**5**	**240**	**1071,84**
pelletizer electricity consumption	**8,06**	**2,03**	**5**	**240**	**19634,16**
Total labour cost					**309411,6**

Appendix 18: Manual method labour productivity

Manual method employee productivity

Assumption

One employee harvest	500 kg of bush (leaves and twigs) per day
Bush haverstable per day at neudamm farm	5000 kg of bush per day
Batch size	500 kg
number of batches produced per day	10
time it takes to produce 10 batches of pellets	5 hours
	3,7 (N$) per worker per hour
	7 (N$) for supervisor per hour

A constant of 400 N$ is paid per worker per month

10	employees required to harvest bush	5000	bush harvested per day	100000	kg of bush harvested per month	900000	kg of bush haversted per year
3	employees in the production line						
1	supervisor						
						6000000	kg of bush pellets produced per year
		(N$)				(N$)	
8	hours per day	6320	Monthly harvesting labour cost			75840	Annual haversting labour cost
		2176	Monthly production labour cost			26112	Annual production labour cost
		1120				13440	Annul supervisor cost
						115392	Total annual cost of labour
						0,02	cost of labour
						6,67	kg produced per hour

Appendix 19: Survey questionnaire

MARKET SURVEY OF EXISTING LIVESTOCK FEEDS AND THE FARMER'S WILLINGNESS TO PAY FOR BUSH BASED FEEDS IN NAMIBIA

Note: this survey is optional and information that you will provide will be treated confidential.

Your name will not be revealed.

(This questionnaire will only take up 10 minute of your time)

Target group: CONSUMERS/FARMERS.

Background information

1. **Demographic information**

Farm Name: ……………………….

District : ……………………

Region : ……………………

Email Address : …………………....

Phone Number : ……………………

Highest education level:…………………..

Age:……………………

Are you a communal or commercial farmer?.......................................

Is livestock farming the major source of your incomes?

What is the carrying capacity of your farm? LSU/ha(Livestock Unit) per hectare/h?............................

SECTION A: FEEDING PRACTICES

2. **How many animals do you have?**

   Cattles…….

   Sheep………

   Goats……….

   Others ………….

3. **Do your animals usually graze/browse or they are given feed**
   - ➢ They only graze/browse
   - ➢ They are given feed

- Both

4. **Which is the source of your animal feed?**
   - Self-produced (I produce it at the farm)
   - Purchased
   - Both (I purchase feed but I also produce some)

5. **In case you purchase the feed, where do you purchase it?**
   - Imported
   - Retailers (Agra, Feed Master,KapAgri)
   - Commercial farmers
   - Other: (specify)…………………………………………………………………

6. **Which type of feed do you purchase?**

   a) *Complete feed. Please specify.
   b) Commercial supplements (e.g. energy, mineral licks).Please specify.
   c) Maize silage
   d) Lucerne
   e) Camelthorn and prosopis pods
   f) Grass hay
   g) Agro industrial byproducts (e.g. cotton cake, marula oil cake, molasses)
   h) Straws/Stover (e.g. millet, wheat, barley, maize and rice)
   i) Others (specify)………………………
   …………………………………..
   …………………………………..

   **Complete feed*: *a feed that contain all the necessary nutrients for the animal and can be fed on its own (e.g. bush feed)*

7. **When do you feed your animals with the commercial feeds?**
   - As supplement year around
   - As supplement in the dry season
   - As supplement under severe droughts
   - As feedlot year around
   - As finishing feed
   - Other………………………………………………

SECTION B: COSTS OF FEEDS

8. **At what price do you buy the feeds?**

Feed no 1 (N$/kg/)…………………

Feed no 2(N$/kg/)…………………

Feed no 3(N$/kg/)…………………

Feed no 4(N$/kg/)…………………

Feed no 5 (N$/kg/)…………………

Feed no 6(N$/kg/)…………………

Feed no 7(N$/kg/)…………………

Feed no 8(N$/kg/)…………………

Feed no 9 (N$/kg/)…………………

Feed no 10(N$/kg/)………………… **(In case you purchase), what is the cost of transporting the feeds?**

- Own transport ……………………………………………………………….
- Retailer transportation cost (delivery cost)………………………..
- Producer transportation costs (delivery cost)………………………

9. Approximately how much do you spend during the following conditions?

- During severe drought……………..
- During dry season………………
- Year round……………..

SECTION C: FEED VALUE

10. How do the livestock respond to the feed?

Cattle

1. No growth rate, it is a survival ratio, it just avoid animals to lose weight in the dry season
2. A slow growth rate (less than 18.9kg a week)
3. Medium growth rate (between 18.9-21kg a week)
4. High growth rate (more than 21kg a week)
5. Other (please specify)

Sheep

1. No growth rate, it is a survival ratio, it just avoid animals to lose weight in the dry season
2. A slow growth rate (less than 4 kg a week)
3. Medium growth rate (between 4-7 kg a week)
4. High growth rate (more than 7kg a week)
5. Other (please specify)

Goats

1. No growth rate, it is a survival ratio, it just avoid animals to lose weight in the dry season

2. A slow growth rate (less than 4 kg a week)
3. Medium growth rate (between 4-7 kg a week)
4. High growth rate (more than 7kg a week)
5. Other (please specify)

…………………………………………………………………………………………………….

11. Which growth/ rate would you like your animals to have (g/day or kg/month)? (please specify animal (growing lamb, heifers..)

Cattle

1. No growth rate, it is a survival ratio, it just avoid animals to lose weight in the dry season
2. A slow growth rate (less than 18.9 kg a week)
3. Medium growth rate (between 18.9- 21kg a week)
4. High growth rate (more than 21 kg a week)
5. Other (please specify)

Sheep

1. No growth rate, it is a survival ratio, it just avoid animals to lose weight in the dry season
2. A slow growth rate (less than 4 kg a week)
3. Medium growth rate (between 4-7 kg a week)
4. High growth rate (more than 7kg a week)
5. Other (please specify)

Goats

1. No growth rate, it is a survival ratio, it just avoid animals to lose weight in the dry season
2. A slow growth rate (less than 4 kg a week)
3. Medium growth rate (between 4-7 kg a week)
4. High growth rate (more than 7kg a week)
5. Other (please specify)

12. Are you satisfied with the current cost of the feed for such growth rates?

…………………………………………………………

13. How much would you be willing to pay for a bush based feed that will ensure high growth rate of your animals? (N$)

Cattle ………………………………………

Sheep ………………………………………

Goats ……………………………………….

14. How much would you be willing to pay for bush based feed iration
Cattle……………………………………….

Sheep………………………………………..

Goats………………………………………..

Thank you for your time!

Appendix 20: Key informant questionnaire

MARKET SURVEY OF EXISTING LIVESTOCK FEEDS IN NAMIBIA AND THE LIVESTOCK FARMER'S WILLINGNESS TO PAY FOR A PROPOSED ANIMAL BUSH-BASE FEED

(KEY INFORMANT QUESTIONNAIR)

Note: this survey is optional and information that you will provide will be treated confidential.

(This questionnaire will only take up 10 minute of your time)

Target group: EXPERT LIVESTOCK FARMERS

1. Demographic information

Farmer's/expert's Name:

Age :

Region of farm :

Total farm size:

Phone Number **:**

2. **Educational Background:**

0. No education
1. Primary
2. Secondary
3. Tertiary

3. **Are you a communal or commercial farmer**?

....

………………………………………………………………………………………….

4. **On average, how many cattle do you own?**

……………………………………………………………………………....................

…………………………………………………………………………………………

5. **Which animal feed(s) do you mostly purchased for your animals?**

…………………………………………………………………………………………

…………………………………………………………………………………………

6. **Where do you mostly purchase your animal feed.**

…………………………………………………………………………………………

…………………………………………………………………………………………

7. **At what price do you buy you animal feed?(e.g. price/ 50kg bag)**

…………………………………………………………………………………………

…………………………………………………………………………………………

8. **How do you transport the feed(s) to your farm?**

………………………………………………………………………………………..…

9. **What are the costs involved in transporting the feed to your farm?**

…………….………………………………………………………………………

………………………………………………………………………………………

10. **Would you consider buying alternative feed(s) from the current feed you buy?**

………………………………………………………………………………………

………………………………………………………………………………………

11. **Would consider buying bush-based feed that will guarantee a high growth rate for your animals?**

………………………………………………………………………………………

………………………………………………………………………………………

12. **At what price are you willing to pay for the bush-based animal feed?(e.g. price/50kg bag)**

....

....

13. **Do you expect the bush based animal feed to be more cheaper/expensive than the current feed prices?**

…………………………………………………………………………………………

14. **Are you engaged in any off farm activities that help you generated off-farm income? If yes mention them**

…………………………………………………………………………………………

....

15. **What are the main challenges do you face in keeping livestock?**

…………………………………………………………………………………………

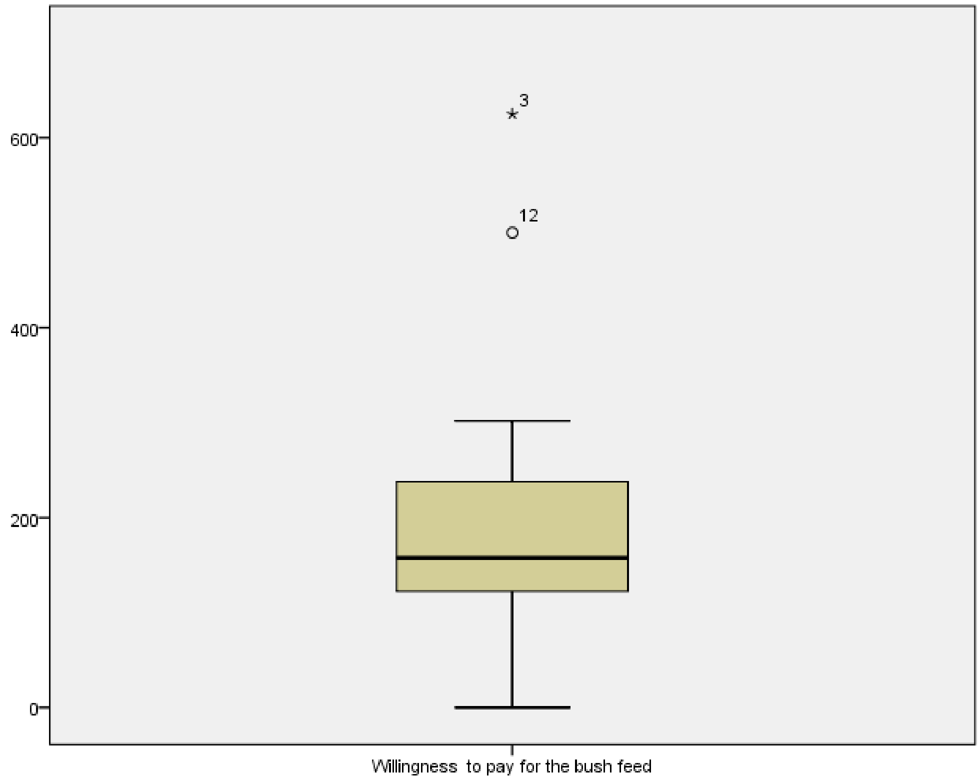
16. **What is your opinion about the current animal feed prices?**

…………………………………………………………………………………………

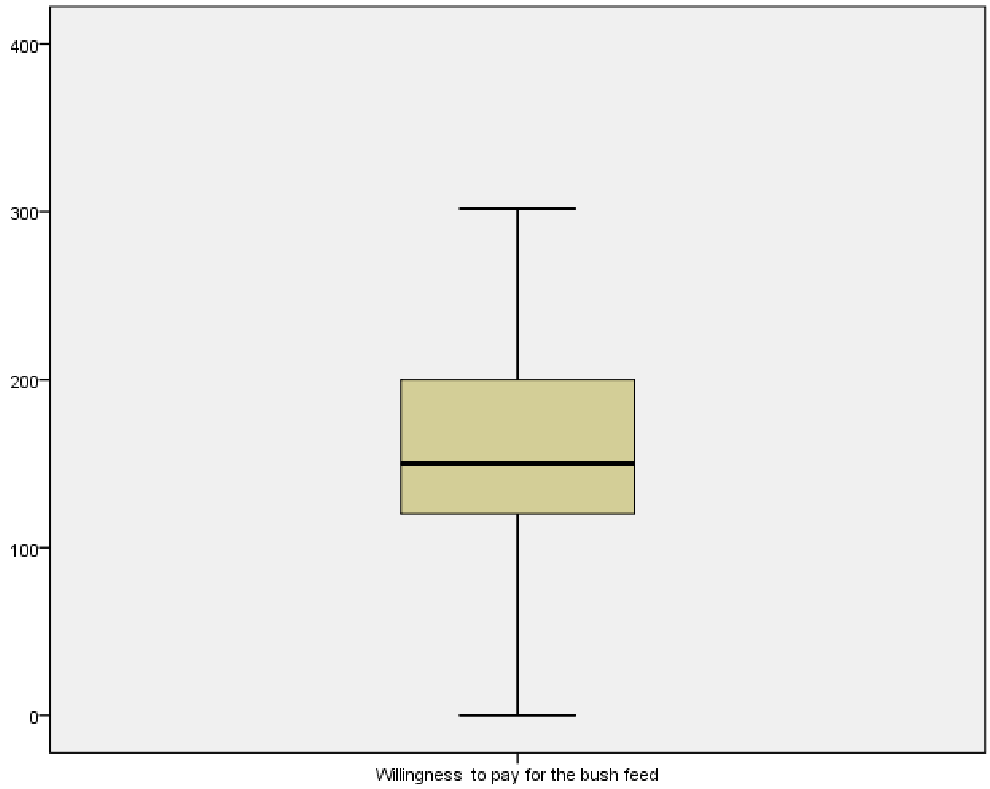
…………………………………………………………………………………………

THANK YOU FOR YOUR TIME!

Appendix 21: whisker box plot displaying detected outliers in the depended variable



Appendix 22: Box with outliers removed from the data



Appendix 23: Questionnaire for bush-feed producers

MARKET SURVEY OF EXISTING LIVESTOCK FEEDS COMPARED TO BUSH BASED FEEDS IN NAMIBIA

Note: Information that you will provide will be treated confidential and your name will not be revealed.

(This questionnaire will only take up 10 minute of your time)

1. **Background information**

   Farm Name :

   District :

   Region :

   Email Address :

   Phone Number :

   Total farm size:

   Farm Bush density (trees/ha):

2. **What tree species do you harvest at the farm?**

………………………………………………………………………………………

3. **Are you an annual or seasonal producer?**

   ………………………………………………………………………..

4. **What technology do you use for bush harvesting (manual, mechanized or semi-mechanized)**

   ………………………………………………………………………………

5. **Please list the machines and equipment you use for harvesting and bush-feed production**

   ………………………………………………………………………………

   ………………………………………………………………………………

   ………………………………………………………………………………

   ………………………………………………………………………………

   ………………………………………………………………………………

………………………………………………………………………………………

………………………………………………

6. **Do you dry and store the harvested biomass or you use it as fresh? (please give the Storage cost if applicable)**

………………………………………………………………………………………

7. **Employee's efficiency**

Type of labour	Number of employees	Equipment and machines used to harvest	Total output/day or month	Hours worked/day
Bush harvesting				
Chipping		-		
Milling		-		
Pelletizing		-		

8. **Machines efficiency**

Machine	Type of machine	Cost of machine	Hours worked/day or month	Litters or kW used/day or month	Cost/litter or kw	Total output produce / day	Total per month
Wood chipper							
Hummer mill							
Mixer							
Pelletizer							
Others							

9. **Do you sell all your produce or you also feed to your animals**

………………………………………………………………………………………

………………………………………………………………………………………

10. **If you sell, what proportion of your products do you sell?**

……………………………………………………………………………………

……………………………………………………………………………………

11. Compared to other commercial feeds in the market, how do the bush feeds prices compare.

……………………………………………………………………………………

……………………………………………………………………………………

…………………….....

12. What is the selling price of your feed(s)?

(N$)……………………………………………………………………….....

N$)……………………………………………………………………….....

13. Where do you sell the feeds that you produce?

- At your premises
- Take to the market
- Others (specify) ………………………

………………………….

………………………….

14. (If you take to the market), what is the transportation cost?

…………………………………………………………………….…………………

………

15. What benefits can you attribute to using bush feed which you have experienced

……………………………………………………………………………………

……………………………………………………………………………………

……………..

THANK YOU FOR YOUR TIME!

Appendix 24: Mechanized harvesting of *Senegalia mellifera* bush

A front end cutter and a brush cut used in a mechanized scale of production

Appendix 25: Transportation of the biomass to the workshop

Transportation of the biomass to the workshop

Appendix 26: Manual harvesting and chipping of *Senegalia mellifera* bush

Manual harvesting of *Senegalia mellifera* bush and feeding in the wood chipper machine on the left picture and Wood chips from the chipper on the right

Appendix 27: Chipped bush feed passing through a hammer mill

The picture on the left shows a hammer mill wheel with milled bush and on the right a mixer that is used to mix the ingredients with milled bush

Appendix 268 Bush feed pelletizing

The picture on the left shows a pelletizer machine set up and on the right bush feed pellets