# RANGELAND MANAGEMENT PRACTICES OF COMMERCIAL CATTLE FARMERS IN THE HIGHLAND SAVANNA OF NAMIBIA


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(2013088568)


Mini-dissertation submitted in the partial fulfilment of the requirements in respect of the master's degree qualification

**Master of Environmental Management**


in the
Centre for Environmental Management
Faculty of Natural and Agricultural Sciences
at the University of the Free State


January 2017

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# DECLARATION

I, **Thecha Grunewald**, declare that the coursework master's degree mini-dissertation that I herewith submit for the master's degree qualification *Master of Environmental Management* at the University of the Free State is my independent work, and that I have not previously submitted it for a qualification at another institution of higher education.

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# ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to the following people, without them this dissertation would not have been possible:

- My supervisor, Dr Ibo Zimmerman, Deputy Director: Agriculture and Natural Resources Sciences, Namibia University of Science and Technology, for his expert advice, guidance and support throughout my study.

- Prof Robert Schall, Statistical Consultation Service, Department of Mathematical Statistics and Actuarial Science, University of the Free State, for his assistance with the statistical analysis and advice on my questionnaire construction.

- Holger Kolberg and Chantel Louw from the Department of Scientific Services, Ministry of Environment and Tourism, Namibia, for their assistance with the GIS map.

- Leon Lubbe, Chief Agricultural Scientific Officer at the Ministry of Agriculture, Water and Forestry, Namibia, and Mr Koos Claassen from Meatco, Namibia, for their advice with my questionnaire.

- The Ministry of Environment and Tourism, Namibia, for their financial support and use of their resources.

- My husband, Nico Gericke, my family and friends for their unending support and motivation.

# ABSTRACT

Land degradation is rife in Namibia. The country experiences major losses of rangeland productivity mainly in the form of bush encroachment. The factors that cause degradation are complex and interrelated, but are mainly a result of unsustainable rangeland management. A case study considering the rangeland management methods used by commercial cattle farmers in the Highland Savanna of Namibia was used to investigate the research questions. Firstly, to determine if the rangeland management methods used by farmers in the Highland Savanna possibly contribute to land degradation/desertification. Secondly, to explore whether farmers are increasing their vulnerability to the effects of drought and climate change. To answer the research questions, a quantitative questionnaire was used to investigate three broad categories of rangeland management as identified in the literature review. The categories are: carrying capacity and stocking rate, drought preparedness and coping strategies, bush encroachment and its management. The results indicated that the rangeland management methods used by the majority of the farmers in the study area are contributing towards degradation and that these farmers are increasing their vulnerability to the effects of climate change. Namibia's rainfall is highly variable and requires adaptive rangeland management in order to overcome the adverse effects of drought. The results identified a lack of drought preparedness as a key area where farmers are increasing their vulnerability to water scarce periods. High stocking rates were also identified as a significant factor that decreases farmers' flexibility to drought and increases their vulnerability to its effects. Vulnerability to drought translates into a vulnerability to the effects of climate change. It was also found that some farmers lack knowledge on key aspects of rangeland function and management. Any interventions implemented to combat land degradation would be in vain if the drivers of degradation are not addressed first. This study has highlighted the drivers of rangeland degradation in Namibia and the recommendations made will assist farmers in their decision-making processes that will hopefully lead to sustainable rangeland management. The study has also identified factors that prevent sustainable rangeland management. Some of these factors need to be addressed by the relevant government agencies, institutions and the farmers themselves.

**Key words:** Degradation, drought, sustainable rangeland management, cattle, stocking rate, carrying capacity, bush encroachment, climate change, vulnerability.

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# LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| CV | Coefficient of Variation |
| DLDD | Desertification, Land Degradation and Drought |
| GDP | Gross Domestic Product |
| GNP | Gross National Product |
| GRN | Government of Namibia |
| ICZ | Intertropical Convergence Zone |
| LSU | Large Stock Unit |
| MAWF | Ministry of Agriculture, Water and Forestry |
| MEA | Millennium Ecosystem Assessment |
| MET | Ministry of Environment & Tourism |
| NSA | Namibia Statistics Agency |
| NRMPS | National Rangeland Management Policy and Strategy |
| SAIEA | Southern African Institute for Environmental Assessment |
| SHPZ | Subtropical High Pressure Zone |
| SRM | Sustainable Rangeland Management |
| UNCCD | United Nations Convention to Combat Desertification |

*Chapter 1*

# INTRODUCTION

## 1.1 Background and Motivation

Drylands cover an estimated 41% of the earth's total land area, and support one third of the global population (Millennium Ecosystem Assessment [MEA] 2005). This is a significant percentage of the population as drylands are considered to be a challenging area in which to practice agriculture and they easily suffer from degradation (Reynolds et al. 2007). Drylands include arid, semi-arid and dry sub-humid areas that experience extreme water scarcity caused by a high rate of mean annual evaporation that exceeds the mean annual precipitation (MEA 2005). Drylands typically experience an unpredictable climate with wide variations in precipitation making agriculture a risky form of livelihood (Reynolds et al. 2007).

The Namibian climate is typical of drylands with extreme water deficits and a highly variable climate (Mendelsohn et al. 2002), resulting in Namibia being the driest country south of the Sahel (Kruger & Kressirer 1996). This makes cattle farming in the country challenging, especially as improper rangeland management has resulted in severe forms of land degradation (Seely et al. 1995).

Degradation can be defined as the long-term decline in the productivity of land (Ward & Ngairorue 2000). Another term that goes hand in hand with degradation is desertification which can be defined as land degradation in arid, semi-arid and dry sub-humid areas, occurring as a result of various factors, including variations in climate and human activities, so this includes both physical and social issues (Reynolds et al. 2007). A climatic factor that makes it significantly harder for farmers to overcome the effects of land degradation and desertification is extended periods of below average rainfall called drought, which frequently occurs in Namibia and requires proactive planning (Rothauge 2007). The combined effects of desertification, land degradation and drought (DLDD) make sustainable rangeland management (SRM) an intricate process that does not always prevail.

Namibia suffers from severe symptoms of land degradation, mainly in the form of bush encroachment with more than 60% of the savanna rangelands affected by this phenomenon (De Klerk 2004). The reasons for degradation are predominantly as a result of overgrazing caused by overstocking of livestock (Zimmermann et al. 2008). Some farmers also understock their farms which will decrease the perennial grass sward and contributes to the bush encroachment problem (Zimmermann et al. 2008). Another factor that contributes to degradation is the lack of adaptability by farmers to the variable climate (Rothauge 2007). Farmers need to prepare for drought by building up fodder reserves, and at the first on-set of drought farmers need to be able to destock quickly to prevent excessive grazing that could contribute to degradation and bush encroachment (Rothauge 2007).

Bush encroachment is a huge concern for several sectors in Namibia. It has dire effects on the biodiversity, water sources and food security, and it is becoming increasingly difficult for livestock farmers to control its occurrence (De Klerk 2004). De Klerk (2004) concluded that bush encroachment is the most significant factor preventing sustainable livestock production in Namibia. Bush encroachment also contributes directly to desertification as it hampers the production of desirable grasses and forbs and thereby decreases the productivity of the land.

The Southern African Institute for Environmental Assessment [SAIEA] (2015) define bush encroachment as the thickening of woody bush species in the recent past (last 20 to 60 years), caused by human activities in conjunction with natural events. Together with overgrazing, fire avoidance behaviour has significantly contributed to bush encroachment in Namibia (De Klerk 2004). Prior to commercial cattle farming fires typically occurred naturally after years of above average rainfall and kept encroacher bush seedlings in check (De Klerk 2004; Zimmermann et al. 2008). The use of fire is, however, not a viable option for severely encroached farms and areas that lack sufficient fuel loads (De Klerk 2004). The methods available for bush control include biological, mechanical and chemical control (De Klerk 2004). Each of the methods of control can have significant negative environmental effects, especially if they are applied incorrectly (De Klerk 2004; Honsbein et al. 2012; SAIEA 2015; Smit et al. 1999) which could contribute to land degradation and desertification of Namibian rangelands.

On top of the effects of DLDD on rangelands, Namibia is also highly vulnerable to the effects of climate change, which is expected to significantly reduce the productivity of rangelands (Midgley et al. 2005) and thus put the income of cattle farmers at risk and increase their vulnerability.

Leary et al. (2006:1) defined vulnerability as "[t]he propensity of people or systems to be harmed by stresses … it is determined by their exposure to stresses, their sensitivity to the exposures, and their capacities to resist, cope with, exploit, recover from and adapt to the effects". There is sufficient literature published to confidently state that cattle farmers in

Namibia are at risk because of the negative effects of desertification / land degradation (Ministry of Agriculture, Water and Forestry [MAWF] 2012; Seely et al. 1995), drought (Hutchinson 1995; Rothauge 2007) and climate change (Dirkx et al. 2008; Midgley et al. 2005; Ministry of Environment and Tourism [MET] 2011; Niang et al. 2014; Reid et al. 2007). However, there is also sufficient literature available to equip farmers to deal with the effects of desertification / land degradation (De Klerk 2004; MAWF 2012; Rothauge 2001, 2007), drought (MAWF 2012; Rothauge 2001, 2007) and climate change (Brown 2009; MET 2011). The management methods practiced by farmers are, however, not always sustainable and could increase their vulnerability to the effects of DLDD and to climate change. It is, therefore, essential to monitor management trends at a land user level and to determine the reasons for the decisions that farmers make. Their management methods then need to be critically analysed and conclusions need to be made as to whether their methods possibly contribute to desertification in Namibia.

The study took place in the Highland Savanna of Namibia which consists of 5.5% of Namibia's total land surface (Joubert et al. 2008). Although the area contributes only a small percentage of the total surface area of Namibia, its high level of endemism and biodiversity makes it of conservation importance (Joubert et al. 2008). However, only 0.2% of the Highland Savanna is under government protection (Joubert et al. 2008); therefore, the conservation of this unique vegetation unit falls primarily on the freehold farmers that occupy the remaining 99% of the area.

## 1.2 Problem Statement

The current rates of degradation have drastically decreased livestock yields in sub-Saharan Africa, which are currently the lowest in the world (Woodfine 2009). The same goes for Namibia where carrying capacities have decreased by 100% or more, resulting in a N$1.4 billion loss of income per annum (MAWF 2012), mostly as a result of bush encroachment (De Klerk 2004). This is happening at a time when the world's population is drastically increasing. Namibia's population is no exception and is continuing to grow, thereby the demand for protein and agricultural land needed to raise livestock is also increasing. This, in turn, will lead to increased pressure on the land currently available. Providing for this increased demand for protein will be difficult for a country that has limited rainfall and high rates of degradation.

Nevertheless, agriculture remains important to Namibia as the Annual National Accounts showed that the agriculture and forestry industry were the second highest primary industry contributor to the Gross Domestic Product (GDP) of Namibia with 3.2% being contributed in 2015 (Namibia Statistics Agency [NSA] 2015). The commercial livestock industry on its own has also been a significant contributor. This industry is, however, not a reliable contributor as it is highly sensitive to climate events. This is evident with the recent drought situation that resulted in a significant drop in the livestock contribution, from 3.2% in 2011 to 1.9% contribution to the GDP in 2015 (NSA 2015). The commercial livestock industry has also seen a drastic decrease of cattle numbers with 2,6 million head of cattle being maintained during the 1950s which dropped to 1,2 million head in 1995 (Lange et al. 1998). A census done in 2007 showed that 745 000 head of cattle were being kept by commercial farmers in Namibia (MAWF 2009). The decrease in cattle numbers has been linked to a decreased carrying capacity of rangelands as a result of land degradation (Lange et al. 1998).

Namibia's climate has been arid for millennia and thus soils in the country are typically undeveloped and nutrient poor; this fact is a major limiting factor for farming in the country, possibly just as limiting as the arid and variable climate (Mendelsohn et al. 2006). Soil erosion is also severe, with 90% of the land showing signs of erosion (Coetzee 2013). Degraded rangelands contribute to climate change as eroded soils emit carbon. However, if soil restoration is applied, dryland rangelands could function as major carbon sinks and help combat climate change (MEA 2005).

The concern for degradation does not only influence the productivity of the livestock industry, but it is also a major threat to the biodiversity of Namibia. Namibia is a signatory party to the Convention on Biological Diversity, therefore rangeland degradation is an issue for government as well (Strohbach 2001). The Namibian government has confirmed its concern for issues regarding DLDD by becoming a signatory party to the United Nations Convention to Combat Desertification (UNCCD) and in 2012 the Ministry of Agriculture, Water and Forestry published the National Rangeland Management Policy and Strategy (NRMPS).

Most Namibian farmers manage the symptoms and effects of DLDD and deal with rangeland management issues on an *ad hoc* basis. However, rangeland degradation will not improve if the drivers of degradation are not identified and managed accordingly.

## 1.3 Research Questions

1. Do the rangeland management methods used by farmers in the Highland Savanna contribute to land degradation/desertification?
2. Are farmers increasing their vulnerability to the effects of drought and climate change?

## 1.4 Aims and Objectives

### 1.4.1 Aims

1. To answer the research questions by critically analysing the results.
2. To make recommendations based on the findings.
    - The recommendations will aim to encourage commercial cattle farmers in the Highland Savanna to practice sustainable rangeland management and improve their rangeland condition and productivity.

### 1.4.2 Objectives

1. To determine if farmers are using farming practices that could contribute to degradation, for example over-stocking.
2. To assess if farmers are increasing their vulnerability to the effects of DLDD and climate change, for example high dependency on cattle as a primary source of income, with no drought preparation strategies in place.
3. To identify factors that prevent sustainable rangeland management, for example issues with markets, lack of updated knowledge, time and money to control bush encroachment.
4. To identify perceptions of farmers on land degradation and the condition of rangeland on their farms.

## 1.5 Chapter Outline

**Chapter 1:** Consists of an introduction to the study and a statement of the research problem. The chapter also states the research questions along with the aims and objectives of the study.

**Chapter 2:** Conceptualises the study through a review of the relevant literature. The causes, effects and management of degradation will be discussed. Drought and the methods available to cope with its occurrence will be explored. Lastly, the effects and management of climate change are discussed.

**Chapter 3:** This chapter provides a description of the study area. The structure of the vegetation map of Namibia is outlined. The abiotic factors such as topography, soils and climate of the study area are briefly discussed. Biotic factors such as plants and animals and their endemism and diversity are briefly discussed. The ownership of freehold land in Namibia is also discussed.

**Chapter 4:** This chapter provides a description of the methodology used in this study. The process used to develop and design the questionnaire is discussed. The methods used to determine the sample population are described. Data collection and analysis methods are explained and the limitations experienced with the data collection process are identified and discussed.

**Chapter 5:** This chapter presents and illustrates the major findings of the study under the respective headings. Recommendations are also provided in this chapter. The questionnaire survey results are described along with the demographics of the sample population. Results regarding carrying capacity and stocking rate are also presented and analysed. Findings on the occurrence of drought along with methods of preparation for its occurrence are examined. Bush encroachment occurrence and management methods used by farmers are presented and discussed. Farmers' perception on rangeland condition and function is analysed and discussed.

**Chapter 6:** The final chapter provides an overall conclusion on the research problem and results found in this study. This chapter also provides key recommendations that could help farmers to decrease their vulnerability to drought and climate change and in the process, improve rangeland conditions.

*Chapter 2*

# LITERATURE REVIEW

## 2.1 Introduction

In this chapter, a thorough review of the literature related to the research questions, aims and objectives will be presented. The first section will discuss degradation as a whole along its causes, effects and management. The most significant issue regarding degradation in Namibia, namely bush encroachment, will be discussed in detail. The second section will discuss drought and the practices available that enable farmers to cope with and prepare for periods of below average rainfall. The third section will discuss the effects of climate change and methods available to decrease a farmer’s vulnerability to its effects, followed by a short conclusion.

## 2.2 Degradation

### 2.2.1 Where it started: Colonialism

Several causes of land degradation and desertification in Namibia can be linked to colonisation, which brought about drastic changes in the administration and governance of the country (Rohde & Hoffman 2012; Seely et al. 2006). Prior to colonisation, livestock farming was practised on a small subsistence scale by pastoral communities (Rohde & Hoffman 2012). Namibia’s climate is highly variable and pastoralists were able to deal with this variability by moving their cattle to areas where water and grazing were available (Adams & Devitt 1990).

Colonisation took place at the turn of the nineteenth century, first by the Germans and later by South Africans, when large tracts of land were fenced off (Adams & Devitt 1990). Western perceptions of economic and ecological sytems were implemented leading to a colonial ecological revolution which is still in effect today (Rohde & Hoffman 2012). One of the most significant concepts introduced was the notion of carrying capacity, which can be defined as the maximum stocking rate of herbivores that a rangeland can support on a sustainable basis (De Leeuw & Tothill 1993). This concept can be problematic for countries such as Namibia where the biomass supply can vary by up to 95% from the one year to the next (Easdale & Domptail 2014). This problem was addressed by the South African Government prior to Namibia's independence by providing considerable subsidies to white cattle farmers in Namibia. The subsidies have since been withdrawn and this left many farmers in Namibia with no other choice but to overstock in order to make ends meet (Odendaal 2006).

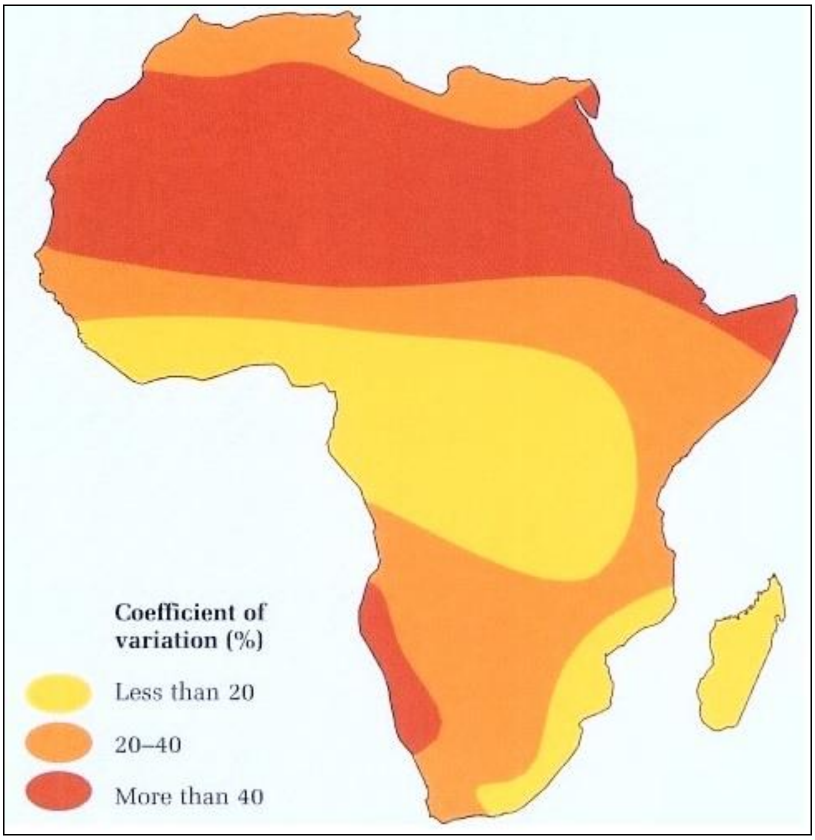
### 2.2.2 Rainfall as a factor

Namibia's hot, dry and variable climate is a result of its position, which is between 17 and 29 degrees south of the equator along the southwestern coast of Africa. This area is subject to three major climate systems, namely the Intertropical Convergence Zone (ICZ), the Subtropical High Pressure Zone (SHPZ) and the Temperate Zone (Mendelsohn et al. 2002). The climate systems are constantly moving north or south in response to the movement of the sun and only a slight inconsistency in the extent or movement of the systems will result in a difference in the weather that is experienced from one year to the next. This is what makes Namibia's climate, especially rainfall, so variable (Hutchinson 1995).

There is a constant struggle of dominance between the ICZ and the SHPZ. The ICZ brings in moist air from the north, while the SHPZ fights back with dry, cold air. It is the SHPZ that usually causes the dry weather that Namibia is known for (Mendelsohn et al. 2002). The overall lack of moisture in Namibia's atmosphere causes very few clouds, and extreme radiation from the sun brings very high daytime temperatures that all adds to the rapid evaporation rate of water (Mendelsohn et al. 2002).

It is the effect of these climate systems that makes Namibia the driest country south of the Sahel (Kruger & Kressirer 1996), with 22% classified as arid desert, 70% semi-arid and 8% dry sub-humid (Seely et al. 2006). The dry nature of Namibia limits food production as only 8% of the country receives more than 500 mm of rain annually which is needed for crop production; 22% is arid and not suitable for any form of agriculture, with the remaining 70% semi-arid land only suitable for livestock production (Government of the Republic of Namibia [GRN] 2004).

Not only is Namibia's climate arid, it also has a highly variable rainfall pattern from year to year. Variation of rainfall can be statistically described through the coefficient of variation (CV) of annual rainfall. The higher the coefficient, the greater the variance of rainfall from year to year and the more unpredictable the rainfall is. In the words of Mendelsohn et al. (2002): "Together with the Sahara Desert, Namibia has the most variable rainfall in Africa." Figure 2.1 illustrates the coefficient of variation of rainfall in Africa.



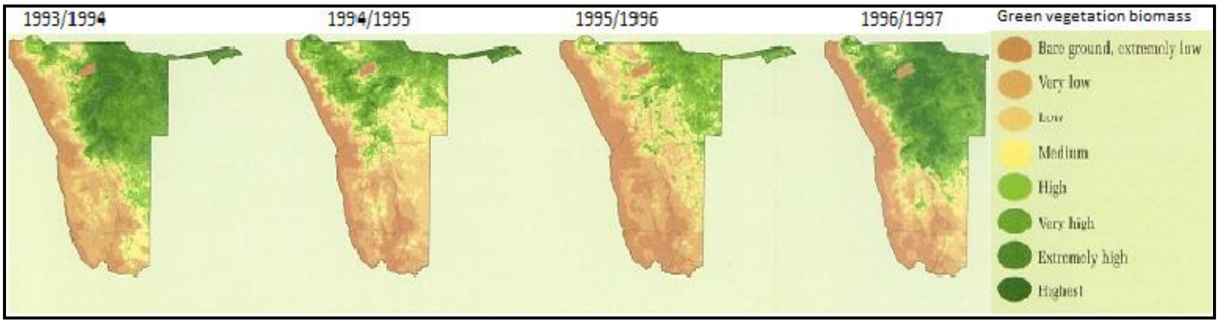

Source: Mendelsohn et al. (2002)

**Figure 2.1: Coefficient of variation of rainfall in Africa**

Namibia's variable rainfall makes livestock farming very risky, as precipitation is the single most important factor to a livestock farmer that makes use of natural rangelands (Humphrey 1962). The quantity of grass growth on a rangeland corresponds to the amount of rainfall that has fallen in the growing season; and therefore, the carrying capacity of a farm fluctuates with the rainfall, which translates into a fluctuation of the farmer's income. Cattle farmers are therefore highly dependent on rainfall to provide their cattle with the necessary amount of grazing needed for growth.

Mendelsohn et al. (2002) illustrated the variability of plant growth between different rainy seasons (Figure 2.2). The growth was measured from October in one year to April the next year; a stark contrast can be seen between the years.

Occasional drought is inevitable in Namibia and proper planning and backup is crucial in the event of below average rainfall seasons. There is currently no form of insurance available to farmers that wish to prepare for drought events (Olbrich 2012) and farmers need to take the responsibility upon themselves to overcome the adverse effects of drought.




Source: Adapted from Mendelsohn et al. (2002:102)

**Figure 2.2: Variation of vegetation biomass in Namibia from year to year**

Rainfall on its own is a significant factor that influences the environment of Namibia, but variability of precipitation between years has not been correlated to degradation as it is a normal occurrence (Tyson 1991).

### 2.2.3 Causes, effects and management

Degradation is widespread over Namibia and presented in many forms. The causes of degradation in Namibia have been directly linked to unsustainable farming methods such as overstocking which leads to overgrazing (De Klerk 2004; Klintenberg & Seely 2004; Seely et al. 1995;) and understocking which leads to overresting (Zimmermann et al. 2008). These unsustainable rangeland management methods in turn lead to the different interrelated and cascading effects that cause severe implications for rangeland management and conservation, mainly in the form of bush encroachment.

#### 2.2.3.1 Decreased perennial grasses

The initial symptom of rangelands that are overgrazed or undergrazed is a decrease of perennial grasses (Joubert et al. 2008). A decreased perennial grass sward greatly affects the carrying capacity of a rangeland as perennial grasses are more persistent and more productive than annual grasses (Rothauge 2007). Once the root reserves of perennial grasses have been reduced they are easily pulled out by livestock, which results in bare soil (MAWF 2012). Bare soils become capped and lead to low water infiltration and high water run-off which in turn leads to water erosion (MAWF 2012). Having a good sward of perennial grasses will also decrease a farmer's level of risk to the effects of drought (Rothauge 2001). A decreased perennial grass sward also allows more moisture to be available for bush to grow, which in turn contributes to the bush encroachment process (Smit et al. 1999; Zimmermann et al. 2008).

#### 2.2.3.2 Bush encroachment: Impacts and management

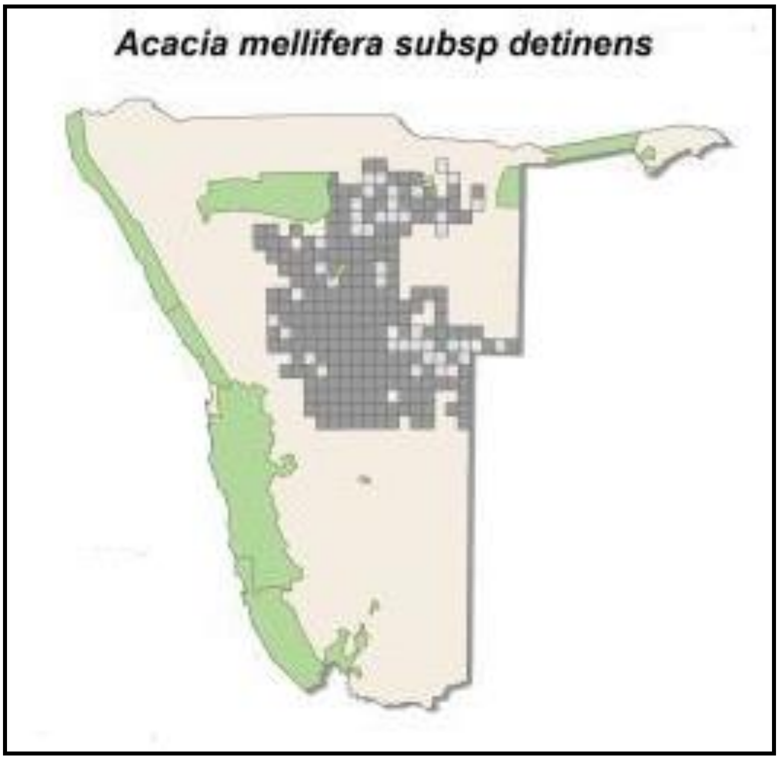
The integrity of a savanna system is controlled by primary factors such as climate and soil, and secondary factors such as fire and the impact of herbivores (Smit et al. 1999). This results in a sensitive balance between the herbaceous and woody components of a savanna ecosystem (Huttich 2011). When this balance is disrupted, the herbaceous layer is compromised and bush encroachment occurs (Joubert et al. 2008). Disruption occurs mainly through the modification of the secondary factors by management methods (Smit et al. 1999). This is true for Namibia as changed fire regimes and overgrazing are considered to be the major causes contributing to bush encroachment (De Klerk 2004).

Fires are considered to play a major role in keeping the balance between trees and grass in savannas and it is believed that fire suppression has contributed to the current bush encroachment issue that Namibia faces (De Klerk 2004; Rothauge 2007). High intensity fires are believed to control bush species in the seedling stages (De Klerk 2004; Zimmermann et al. 2008). However, the Soil Conservation Act, No. 6 of 1949, prohibited the burning of veld in commercial areas (De Klerk 2004). The act created a strong fire avoidance behaviour amongst farmers that is still present today and fires are stopped whenever possible. This complicates rangeland management, especially during periods of above average rainfall when bush encroacher seedlings are established (Holz & Bester 2007; Joubert et al*.* 2014).

Bush encroachment is further encouraged by a decrease of browsers that are believed to have played a part in keeping *Acacia* species under control (De Klerk 2004; Zimmermann et al. 2008). Other factors thought to have prevented bush encroachment prior to commercial livestock production are the presence of large ungulates, such as elephants, that cause mechanical damage to bush, more competition from grass and frost (Trollope 1980).

Bush encroachment has an effect on the water table of an area and can lower the amount of water available to other plants and decrease the recharge rate of aquifers (De Klerk 2004). The major specie causing bush encroachment in the central regions of Namibia is *Acacia melifera subsp detinens* (blackthorn) (Bester 1999). Blackthorn uses seven times more water than fodder bushes such as *Grewia flava*, which can cause a water deficit on farms that are heavily encroached and result in artificial droughts (De Klerk 2004). This fact is a major problem for the driest country south of the Sahel (Kruger & Kressirer 1996).

Approximately 30 million hectares (31,5% of total land surface area) of central and northern Namibia is currently bush encroached (MAWF 2012). See Figure 2.3 for the full extent of encroachment by *Acacia melifera subsp detinens.*




Source: Adapted from SAIEA (2015)

**Figure 2.3: Extent of encroachment by *Acacia mellifera subsp detinens* in Namibia**

Blackthorn is considered to be an aggressive encroacher as it has the ability to outcompete other plant species and thereby change the structure of the vegetation from heterogeneous to largely homogenous areas (Bester 1999). One positive factor regarding this encroacher specie is that it will only form new stands in the event of three consecutive years of above average rainfall (Joubert et al. 2008). Farmers should therefore intensify their efforts to control bush after such an above average rainfall period and before juvenile plants become established (Holz & Bester 2007).

Bush play a vital role in the savanna ecosystem by providing shade for desirable grass species, increasing soil fertility, supplying browse for game and preventing soil erosion (De Klerk 2004). Bush should therefore never be erradicated completely. The Ministry of Agriculture, Water and Forestry (2015) has recently introduced a bush control licence that needs to be obtained by farmers who wish to control bush on their farms. This is a step in the right direction in order to regulate control methods and to obtain data on areas undergoing treatment. Hopefully, the need for a licence will not discourage farmers from practicing bush control.

SAIEA (2015) estimates that some 45 million hectare of Namibia is affected by bush encroachment, resulting in a decrease in the productivity of the land by more than 100% (De

Klerk 2004). Farmers therefore desperately need to control bush on their farms in order to maintain and possibly increase their carrying capacity.

The methods of control that are available – chemical, biological and mechanical control (De Klerk 2004) – will be discussed in the following sections.

#### *2.2.3.2.1 Chemical control*

Several generic arboricides are available. The most commonly used types contain the active ingredient Tebuthiuron or Bromacil or a combination of both (Honsbein et al. 2012). Chemical control can be administered through manual application (soil applied and plant applied) or aerial spray; each method having its advantages and disadvantages as tabulated in Table 2.1.

Aerial treatment of bush has recently become a prohibited form of bush control (Republic of Namibia 2015) as this method kills non-target protected species (SAIEA 2015).

**TABLE 2.1: ADVANTAGES AND DISADVANTAGES OF DIFFERENT CHEMICAL TREATMENT OPTIONS TO CONTROL BUSH ENCROACHMENT**

| Method | Advantages | Disadvantages |
|---|---|---|
| Soil applied | • Rapid<br>• Supresses seedling regeneration for up to five years<br>• Use small quantities therefore least expensive | • Can affect trees not chosen for treatment<br>• Slow acting method that needs rain to carry it into the soil profile, can take two years for plants to die<br>• Nutients remain trapped in dead trees for a long time<br>• Treatment on soils with high clay content can be ineffective<br>• Large numbers of dead standing trees are unattractive to tourists |
| Plant applied | • Selective, with very little chance of untreated trees being affected<br>• Trees that are cut back and treated die immediately<br>• Trees can be harvested and used to recover costs of treatment, for example charcoal production<br>• Result is aesthetically pleasing | • Time-consuming<br>• Labour intensive and expensive |
| Aerial application | • No individuals escape treatment (can be a disadvantage)<br>• Large areas covered rapidly<br>• Little labour needed | • Expensive, only viable in cases where woody plants are very dense<br>• Method is non-selective so valuable plants may be affected |

Source: Smit et al. (1999)

Although chemical treatment is effective in treating the bush encroachment problem in Namibia, the possibility of negative impacts on the environment cannot be ignored. It is only with long-term studies and monitorring that it would be possible to determine the full environmental impact of chemical use in Namibia. In the meantime farmers need to be vigilant and monitor their veld closely.

Some concerns include the toxic effect of Tebuthiuron on small mammals, which was found to be slightly toxic to small mammals when ingested and highly toxic via inhalation (Honsbein et al. 2012). Bromacil was found to have a toxic effect on dogs when ingested (Honsbein et al. 2012). A toxic effect on other carnivores that occur in the study area can therefore not be excluded. Bromacil is also toxic to birds at high dosages (De Klerk 2004). These toxic effects are a concern as the chemicals stays on the soil surface until sufficient rain can carry in into the soil profile (Smit et al. 1999) and thereby exposing wildlife to possible toxic effects.

Another concern is the effect that arboricides might have on soil conditions. Soil formation and development is typically slow in dryland areas and should be promoted wherever possible. Disregarding soil conservation is a major driver of desertification (MEA 2005). Due to a lack of moisture in drylands, microbial and arthropod diversity is low, making these populations sensitive to disturbances (Wall & Virginia 1999). Honsbein et al. (2012) conducted a desk-top study on the possible environmental effects that Tebuthiuron and Bromocil might have in Namibia; however, it is only with intensive research that it could be determined whether or not these common arboricides have a detrimental effect on soil quality. It would be disasterous for an arid country such as Namibia if they did.

Tebuthiuron has no long-term toxicity in surface water (Honsbein et al. 2012). However, Bromacil can contaminate groundwater and should therefore never be used near drinking water or recharge areas (Honsbein et al. 2012). This fact is alarming as approximately 40% of Namibia’s fresh water supply is derived from groundwater sources (Dirkx et al. 2008).

Chemical treatment is by no means a once-off solution. A sound follow-up treatment plan is needed to sufficiently curb the problem of bush encroachment (De Klerk 2004; Honsbein et al. 2012; Smit et al. 1999).

#### *2.2.3.2.2 Biological control*

**a) Fire**

Fires are natural occurrences that shaped the structure of savannas and prevented bush encroachment prior to commercial livestock production (Trollope 1980). Fire is, however, rarely used by commercial farmers as a management tool due to behavioural customs created by past policies (De Klerk 2004), temporary loss of grazing, the perceived economic losses resulting from burning (Trollope 1980) and concern over legal implications from runaway fires (Joubert et al. 2014). The use of fire is considered to be the most economically viable method in controlling bush encroachment (Trollope 1980). However, De Klerk (2004) does not consider fire as an option for farms with high bush densities as a minimum of 1 500 to 2 000 kg of grass per hectare is needed for a burn to be effective, and most mature bushes will survive the fire and coppice. The author recommends stem burning for these cases. He further recommends that burning should rather be used as a follow-up treatment and maintenance on areas prone to bush encroachment (De Klerk 2004).

**b) Browsers**

Smit et al. (1999) do not consider browsing by game (except for elephants) as an effective means to control bush encroachment. However, they recommend that boer goats can be used effectively as their browsing frequency and intensity can be controlled; however, their use is not popular as they require a high level of management and adequate fences. On the other hand, De Klerk (2004) is of the opinion that boer goats are not suitable for high density encroached areas, but are most effective when used as a follow-up treatment. The use of goats will also add to a farmer's total meat production.

#### *2.2.3.2.3 Manual and mechanical clearing*

**a) Manual (stumping/felling)**

Stumping or felling involves bush being removed above ground by using axes, handsaws or chainsaws. The harvested wood can then be used for charcoal production to reclaim costs. This method, however, results in coppicing and it is not sufficient to restore rangeland for livestock production unless aftercare methods are used. Manual removal of bush is labour intensive and will contribute towards job creation in Namibia (De Klerk 2004).

**b) Mechanical (bulldozing)**

A bulldozer is used to remove trees and often their roots as well. However, soil disturbance with this method can be severe, leaving a soil condition that is only suitable for unpalatable species, and often bulldozed areas can become more encroached than it was before. This method is therefore not generally recommended (Smit et al. 1999).

#### *2.2.3.2.4 End-use opportunities for encroacher bush*

The methods of control discussed can greatly increase a farmer's input costs and it is therefore essential for farmers to find a way to regain some of those costs, and possibly even make a profit from the wood from encroacher bush. Production costs of cattle farms increased by 120% during 2007-2015; however, the price of beef only increased by 73% (SAIEA 2015). This puts farmers without an additional income at risk of not being able to sustain their bush control efforts.

Trede and Patt (2015) have identified end-use opportunities for the 260 to 300 million tonnes of biomas available from encroacher bush that will turn this major environmental problem in Namibia into an asset. Their study indicates that once sound industries have been established, encroacher bush can be used for purposes such as residential fire wood, industrial heat and power generation, construction materials, indoor wood products, pulp and paper and agricultural purposes such as compost and animal feed. Using encroacher bush as animal feed will be particularly valuable to livestock farmers, especially during droughts.

## 2.3 Coping with Drought

Namibia's climate is typical of drylands where rainfall is highly variable in space and time and can differ drastically from one year to the next with drought occurrence being inevitable (Hutchinson 1995). Farming methods therefore need to be highly adaptable and farmers need to be prepared in order to counteract the effects of below average rainfall periods. Preparation requires careful planning well in advance of the next drought period. As rainfall fails in a drought year, many farmers find themselves helpless as their grazing capacity rapidly decreases. Rothauge (2001; 2007) provided some drought management strategies in the form of establishing grazing reserves, building a fodder bank and maintaining a herd that would be easy to destock when necessary. The need for income diversification as a means to cope with drought will also be considered.

### 2.3.1 Grazing reserve

The establishment of a grazing reserve is not only considered as a principle of sound rangeland management, but it is an essential drought preparation strategy (MAWF 2012). Through grazing management, farmers can build up a grazing reserve by resting a portion of the veld and allowing a healthy grass sward to develop as backup when the grazing capacity decreases in times of drought (Rothauge 2001).

Resting enables the establishment of a healthy grass sward in the following ways: it allows grass to develop and complete processes necessary for their sustained health (Tainton & Danckwets 1999); it allows organic matter to build up and increase soil cover; seed production is maximised and seedling establishment is promoted (MAWF 2012). Depending on the farm size and aridity of the area, at least one third to one quarter of the farm should be rested for a complete growing season, allowing the grass to recover from grazing pressure (Rothauge 2007). Tainton and Danckwets (1999) recommend that even if no other grazing management systems are implemented, veld should never be grazed without appropriate resting periods. Rothauge (2007), however, believes that resting can be problematic for smaller farms and grazing reserves might not be a viable drought preparation strategy for them.

### 2.3.2 Building a fodder bank

Another method available to create a buffer against the effects of drought is establishing a fodder bank, which should be built up during years of above average rainfall and used as supplementary feeding during periods of drought. Approximately 10% of the ranch area should be dedicated to this purpose, at least 5% of the rangeland should consist of cultivated dryland pastures of indigenous grasses, and another 5% should consist of exotic or indigenous drought resistant fodder crops (Rothauge 2001).

Indigenous perennial grass species such as *Cenchrus ciliaris* or *Anthephora pubescens* are adapted to local climatic conditions and commonly used for cultivated pastures on fertile soils (Rothauge 2007).

Drought resistant fodder crops such as exotic *Opuntia* spp. and *Aloe* spp. can be planted and used during a drought (Rothauge 2007). The use of exotic fodder crop species do, however, pose a threat if they become invasive (Sweet & Burke 2006). This is especially true for cattle and bird dispersed species such as *Opuntia* spp., which have invaded semiarid rangelands in South Africa (Milton et al. 2003). Possible invasion by *Opuntia* spp. is already a concern for the Namibian government that have listed *Opuntia* spp. as one of ‘Namibia’s Nasty Nine’ (Bethune et al. 2004). The use of indigenous fodder crop species remains to be investigated (Rothauge 2001).

Many farmers buy hay during a drought, which greatly increases their input costs and increases their risk of not being able to financially sustain the costs associated with a drought. The national demand for fodder can range from 10 000 tons per annum in a normal rain year to 150 000 tonnes per annum when a drought occurs (Trede & Patt 2015). The

Namibian government previously subsidised fodder during times of drought, but have ceased doing this so that farmers are encouraged to build up their own fodder reserves and to discourage overstocking during times of drought (Sweet & Burke 2006). It is therefore vital for farmers to produce fodder on their farms. The start-up costs associated with fodder production could, however, dissuade farmers from establishing cultivated pastures. Horsthempke (2000) produced a 20-year cost-benefit analysis of planting cultivated pastures of *Cenchrus cilliaris* and concluded that it is not financially viable. Zimmermann (2009), however, reported that there are farmers that have planted cultivated pastures and have not been disappointed.

On the other hand, there might be an alternative solution for farmers that do not have the means or suitable landscape to plant cultivated pastures. This alternative could also solve the major issue of bush encroachment. It is becoming increasingly evident that encroacher bush can be used as livestock fodder (Trede & Patt 2015). The Support to De-bushing Project is a bilateral cooperation between Namibia's Ministry of Agriculture, Water and Forestry and Germany's Gesellschaft für Internationale Zusammenarbeit (GIZ). The project is currently researching methods to use encroacher bush as animal feed. Harvested bush is used as the main ingredient and is mixed with supplements to increase the nutitional value and digestibility of the feed (De-bushing Advisory Service [DAS] 2016). The bush-to-feed initiative is in its pioneer phase, but some commercial farmers have already had remarkable success and in many cases this form of fodder has been the only viable option as emergency feed during drought (DAS 2016). Hopefully in the future, farmers will make use of this unique method to increase their drought preparedness and in the process find value from their encroacher bush.

### 2.3.3 Stocking rate and de-stocking

A major factor that contributes to the degradation of rangelands is whether farmers adapt their management methods during a drought, especially in terms of stocking rate that should be decreased if the rains are late or if a below average rainfall season is evident. However, destocking to acceptable levels is not a common practice in Namibia (Rothauge 2007). With the first signs of drought, a farmer should reduce his stocking rate immediately. In order to do that, Rothauge (2001) advises farmers to allocate one third of their total herd size to filler stock. Filler stock are animals that are not yet reproductive, animals growing out to be slaughtered or castrated animals that do not contribute to the main breading herd. These animals can be more readily sold during periods of drought as the farmer is not as sentimentally or economically attached to them. Removing filler stock will, therefore, allow more feed to be available to the main breeding herd and decrease the pressure on the rangeland during drought, thereby preventing further degradation (Rothauge 2007).

Commercial cattle farmers in the Highland Savanna have an added advantage compared to cattle farmers in other regions of Namibia as they have easy access to processing facilities in Windhoek and Okahandja (Mendelsohn et al. 2006). This fact gives farmers in the area an opportunity to react fast to price incentives and to destock readily during years of below average rainfall (Von Bach et al. 1992).

After a drought has occurred, farmers need to restock their cattle herd. However, veld is sensitive after drought and restocking too quickly, as many commercial farmers do, can increase desertification as the veld is not given enough time to recoup (Ward et al. 2004). Farmers should wait until sufficient rains have fallen and the vegetation has been given adequate time for growth before restocking (Rothauge 2001).

### 2.3.4 Income diversification

A farmer's level of risk to the negative impacts of drought can be determined by their level of dependence on cattle farming for their annual income. Other off- or on-farm activities that contribute towards the annual income of a farmer can create a buffer against the negative economic impacts of a drought. Farmers that do not have any other income generating enterprises and rely heavily on cattle farming as an income, will be more reluctant to destock their farms during years of drought. Therefore, income diversification will promote sustainable rangeland management. Namibia's NRMPS advocates the need for farmers to diversify their sources of income in order to avoid increased grazing pressure during drought (MAWF 2012). Income diversification will also help farmers decrease their vulnerability to the effects of climate change. Income diversification through wildlife utilisation will be discussed further in the next section.

## 2.4 Climate Change

Namibia is considered as one of the countries that is most susceptible to the negative effects of climate change (MET 2011). Predictions show that Namibia's already arid climate will become hotter and drier. Namibia's temperatures have already shown to be increasing at a rate that is three times higher than the global mean temperature increase for the twentieth century (Reid et al. 2007). The occurrence of drought will also increase (Dirkx et al. 2008; Niang et al. 2014) and when rain does come it will likely be more intense, resulting in an escalated risk of erosion and floods (Reid et al. 2007). Predictions for the central regions of

Namibia are of particular concern. Temperatures in this region will increase by 2 °C to 6 °C by 2100 and rainfall will decrease by 30% by 2080 (MET 2011). Severe reductions in rainfall will be particularly apparent in Windhoek and the surrounding highlands (Midgley et al. 2005).

The predicted climatic changes will affect the reproductive abilities of fauna and flora as they increasingly find themselves outside of their normal ranges (MacGregor et al. 2006). A significant impact on the ecosystem structure and function of Namibia's rangelands is therefore inevitable. Midgley et al. (2005) predicted that by 2050 much of Namibia's vegetation cover and net primary productivity will be significantly reduced. These authors also proposed that Namibia's biodiversity is vulnerable to the effects of climate change and that 30% to 40% of plant species could become critically endangered or extinct by 2080. Mammal species will also be affected, increased aridification could cause extinction of three mammal species and a decline of ranges for ten species and range increase for two species (Reid et al. 2007).

The livestock industry will also be directly affected as pressure from vectors and diseases are expected to increase with climate change (Niang et al. 2014). It will also become increasingly difficult to supply livestock with adequate water as climate conditions become hotter and drier (Niang et al. 2014).

These effects are likely to have an effect on the Namibian economy and increase the vulnerability of farmers. Once more, the need for cattle farmers to adapt current rangeland management methods and to diversify their income is emphasised.

### 2.4.1 Effects on the economy

Reid et al. (2007) used a computable general equilibrium model to measure the economy-wide and welfare distribution effects that climate change will have on the production of sectors that rely on natural resources. Data from 2002 was used to model best and worst case scenarios of possible effects. The authors calculated a total productivity loss of livestock production ranging from 20% to 50%. This will not only have an effect on the economy and welfare of individual farmers, but will also have social impacts in Namibia caused by inevitable job losses. Agriculture remains the most important employment industry in Namibia, providing jobs to 27% of the country's workforce (Brown 2009). The impending loss to the livestock industry makes the Namibian Government and its people highly vulnerable to the effects of climate change. It is therefore vital for farmers to consider other income generating options available to them and for government to provide supporting policies that address the issues of climate change. The Namibian Government has recently honoured the National Agricultural Policy

### 2.4.2 Vulnerability

One of the most pertinent issues regarding climate change is the effect that it will have on food security; the increased climate extremes that Africa will continue to experience will decrease farmers' ability to produce food (Reid et al. 2007). Furthermore, the Namibian economy is highly dependent on natural resources (MET 2011), making the country especially vulnerable to the effects of climate change. Leary et al. (2006), however, found that the adverse effects of climate change are significantly less where social, economic and governance systems support effective responses that enable affected populations to prevent, cope with, recover from and adapt to changes. The Namibian Government has already confirmed its commitment to overcoming the adverse effects of climate change by being one of the few countries in Africa that has constructed a climate change policy (Niang et al. 2014). The National Policy on Climate Change is, however, not confident that Namibia can effectively adapt to climate change effects due to its high dependence on natural resources and low economic growth (MET 2011). Any government intervention will also likely first concentrate on the highly vulnerable subsistence farmers. Commercial cattle farmers should therefore not rely on the government to implement climate change adaptation strategies, but rather take this task upon themselves. Applicable policies can be used as a guideline to prevent, cope with and recover from the adverse effects of climate change.

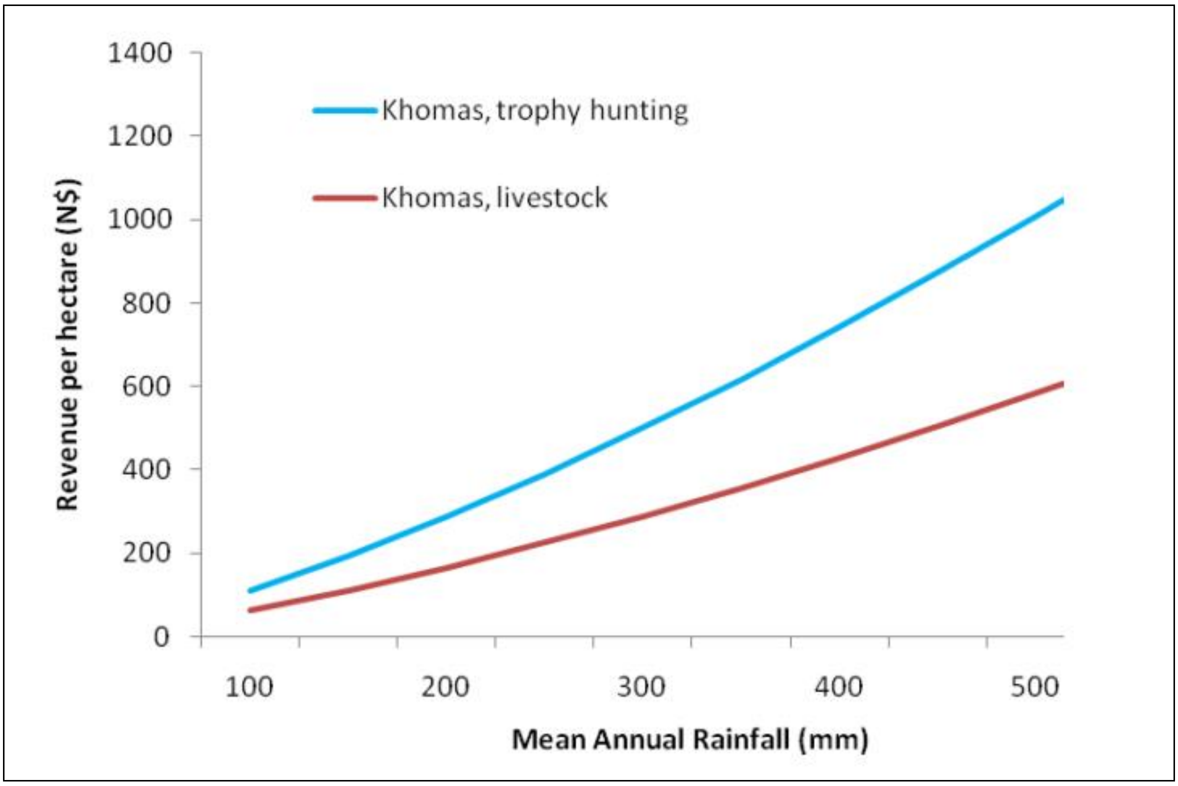
Farmers that largely depend on cattle farming for their income will find themselves more vulnerable to the adverse effects of climate change. They will also more likely deal with drought on an *ad hoc* basis, thereby decreasing their ability to cope with and recover from periods of water scarcity.

### 2.4.3 Need for diversification

Diversification of livelihoods will directly decrease vulnerability to the effects of climate change (Niang et al. 2014). This is especially true for Namibia, as much of the country's agricultural land is already marginal and the predicted aridification caused by climate change (Midgley et al. 2005) could make any form of agriculture unfeasible in the near future. It is therefore of utmost importance that cattle farmers diversify their farm's income. Rangelands provide an ideal habitat for wildlife and populations have increased by up to 100% between 1970 and 2000, whereas livestock numbers have decreased by 45% during the same period (Barnes et al. 2009). Namibia's wildlife stock is comparable to the fish, minerals and forest stocks and was estimated to have a value of N$10.5 billion in 2004 (Barnes et al. 2009). This provides farmers with an opportunity to diversify their income through consumptive and non-consumptive wildlife use. However, care should be taken when farming with wildlife, as they continuously graze rangelands and cannot be moved as easily as livestock, thereby preventing grass from experiencing essential rest periods. Highly overgrazed game farms are a common sight in Namibia. To prevent this from happening farmers need to be conscious of their carrying capacity and control game populations with the fluctuating rainfall.

Barnes et al. (2009) calculated the value of wildlife use in Namibia for 2004 to have a gross output of N$1.5 billion and contributing N$700 million to the Gross National Product (GNP), which represented 2.1% of the GNP. The authors found that wildlife viewing tourism proved to be the most significant contributor by providing 62% of the total wildlife sector's GNP input, with hunting tourism providing 19% and of the hunting tourism contribution, and trophy hunting contributed 97%.

There is no doubt that climate change will have a significant impact on Namibian rangeland productivity (Midgley et al. 2005). The most viable methods of income generation and water use should therefore be pursued. Brown (2009) found trophy hunting to be a significantly more efficient and viable form of land use per millimetre of precipitation when compared to livestock farming (Figure 2.4).




Source: Brown (2009)

**Figure 2.4: Effect of rainfall on revenue generated per hectare for livestock production and trophy hunting in the Khomas region**

Efficient water use will become increasingly significant, especially in critical times of drought. The GRN (2004) found that water used for agriculture had a very low value of N$7.2/m³ as opposed to tourism which had a value of N$574/m³.

Climate sensitive sectors such as livestock farming can be substituted or complimented by tourism in the central region of Namibia. Reid et al. (2007) proposed that tourism can increase by up to 20% in this area. Tourism does, however, rely on diverse and intact ecosystems and climate change could therefore pose a risk for tourism growth (MET 2011). This fact should not deter cattle farmers from making use of wildlife, especially as Barnes et al. (2009) predicted that wildlife use values will triple over the next 30 years.

## 2.5 Conclusion

From this chapter, it was determined that rangeland degradation is a complex issue in Namibia with several interrelated factors that have severe impacts on rangeland function and productivity. The causes of degradation are predominantly because of past and current unsustainable rangeland management. Bush encroachment is the most severe symptom of degradation and the methods available for bush control can be detrimental to rangeland ecosystems in Namibia. From a review of the literature it was found that farmers are vulnerable to drought. However, several methods are available for farmers to use that will help them to prepare for and cope with the effects of drought. Sufficient evidence indicates that Namibia is at high risk to significant climatic changes. These climatic changes, along with the current rates of degradation, will greatly affect rangeland productivity. Cattle farming may therefore not be viable for many farms that are already marginal; commercial cattle farmers are therefore advised to diversify their income. The next chapter will provide a description of the study area where data were obtained for this survey.

*Chapter 3*

# DESCRIPTION OF STUDY AREA

## 3.1 Introduction

In the previous chapter, a review of the literature provided insight on the causes and consequences of rangeland degradation in Namibia. It was found that unsustainable rangeland management practices could significantly contribute to degradation. In order to gain insight on the management methods used by commercial cattle farmers, a survey of the methods used was conducted. It is beyond the scope of this study to survey the whole of Namibia, therefore, one vegetation type, the Highland Savanna, was chosen. The Highland Savanna falls within the main cattle ranching system of Namibia. The capital city, Windhoek, is within the borders of this vegetation type, which made it easier to reach respondents.

The structure of Namibia's vegetation map will be discussed in this chapter, followed by a short description of the relevant factors that influence the ecosystem of the study area. These factors include natural occurrences such as topography and soils, climate, plants and animals and anthropogenic factors such as land ownership.

## 3.2 Vegetation Map

Namibia's vegetation is highly influenced by rainfall; this is evident when considering the tall lush plants found in the north-east and the short and sparse plants of the west and south. However, when constructing a vegetation map botanists are able to distinguish between distinct vegetation types based on the soil types and topography that also influence vegetation type and structure (Mendelsohn et al. 2002).

Giess (1971) produced the first vegetation map of Namibia. His map delineates 15 distinct vegetation types into three biomes. The study area, known as the Highland Savanna, was first identified by Giess (1971). Mendelsohn et al. (2002) updated the original map to include 29 vegetation types in six biomes (Appendix A), leaving the area of the Highland Savanna from Giess's original map unchanged. The Highland Savanna vegetation type falls under the Acacia Tree-and-shrub Savanna biome as described by Mendelsohn et al. (2002), which is characterised by open grasslands and scattered *Acacia* trees. The dominant vegetation structure in the Highland Savanna is shrubs and low trees.

## 3.3 Topography and Soils

The Highland Savanna is situated in central Namibia and spans over 45 000 km², making up 5.5% of Namibia's total land surface area (Joubert et al. 2008). The dominant soil types are lithic leptosols, which are generally shallow (Joubert et al. 2008) and eutric regosols (Mendelsohn et al. 2002). The area is undulating with altitudes ranging between 1 350 to 2 400 m above sea level (Joubert et al. 2008) and the dominant landscape is the Khomas Hochland Plateau (Mendelsohn et al. 2002).

## 3.4 Climate

### 3.4.1 Rainfall and evaporation

The long-term mean annual rainfall of Windhoek (which is central to the Highland Savanna area) is 361 mm (Joubert et al. 2008), making the area unsuitable for crop production (GRN 2004), but suitable for cattle production which requires more than 300 mm of precipitation annually (Von Bach et al. 1992). Rainfall in the study area ranges between 250mm and 400mm per annum (Mendelsohn et al. 2002). As with much of Namibia, rainfall in the area is highly variable and seasonal with 80% of the rainfall occurring over only three months period between January and March (Joubert et al. 2008). The study area is expected to have a low annual rainfall of 100−200 mm every 14 years (Mendelsohn et al. 2002).

The annual evaporation rates for the study area range between 2 100 and 2 240 mm resulting in a massive water deficit of 1 500 to 1 700 mm each year (Mendelsohn et al. 2002).

### 3.4.2 Temperature

According to Mendelsohn et al. (2002) the average maximum temperature for Windhoek and the surrounding highlands is between 30 °C to 34 °C. Average minimum temperatures during the coolest months range between 2 °C and 8 °C with 10 to 30 frost days per year.

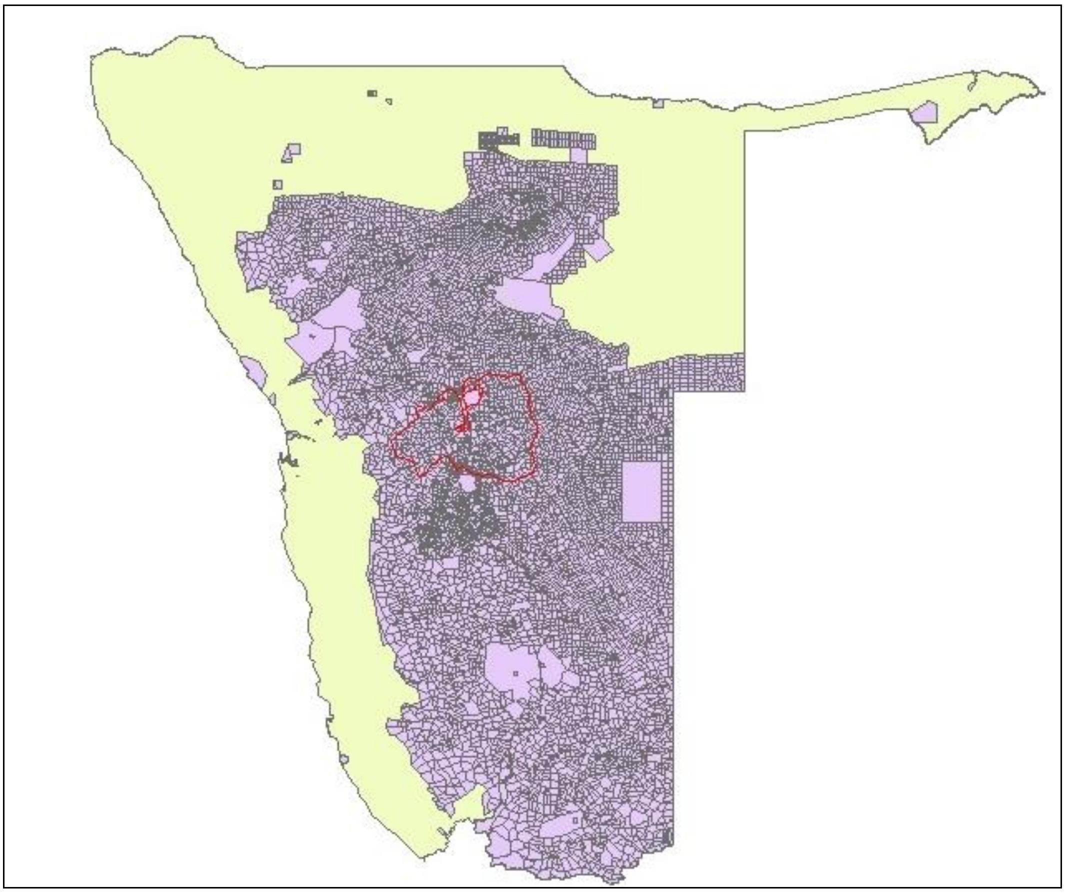
## 3.5 Plants and Animals

Mountainous areas such as the Highland Savanna consist of various types of geology that result in numerous microclimates which provide ideal conditions for different plant species to flourish (Mendelsohn et al. 2002). The Highland Savanna therefore has areas of remarkable plant diversity. The area also has numerous endemic plants, including local endemics that do not grow anywhere else (Mendelsohn et al. 2002).

According to Mendelsohn et al. (2002) the variety of habitats found in the study area provide a home for more than 230 bird species (7 endemic species); approximately 75 mammal species (6 endemic species) and approximately 80 reptile species (20 are endemic).

## 3.6 Freehold Land

The subjects surveyed for this study are commercial cattle farmers on freehold land. Privately owned farm land extends over 356 533 km² in Namibia (see Figure 3.1), consisting of 43% of the country's total land area (Mendelsohn et al. 2006).



Source: Map produced with ESRI ArcGIS using data provided by the MAWF

**Figure 3.1: Map of Namibian freehold land with the study area outlined in the centre**

The colonial era resulted in two agricultural sectors of land-ownership, the communal sector with unsecure land tenure and the commercial sector, with secure tenure of the land they own (Mendelsohn et al. 2006). Almost all commercial farms are owned by white farmers (Odendaal 2006). The respondents will therefore be white and of German or South African (Afrikaans) descent.

The study area falls in the cattle ranching system as described by Mendelsohn et al. (2006) where cattle are farmed for beef production and mostly exported or sold locally. Many cattle farmers have been practicing mixed game and cattle farming since the 1970s (GRN 2004).

## 3.7 Conclusion

The Highland Savanna comprises only a small percentage of Namibia, but it has an exceptional level of diversity of fauna and flora. The study area also has a high rate of terrestrial endemism, including a few plants that are locally endemic. Conservation of this area is therefore crucial. The study area, however, lacks formal conservation areas and is mostly under freehold ownership, placing the responsibility for the conservation of this unique vegetation type on the farmers.

In order to critically analyse the farming methods used by commercial cattle farmers a survey needs to be done. In the next chapter a detailed description of the methodology used in the study will be provided.

*Chapter 4*

# METHODOLOGY

## 4.1 Introduction

Leedy and Ormrod (2010:2) define research as “a systematic process of collecting, analyzing, and interpreting information (data) in order to increase our understanding of a phenomenon about which we are interested or concerned”.

This study aimed to not only answer the research questions of whether farmers in the study area are contributing towards land degradation/desertification and whether farmers are increasing their vulnerability to drought and climate change, but also to critically analyse the findings and make recommendations based on the findings. In order to do that the following objectives needed to be reached:

1. To determine if farmers are using farming practices that could contribute to degradation, for example over-stocking.
2. To assess if farmers are increasing their vulnerability to the effects of DLDD and climate change, for example high dependency on cattle as a primary source of income, with no drought preparation strategies in place.
3. To identify factors that prevent sustainable rangeland management, for example issues with markets, lack of updated knowledge, time and money to control bush encroachment.
4. To identify perceptions of farmers on land degradation and the condition of rangeland on their farms.

To reach these objectives, data were collected using a questionnaire and analysed by means of descriptive statistical analysis.

This chapter aims to outline the methodology used throughout the study. The advantages and disadvantages of questionnaire use will be considered, as well as the steps taken to construct the questionnaire. Informal methods used to determine the sample population size will be discussed. The data collection, as well as limitations with the data collection process, will be discussed, along with the data analysis methods.

## 4.2 Questionnaire

In this section, the reasons for choosing to use a questionnaire as a data collection tool as opposed to face-to-face interviews will be discussed in the advantages section. The disadvantages of using a questionnaire will also be outlined, followed by a discussion of the steps taken to set up the questionnaire.

### 4.2.1 Advantages

The use of a questionnaire allows the answers given by the respondent to be free from bias, respondents can choose to give the answers in their own words (Kothari 2004). This was an important reason for using questionnaires as opposed to interviews as the researcher already had her own perceptions of the study problem and personally knows many of the farmers. By taking herself out of the equation, more honest and applicable data could be received.

Questionnaires are a cost-effective tool used by researchers to reach respondents that are inaccessible (Babbie & Mouton 2014). By using a questionnaire, the researcher could reach farmers that would have been otherwise difficult and expensive to reach if face-to-face data collection approach such as interviews were used.

A questionnaire allows respondents to answer questions in their own time. An interview situation can put respondents on the spot and often results in over-exaggerated answers that undermine the quality of data (Kothari 2004).

### 4.2.2 Disadvantages

The response rate of questionnaires is typically low (Kumar 2011). This limitation was addressed by keeping in contact with respondents via email and telephone and enquiring whether the respondents had any issues or questions regarding the questionnaire.

Once a questionnaire is sent out to the respondent, a researcher loses control over it (Kothari 2004). This limitation will be discussed under section 4.5.

Questionnaires often result in ambiguous replies or answers being left out and interpretation of ambiguities and omissions can be difficult (Kothari 2004). This limitation will also be discussed under section 4.5.

### 4.2.3 Formulation of the questionnaire

#### 4.2.3.1 Literature review

A literature review is fundamental to any research in that it helps a researcher to develop a theoretical and conceptual framework. A literature review helps to place a study in perspective with what others have researched about the issue and helps to improve the methodology (Kumar 2011).

The literature review played a crucial part in the development of the questionnaire. The researcher was able to identify management methods that are pertinent to the DLDD issues that Namibia faces. From the literature review three main themes were identified, which upon investigation, could determine whether farmers are prepared for and coping with the effects of DLDD and climate change or whether they are contributing to desertification / land degradation. The main themes are: carrying capacity and stocking rate, drought preparedness and coping strategies, bush encroachment and its management.

#### 4.2.3.2 Pilot study

A provisional questionnaire was handed to three farmers before it was distributed within the study area. The questionnaire was also sent to two experts in the field of rangeland management. Both experts replied with valuable comments and one farmer responded in the pilot study. Issues identified during the pilot study were addressed in the following ways: some questions were identified as unnecessary and were removed from the questionnaire, all open-ended questions were converted to closed-ended questions and possible answers were provided for farmers to choose from. This streamlined the questionnaire slightly, which was important as it was quite lengthy.

### 4.2.4 Questionnaire design

#### 4.2.4.1 The introduction

An introduction was provided explaining the scope of the study and providing guidelines for answering the questionnaire (See Appendix B). This was done to give farmers a background on what to expect from the questionnaire and to explain the purpose and relevance of the study. An introduction such as this is especially important when using a questionnaire in order to assure that quality data is obtained (Kumar 2011).

The respondents were assured of the confidentiality of the study and that their answers would only be used for the purposes of this study. This clarification was important as the researcher was employed by the MET at the time of the study and the respondents might think that their answers could be used for other purposes, for example answers concerning their income generated by wildlife use.

A map of the study area was provided with the introduction and farmers were asked to mark their farm on the map so that the researcher could produce a map of all the farms that were covered.

A list of some terminology was provided as part of the introduction in Appendix B. The terminologies were given so that farmers could familiarise themselves with terms that they might not be familiar with.

#### 4.2.4.2 The questionnaire

The questionnaire appears in Appendix C.

The questionnaire was designed with the intention to reach all the objectives and final aim of this thesis. It was divided into six sections, each section consisting of questions specific to the themes identified in the literature review, namely:

**Section 1:** Farmers' demography and on-farm income.

**Section 2:** Carrying capacity, stocking rate and rainfall data.

**Section 3:** Methods used to prepare for droughts.

**Section 4:** Coping and recovery strategies used to manage droughts.

**Section 5:** Perceptions of farm condition, bush encroachment and its management.

**Section 6:** Opinions of some statements regarding rangeland management.

The questionnaire consisted primarily of closed-ended questions. Closed-ended questions are questions that have a list of categories as possible answers whereby the respondent can choose one or several answers that most accurately relate to their situation. The researcher chose to use mostly closed-ended questions as they provide data that are easier to process and analyse and keep answers relevant to the study (Babbie & Mouton 2014). It is, however, not always possible to foresee all the potential response categories and it is for this reason that an open-ended category was made available for some questions, where respondents could add a category that might not be in the list provided.

A few questions were open-ended, requiring numerical answers, for example the size of the respondent's farm that was answered in number of hectare. In order to test respondents' knowledge and perceptions, some statements were presented with three options to choose from, namely ‘’agree, disagree or do not know’’.

## 4.3 Sample Population

Determining the sample population proved to be quite difficult as no population data specific to the study area was available. Two methods were identified to gain some clarity on the population size, namely contacting farmers’ associations in the study area to obtain a list of their members, or counting all farming units on the map available and estimating the number of farmers. The latter method was selected as it would be too time-consuming to contact all the farmers’ associations in the area. The former method would also not provide an accurate count, as some farmers might not be members of any association and some farmers might be members of more than one association.

A total of 194 farm units were counted in the map of the study area. Approximately 20% (39) of these farms are game farms and they do not farm with cattle at all, leaving approximately 155 cattle farms in the study area. Some farmers own more than one farm, and consequently the total number of farmers in the study area was estimated to be 120.

## 4.4 Data Collection

A self-administered questionnaire was used for the survey, where respondents answered and filled in the questionnaire themselves (Babbie & Mouton 2014).

Farmers are not easily accessible and therefore the researcher took advantage of her work situation to reach respondents. The researcher was at the time of the study a warden at the Permit Office of the MET in Windhoek and she came into contact with farmers on a daily basis. Cattle farmers in Namibia depend on natural rangelands for their grazing needs and all rangelands contain wildlife. Permits to utilize game species are applied for at the Permit Office of the MET.

The study was advertised at the reception of Permit Office in the first week of May 2016 and farmers were requested to come see the researcher should they be interested to take part in the survey or obtain more information. This proved to be too passive an approach, as two weeks passed without any response. The researcher then decided on a more active approach by contacting farmers that fall in the study area directly. As an employee of the MET the researcher had access to farmers’ contact numbers. The researcher first contacted farmers that she knows through her work as they might be more willing to take part in the study. The researcher also asked the farmers if they could put her in contact with other farmers in the area. Some farmers also sent the questionnaire directly to other respondents. A non-probability snowball sampling technique was therefore used as a data collection method (Babbie & Mouton 2014). The questionnaire was then either emailed to willing respondents or picked up from the researcher on their next visit to the MET.

Data collection took place during May and June 2016. In that time, the researcher personally distributed the questionnaire to 36 farmers who were willing to take part in the study. Two farmers' associations were also emailed who distributed the questionnaire amongst their members. Some farmers also sent the questionnaire to neighbouring farms. It is estimated that in total 70 farmers (58% of target population) were reached. It proved to be quite difficult to reach farmers via telephone as they were often in the field or their phone lines were out of order. Reaching them through email was also difficult as many farmers do not have email and the internet is also often out of order.

Once farmers had received the questionnaire, they were given time to complete it. The researcher was also available to answer any queries or to elaborate on a question that the respondents were unsure of. The farmers that the researcher was in direct contact with were contacted a few weeks after the questionnaire was sent to them to enquire if they had any issues with answering the questionnaire and to remind them about the deadline. Completed questionnaires were then emailed back to the researcher or delivered in person. Once all the questionnaires had been received, they were numbered for data capturing purposes.

## 4.5 Limitations Experienced with Data Collection

After the questionnaire was sent to the respective respondents, the researcher lost control over it. This was a limitation for this study as some respondents forwarded the questionnaire to farmers they know in the area. This resulted in one farmer, whose farm falls just outside of the study area, answering the questionnaire. It was only realised when the researcher contacted farmers who had not yet marked the position of their farm on the study area map; this was after data had already been entered and processed. However, this was not seen as a major limitation as the farm is very close to the border of the study area and the slight difference in vegetation and climate (if any) should not affect management methods.

Some ambiguities were found, for example, a question requesting farmers to give their stocking rate for both below average and above average rainfall years. The stocking rate for below average rainfall years should be lower than for above average rainfall, because no farmer would increase his or her stocking rate for years that receive below average rainfall. However, some farmers gave a higher stocking rate for below average rainfall and a lower rate for above average rainfall years. The majority of the farmers were contacted to enquire if they had mixed up the two values, which they confirmed that they had. When this data was entered into Microsoft Excel, it was assumed that the remaining few farmers had also mixed up the two values. The lower value was then entered under below average stocking rate and the higher value under above average rainfall years.

Some farmers also failed to answer all questions, this was also not deemed as an issue and they were simply omitted from the sample size of the results for that specific question.

## 4.6 Data Analysis and Reporting

Data were coded and captured in Microsoft Office Excel 2007.

In order to condense the results, they were presented in summary tables and only the most significant results were discussed. The results were mostly reported as percentages. When $N \leq 10$, the results were reported as raw data. Some data were also expressed through descriptive statistics.

Associations (correlations) between two variables of ordinal data were assessed by the Mantel-Haenszel Correlation Test. The relevant chi-square statistic (one degree of freedom in each case) was applied with associated P-value testing of null-hypothesis if no association (no correlation) between the two variables in question had been observed. Changes over time in quantitative variables were tested using the non-parametric Wilcoxon signed rank test for paired data. All analyses were carried out using the SAS/STAT Software version 13.1 (SAS 2013).

## 4.7 Conclusion

This chapter aimed to explain the methods used in the research process. The steps taken to construct the questionnaire were explained along with the methods to determine the sample population size. The methods used to collect data were explained and the limitations with data collection were discussed. Methods used to analyse and report the data were also explained.

The objectives were stated in the introduction of this chapter. The next chapter will address these objectives by analysing and describing the data that was collected. Recommendations on how farming methods can be adapted will also be made.

*Chapter 5*

# RESULTS AND DISCUSSION

## 5.1 Introduction

The previous chapter described the methodology used to collect and analyse data. In this chapter the data will be interpreted and critically analysed in order to reach the objectives set out for this study. Results will be related back to the literature discussed in the literature review chapter. Recommendations will also be made throughout this chapter as this will enable a grasp of the issue at hand and comprehension of the management changes that need to be made. The ultimate purpose of this chapter is to reach the aims and objectives set out for this study.

In this chapter, the questionnaire survey results will describe the survey sample of respondents and farms covered in the study. A description of the farmers' demographics, including income reliance on cattle farming, will then follow. The status and risks regarding carrying capacity and stocking rate of farms in the study area will be described and discussed. Data on the variation of rainfall in the study area will be illustrated. Drought preparation methods, as well as post-drought effects and management, will be analysed and discussed. Data gathered on methods used to control bush will be summarised and discussed. Lastly, farmers' perception of their farm's rangeland condition and general function will be discussed.

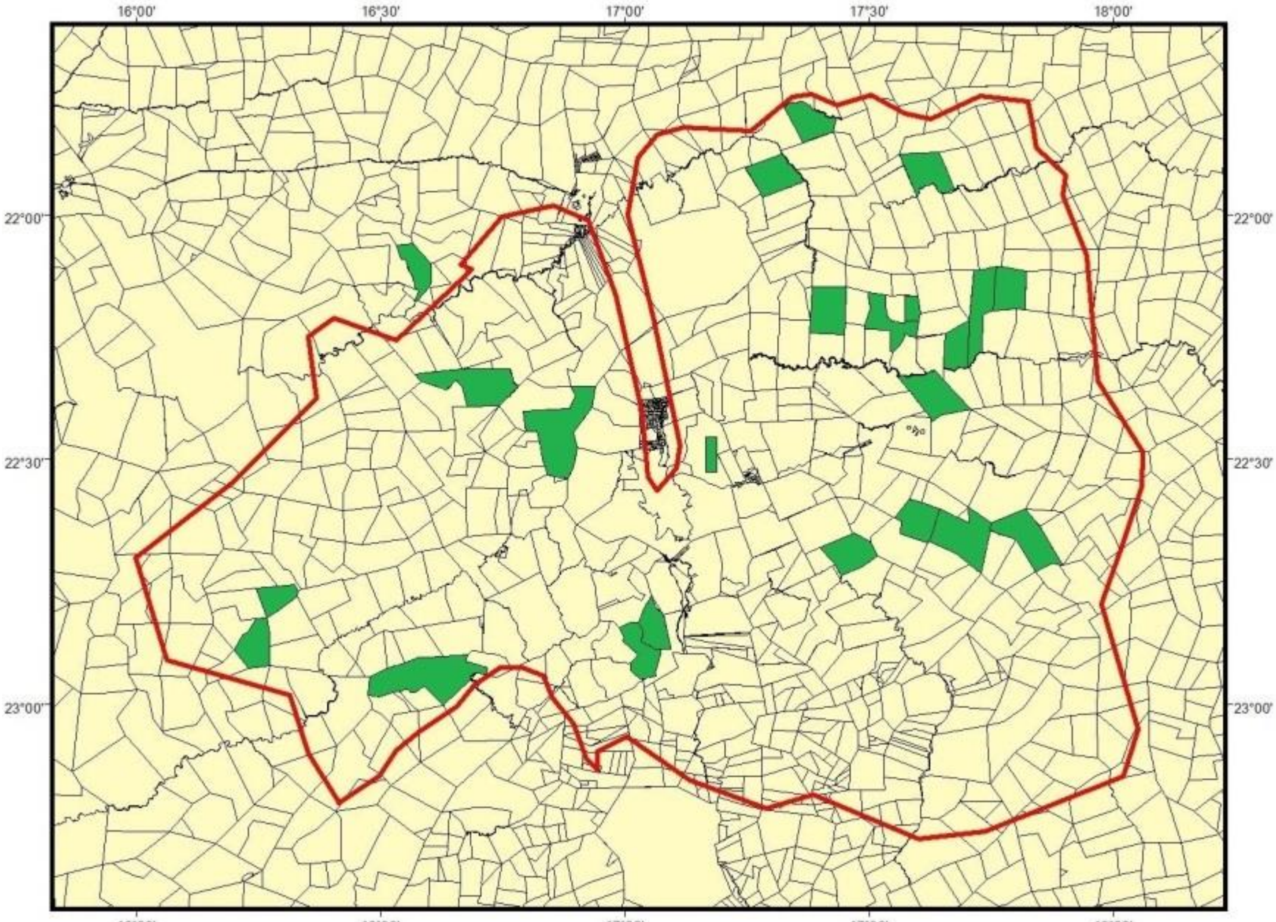
## 5.2 Questionnaire Survey Results

### 5.2.1 Survey sample

There are an estimated 120 commercial cattle farmers in the study area. Approximately 70 farmers received the questionnaire. A total of 21 respondents returned the completed questionnaires, giving a response rate of 30% and representing 18% of the 120 commercial cattle farmers in the Highland Savanna.

### 5.2.2 Farms covered in the study area

A total of 26 farms extending over an area of 160 303 ha (3,6% of total study area) in the Highland Savanna were covered by responses to questionnaires. Figure 5.1 is a map of the study area indicating the 26 farms covered in the survey. One respondent's farm falls just outside of the study area (as explained in 4.5).




Source: Map produced with ESRI ArcGIS using data provided by the MAWF

**Figure 5.1: Map of farms covered in the survey of the Highland Savanna**

## 5.3 Demographics

As seen in Table 5.1, the majority of the respondents were German speaking males between the ages of 46 to 55 with a diploma or bachelor degree education level.

**TABLE 5.1: SUMMARY OF RESPONDENT DEMOGRAPHICS**

| Characteristics | Percentage (N=21) |
|---|---|
| Gender | |
| Male | 86 |
| Female | 14 |
| Age | |
| 35 and younger | 10 |
| 36 – 45 | 19 |
| 46 – 55 | 33 |
| 56 – 65 | 19 |
| 66+ | 19 |
| Ethnicity | |
| Afrikaans | 14 |
| German | 86 |
| Education | |
| High school | 14 |
| Trade/apprenticeship | 24 |
| Diploma/Bachelor's degree | 48 |
| Master's degree / Doctorate | 14 |
| Years farming in study area | |
| 0 – 10 | 19 |
| 11 – 20 | 19 |
| 21 – 30 | 24 |
| 31 – 40 | 24 |
| 41 – 50 | 9 |
| More than 50 | 5 |

### 5.3.1 Income

#### 5.3.1.1 Dependence on cattle farming

Respondents were asked to provide the percentage that cattle farming contributes to their annual income for the years 2005−2010 and 2010−2015. When comparing the averages of all data for both periods, a slight decrease in income dependence on cattle farming is observed for the period 2005−2010 to 2010−2015, although this is not significantly different (P=0.4758).

The slight decrease could be due to the current drought situation in Namibia or farmers might be finding it more difficult to make a living from cattle farming and are diversifying to other on-farm income generating enterprises such as trophy hunting and tourism.

#### 5.3.1.2 Other on-farm income

Three farmers depended 100% on cattle farming for their income and had no other on-farm enterprises. For the remaining 18 respondents, an average of 48% (min = 1%, max = 90%) of their income was derived from other on-farm activities. All remaining respondents utilised game through trophy or biltong hunting and other forms of utilisation such as selling of game meat and selling of live game. Six (33%) of the farmers also generated an income through tourism. None of the farmers generated any income from crop farming or charcoal production.

### 5.3.2 Summary

The majority of respondents had diversified their income by making use of other on-farm enterprises such has game utilisation and tourism. These activities would help to create a buffer against the economic losses typically accrued during drought years, as these activities are generally less drought sensitive.

Much of the study area is marginal for cattle farming and with the expected decrease in productivity of rangelands in Namibia, farmers would increasingly find themselves vulnerable to the effects of drought and climate change. This is especially applicable to farmers that are highly dependent on cattle farming. It is therefore promising that the larger part of the respondents are complimenting their income with other sources and not relying on cattle farming alone.

## 5.4 Carrying Capacity and Stocking Rate

#### 5.4.1.1 Carrying capacity

In order to determine the stocking rate of a farm, a farmer first needs to determine the farm's carrying capacity. Determining the carrying capacity of a farm can be a complicated and time-consuming exercise that farmers generally skip. When considering their farm's carrying capacity, 19 of the 20 farmers (95%) in the Highland Savanna mostly monitored grass growth and 9 farmers (45%) monitored rainfall. One respondent made use of a consultant and one respondent did not consider the farm's carrying capacity at all.

According to Lubbe (2005), farmers in Namibia largely use subjective methods to estimate their carrying capacity. The author stated that formal methods such as the objective biomass principle could be more accurate. The biomass method as described by Bester (1998) entails calculating the grass biomass collected from 40 × 1 $m^2$ quadrants placed along a line transect. This method can be used to calculate the carrying capacity of each camp. However, the method would be more suited for grass dominated rangelands, which could be problematic for bush encroached areas (Lubbe 2005).

#### 5.4.1.2 Carrying capacity trends

Farmers were asked whether they believed their farm's carrying capacity had increased, decreased or stayed the same in the time that they had been farming with cattle in the Highland Savanna. Table 5.2 is a summary of the results found for the carrying capacity trends.

**TABLE 5.2: PERCEPTIONS OF CARRYING CAPACITY TRENDS IN THE STUDY AREA**

| | Increased (%) | Decreased (%) | Stayed the same (%) |
|---|---|---|---|
| Carrying capacity trend (N=21) | 52 | 38 | 10 |

Informal calculations of carrying capacity could result in over- or understocking of a rangeland. However, more than half (11 out of 21) of the farmers were of the opinion that their carrying capacity had increased in the time that they had been farming in the study area.

The reasons for the perceived increased carrying capacity are summarised in Table 5.3.

**TABLE 5.3: REASONS FOR INCREASED CARRYING CAPACITY OBSERVED**

| Reasons for increased carrying capacity* | Percentage (N=11) |
|---|---|
| Resting a portion of farm | 9 |
| De-bushed the farm | 55 |
| Destocked farm for two or more years | 36 |
| Use of fires | 9 |
| Added more sources of water | 9 |
| Use of a fast rotation system | 9 |

* More than one option could be chosen

The reasons for the perceived increased carrying capacity were mostly attributed to bush encroachment control (55%) and decreasing their stocking rate for two or more years (36%). One respondent commented that the carrying capacity increased with the use of fires, indicating the importance of this age-old method. One respondent commented that the carrying capacity had increased because he added more water sources for cattle. However, this could decrease the carrying capacity as areas around water sources could suffer from degradation. The majority of the respondents that perceived an increase in their carrying capacity used only one of the methods listed in Table 5.3. The remaining respondents reported that they used a combination of methods mainly by destocking their farm for two or more years and by de-bushing their farms. The level of carrying capacity increase was not determined in this study, however, it is expected that using a combination of methods would more likely result in an increased carrying capacity or a higher level of increase.

The reasons for a decreased carrying capacity during the time that the respondents have been farming in the study area, are summarised in Table 5.4.

**TABLE 5.4 REASONS FOR DECREASED CARRYING CAPACITY**

| Reasons for decreased carrying capacity* | Number of respondents (N=8) |
|---|---|
| Farm experienced overgrazing in the past | 4 |
| Bush encroached | 7 |
| Farm experienced degradation in drought | 4 |
| Increase in grazer game | 1 |

* More than one option could be chosen.

The majority of the respondents who felt that their carrying capacity had declined, chose bush encroachment as the reason. Half of the respondents attributed the decrease to the effects of overgrazing that their farm experienced in the past. Half of the respondents also indicated that their farm experienced degradation from drought. One respondent commented that the carrying capacity had decreased due to the increase in grazer game species, presumably from Mountain Zebra (*Equus zebra hartmannae)* that have been a problem in the study area for several years. Quotas to harvest Mountain Zebra are regulated as they are listed as a CITES (Convention on International Trade in Endangered Species) Appendix II species (Novellie et al. 2002), making it difficult for farmers to control their numbers. Some farmers have reported that they had 600 Mountain Zebra on their farm at a certain time, which could have a massive impact on the rangeland and water availability of a farm. Factors such as the increase of grazer game can further complicate rangeland management in the study area as it just another factor that they cannot control.

Any interventions to improve rangeland conditions such as de-bushing or decreasing a stocking rate for several years could become futile if farms are overstocked during critical grass growth periods and if not enough time is allocated for crucial resting periods.

### 5.4.2 Stocking rate

#### 5.4.2.1 Factors affecting stocking rate

Several factors could determine a farmer's decision on the number of cattle to keep on their farm. The respondents were offered three choices that most significantly could have affected their stocking rate decisions and this question provided interesting results. They were free to choose more than one answer and to provide an answer that differed from those in the list.

Almost all farmers (19 out of 20, 95%) chose rainfall and grass growth as the most significant factor, as expected. Only 1 out of 20 (5%) chose the 'financial situation' option. It was expected that more respondents would choose this option as cattle farming is a major (and for a few farmers it is the only) source of income. This question might not have been answered as honestly as expected, because questions that involve a respondent's income are regarded as sensitive (Kumar 2011).

Market factors, such as the price of beef, was also a factor that affected stocking rate, with 2 out of 20 (10%) of the respondents choosing this option. Another two out of 20 (10%) respondents commented that water availability affected their stocking rate, which indicates the importance of water for farming in the study area.

#### 5.4.2.2 Stocking rate of study area

Mendelsohn et al. (2006) suggested a stocking rate ranging between 12 to 20 kg live weight per hectare for the Highland Savanna area. However, degradation effects such as decreased perennial grasses and bush encroachment can drastically decrease carrying capacity.

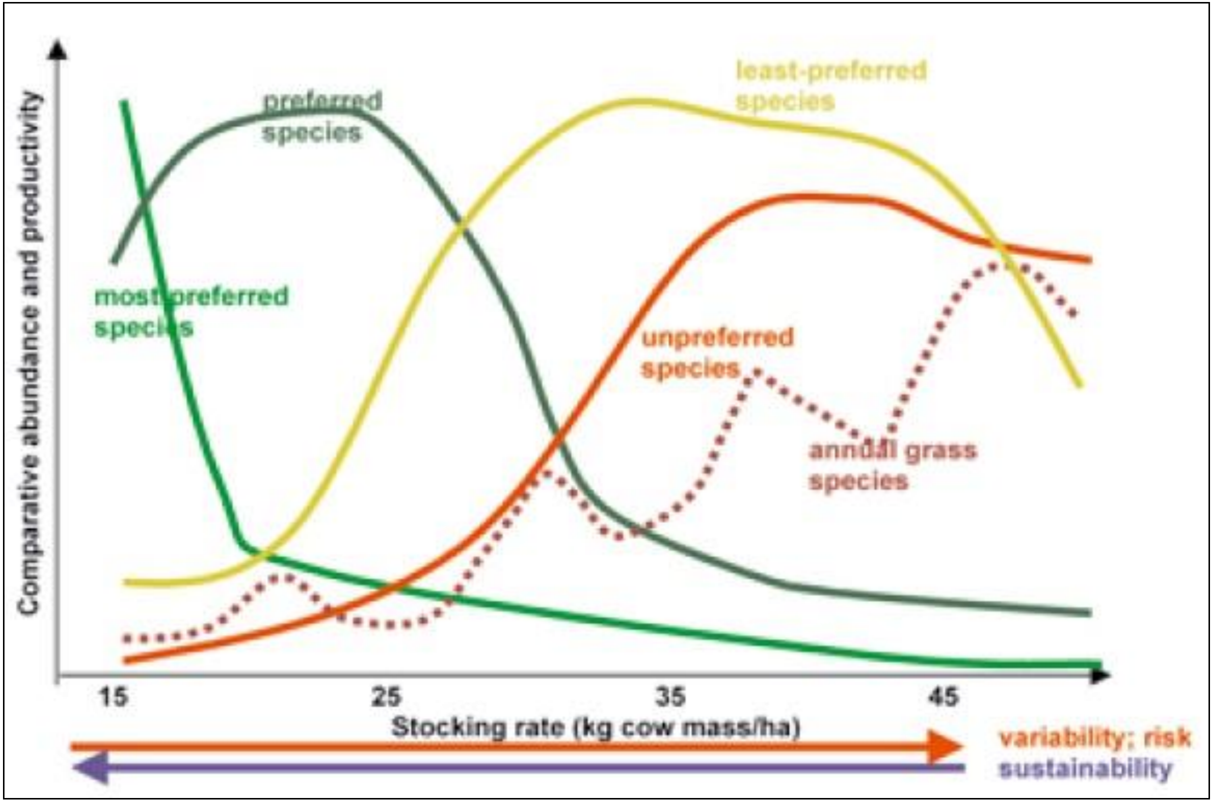
Respondents were asked to provide their stocking rates for above and below average rainfall years. Table 5.5 is a summary of stocking rates provided by 19 respondents for above and below average rainfall periods.

**TABLE 5.5: THE MEAN, MAXIMUM AND MINIMUM FOR KILOGRAM LIVE WEIGHT STOCKED PER HECTARE FOR ABOVE AND BELOW AVERAGE RAINFALL YEARS**

| Stocking rate (N=19) | Above | Below |
|---|---|---|
| Mean (kg/ha) | 38 | 27 |
| Maximum (kg/ha) | 64 | 45 |
| Minimum (kg/ha) | 4 | 1 |

The mean stocking rate calculated for above and below average rainfall years was significantly higher than the stocking rate suggested by Mendelsohn et al. (2006).

Rothauge (2007) investigated the effect of an increasing stocking rate gradient on vegetation as illustrated in Figure 5.2.




Source: Rothauge (2007)

**Figure 5.2: Effect of increasing stocking rate on groups of grass species**

According to Rothauge (2007), as the stocking rate of a farm increases livestock will over-utilise preferred grasses such as perennials, they will then be forced to utilise less preferred grasses. Less preferred grasses are less palatable and will not meet the nutritional needs of livestock, thus animal condition and productivity will drastically decrease and can lead to death. As stocking rates increase the sustainability of the rangeland system decreases and a farmer's risk increases. Rothauge (2007) concluded that at stocking rates that exceed 45 kg/ha a major system collapse occurs and bush encroachment sets in.

Table 5.6 summarises the number of respondents that stock at rates suggested by Mendelsohn et al. (2006) and the number of respondents that stock at rates that can result in bush encroachment as found by Rothauge (2007) for both below and above average rainfall years.

**TABLE 5.6: PERCENTAGE OF RESPONDENTS STOCKING AT DIFFERENT RATES FOR ABOVE AND BELOW AVERAGE RAINFALL YEARS**

| Percentage of respondents stocking (N=19) | Above average rainfall (%) | Below average rainfall (%) |
|---|---|---|
| 20 kg/ha and under (Risk = Low) | 10 | 26 |
| 21−44 kg/ha (Risk = Medium) | 48 | 69 |
| Over 45 kg/ha (Risk = High) | 42 | 5 |

From Table 5.6 it can be determined that the majority of the farmers stocked at medium to high risk levels that would result in degradation, including bush encroachment. Rangelands can support more cattle during above average rainfall years. However, Campbell et al. (2006) suggested a more conservative stocking strategy for areas where rainfall is highly variable and unpredictable and where degradation is likely. The authors defined a conservative stocking strategy as "one that maintains a relatively constant stocking rate, which is set on the basis that carrying capacity is unlikely to be exceeded in dry years". However, a conservative stocking rate might not be economically viable for farmers that have a high dependence on cattle farming for their income. A conservative stocking rate might also require farmers to burn their rangelands as moribund grass can build up. A slight decrease in stocking rates was seen in periods of below average rainfall years. However, in periods of water scarcity, stocking rates should be drastically decreased to levels even lower than those suggested by Mendelsohn et al. (2006). Not practising destocking during drought contributes greatly towards desertification (Rothauge 2007).

### 5.4.3 Summary

More than half of the respondents were of the opinion that their farm's carrying capacity had increased. However, when considering the current stocking rates, this in reality does not seem likely. Rothauge (2007) warned that the system's productivity response to an increasing stocking rate is bell-shaped. An increased stocking rate would initially result in an increase in productivity of livestock. However, this productivity would not last long as the stocking rate continues to rise, and in the end, the total system productivity would start declining and cattle start dying faster than they are born. High stocking rates would also drastically increase a farmer's level of risk to the adverse effects of drought and essentially increase their vulnerability to the effects of climate change. Farmers are advised to use formal methods in order to objectively determine their carrying capacity, which should be calculated after the rainy season on a yearly basis. The importance of calculating carrying capacities every year is demonstrated in the next section.

## 5.5 Drought

### 5.5.1 Variance of rainfall in study area

Farmers are highly dependent on rainfall for their livestock grazing needs. In order to establish the vulnerability of cattle farmers in the study area to rainfall variability they were asked to provide rainfall data for 24 years from the 1991/1992 season to the 2014/2015 rainfall season. Ten respondents were able to provide data for all the years from which the coefficient of variation (CV) was calculated for each year and for each farm over the 24-year period.

#### 5.5.1.1 Rainfall variance between years

Variance of rainfall between farms over the 24-year period illustrates the dynamic nature of rainfall in the study area. As illustrated in Figure 5.3, the CV of the ten farms is at times stable for a few years and can then drastically decreased or increased from one year to the next, illustrating the unpredictability of rainfall in the study area.

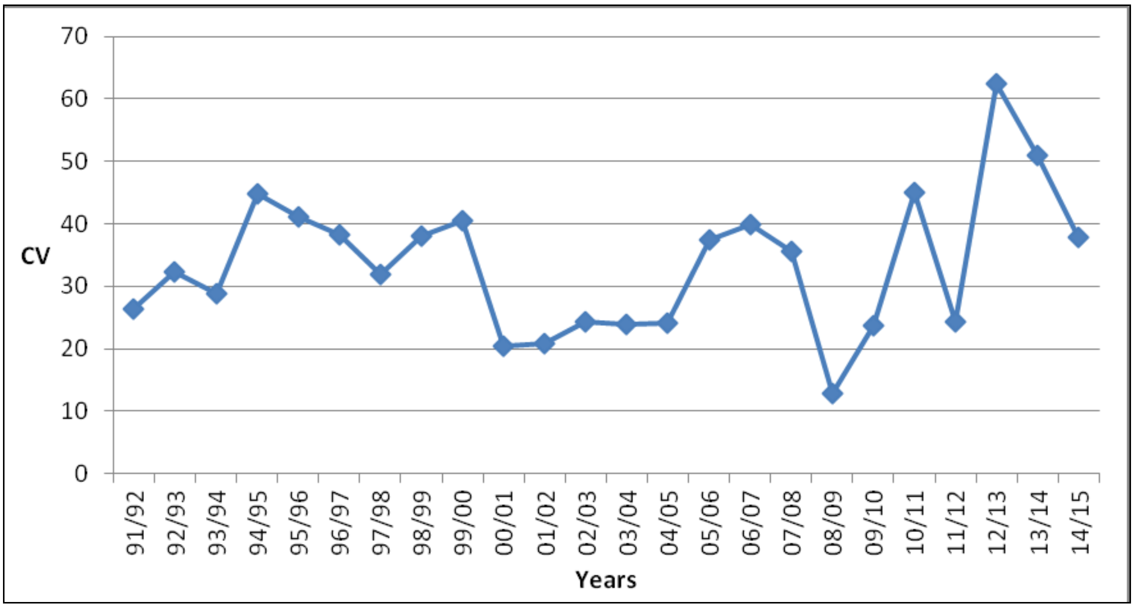



**Figure 5.3: The coefficient of variation (CV) of rainfall between the 10 farms over the 24-year period**

The season with the highest coefficient of variation calculated was the 2012/2013 season. This marked the start of the current drought that Southern Africa is facing. Most farms in the study area received under 200 mm rainfall, with one farm receiving only 60 mm and another farm receiving more than 500 mm.

#### 5.5.1.2 Rainfall variance of individual farms

The CV was calculated for each farm in order to establish their variance of rainfall over the 24-year period. The ten farms were compared in ascending order in Figure 5.4.

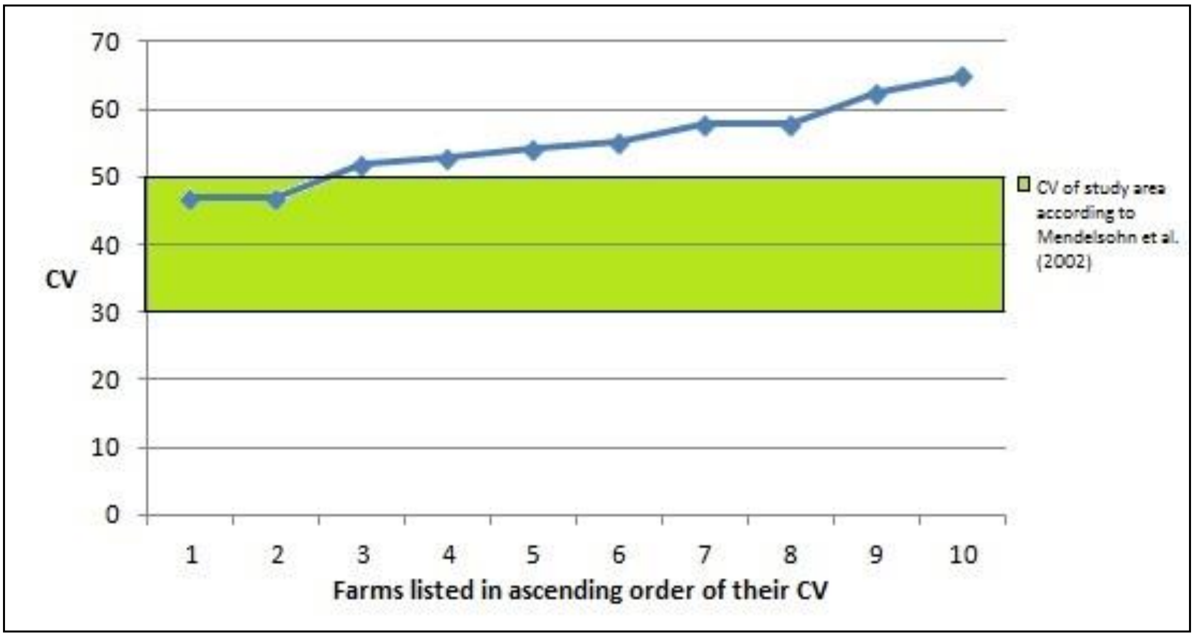



**Figure 5.4: The coefficient of variation (CV) for rainfall data provided by 10 farmers for the years 1991/1992 to 2014/2015**

Mendelsohn et al. (2002) calculated a CV ranging between 30% and 50% for the study area. Based on the findings of this study, farms in the study area experienced a CV that was significantly higher over the 24-year period than that calculated by Mendelsohn et al. (2002), with only two farms falling within the boundaries calculated by the authors. The reason for the considerably higher CV calculated in this study could be that Mendelsohn et al. (2002) had more data avaiable to even out the final result. Nevertheless, with CVs this high, it would be difficult to adapt farming methods. For example, one farm experienced 700 mm in the 2011/2012 season, 60 mm in the 2012/2013 season and 530 mm in the 2013/2014 season.

Rainfall in Namibia is highly variable (Mendelsohn et al. 2002), with the study area clearly being no exception. When farms receive little rainfall, farmers do not have the option to move cattle to areas where rainfall has occurred as their farms are generally situated in one geographical area. However, preparing for drought is possible as discussed in the literature review. The next section will discuss whether farmers in the study area are drought prepared.

### 5.5.2 Drought preparation

Twenty percent (5 out of 20) of the respondents felt that droughts are not something that can be planned or prepared for. However, the results from a question asking farmers whether they were prepared for the last/current drought before it occurred, showed that 89% (17 out of 19) of the respondents felt that they were prepared. It was found that three respondents indicated that they were drought prepared, but were also of the opinion that droughts are not something that can be planned or prepared for. A possible reason for the contradiction observed for the three farmers could be that although they felt they did prepare for the last/current drought, their preparation might not have been enough and they still experienced loss of income.

Nevertheless, Table 5.7 summarises the methods used by farmers in order to prepare for drought.

**TABLE 5.7: SUMMARY OF DROUGHT PREPARATION METHODS USED BY FARMERS**

| Ways prepared* | Percentage (N=17) |
|---|---|
| Savings account to buffer losses | 18 |
| Rested a part of farm | 24 |
| Supplementary feed stored | 29 |
| Able to destock quickly | 70 |

* More than one option could be chosen.

Some of the different methods of drought preparation will be discussed in the sections below.

#### 5.5.2.1 Destocking

The majority of farmers were able to destock quickly prior or during the current drought. This could mean that much of the respondents' cattle herd consisted of filler stock that could be more readily sold during periods of below average rainfall. This strategy is a suitable method to use when preparing for and coping with drought and will decrease chances of rangeland degradation during drought (Rothauge 2007). The high percentage of destocking before and during drought was expected for the study area as farmers in the Highland Savanna have easy access to the major processing facilities in the country (Mendelsohn et al. 2006). They can therefore react fast to price incentives and destock readily in times of drought (Von Bach et al. 1992).

Table 5.8 provides a summary of the destocking trends used by the commercial cattle farmers at the onset of drought and during drought.

**TABLE 5.8: SUMMARY OF DESTOCKING TRENDS IN THE HIGHLAND SAVANNA**

| Category | Percentage |
|---|---|
| Farmers that removed cattle at the beginning of drought (N=21) | 81 |
| Mean percentage of herd removed | 31 |
| Farmers that also removed cattle later in drought (N=19) | 42 |
| Mean percentage of herd removed | 17 |
| Farmers that did not destock at all (N=21) | 19 |

The majority of the farmers were able to destock at the beginning of the current/last drought. A mean of 31% was removed in the beginning of the drought, this is in line with the recommendations made by Rothauge (2001), who advised that one third of the herd should consist of filler stock that can be easily removed during drought years. Quick destocking at the first on-set of drought prevents degradation and this hands-on approach could contribute to the increase in carrying capacity experience by the majority of farmers as summarised in Table 5.2. Further destocking might be necessary as the drought intensity increases. Almost half of the farmers also had to remove cattle later on in the drought. Almost one quarter of farmers did not destock at all.

The factors that prevented farmers from destocking to ideal levels are summarised in Table 5.9.

**TABLE 5.9: REASONS THAT PREVENTED FARMERS FROM DESTOCKING IN THE HIGHLAND SAVANNA**

| Reason* | Percentage (N=13) |
|---|---|
| Low price of beef | 69 |
| Low weight of livestock | 38 |
| Herd consisted of breeding stock | 31 |
| No immediate market available | 23 |
| Believing that more rain will come | 31 |

* More than one option could be chosen.

The majority of the cattle farmers did not destock due to the low price of beef and some did not destock due to the low weight of their livestock. This could be prevented by destocking prior to the onset of the drought, before the markets were saturated and while filler cattle were still in a good condition (Rothauge 2001). Some respondents also did not destock as their herds consisted mostly of breeding stock. These farmers are advised to increase their filler stock as these are animals that can be destocked more readily during drought (Rothauge 2001). It also seemed that a few farmers had issues with no immediate market being available which should be addressed by The Meat Corporation of Namibia (Meatco) who are the main meat processing and marketing entity in Namibia. Some farmers did not destock as they believed that more rain would come, this was a dangerous gamble that hopefully did not come at a costly price.

#### 5.5.2.2 Resting for a full growing season

Just under half (48%) of the 21 respondents rested a portion of their farm for a full growing season. Farmers rested on average 31% of their rangeland for a full growing season, which is also in line with the recommendation made by Rothauge (2007), that one quarter to one third of a farm should be rested for a full growing season.

The NRMPS considers sufficient rest as a principle of sound rangeland management and as an essential drought preparation strategy (MAWF 2012). The reasons for not resting for a full growing season are summarised in Table 5.10.

**TABLE 5.10: SUMMARY OF REASONS WHY FARMERS DID NOT REST FOR A FULL GROWING SEASON**

| Category* | Percentage (N=11) |
|---|---|
| Not familiar with method | 9 |
| Will put pressure on remaining grazing | 36 |
| It will not help | 0 |
| Farm is too small | 36 |
| Cannot control game | 18 |
| No fences | 9 |

* More than one option could be chosen.

A third (4 respondents) of the farmers believed that their farm was too small for them to allow their veld to rest and that it would put the remainder of their grazing under pressure. Rothauge (2007) believes that resting might not be a viable option for small farms. The size of a farm should, however, not be deemed as a justifiable reason for not resting a farm's rangeland. Rangelands need rest from grazing (Tainton & Danckwets 1999), it is essential for sustainable rangeland management and stocking rates of small farms should rather be adjusted accordingly in order to accommodate resting periods. The average farm size of the four respondents that felt their farm was too small is 5 344 hectares (min= 3050 and max =

7800). These results indicate that farmers are under the false impression that their farms are too small, because their farms sizes are quite adequate for resting.

#### 5.5.2.3 Other drought preparation strategies

Even though the majority of farmers destocked and almost half of the respondents rested their veld for a full growing season, they would most likely still need to incorporate other drought preparation strategies in order to cater for the remaining herd. Other methods include maintaining cultivated grass pastures, growing exotic or indigenous fodder crops and building a fodder bank.

##### *5.5.2.3.1 Cultivated grass pastures and fodder crops*

Only 14% (3 out of 21) of the respondents maintained cultivated grass pastures with an average pasture size of 24 ha. Two respondents grew *Cenchrus ciliaris* and one farmer had a small area of irrigated lucerne and 'cow candy' grass.

Table 5.11 is a summary of the reasons that prevented the farmers from maintaining cultivated pastures.

**TABLE 5.11: FACTORS PREVENTING FARMERS FROM MAINTAINING CULTIVATED PASTURES**

| Reason* | Percentage (N=15) |
|---|---|
| Unfamiliar with this method | 6 |
| Farm is too dry | 33 |
| It is too expensive | 20 |
| Do not believe it is necessary | 20 |
| Farm is too mountainous | 40 |

* More than one option could be chosen.

The majority of the respondents commented that their farm was too mountainous to plant cultivated pastures. However, most farms have a few hectares that are flat and farmers should at least try this method of drought preparation as it could greatly decrease their vulnerability to the effects of drought. All respondents that did maintain cultivated pastures did not regret their decision to do so. This should be a good enough indication that growing cultivated pastures is possible in the Highland Savanna. To ensure establishment of a cultivated pasture, water will need to be available for irrigation. Farmers should also monitor the pasture and ensure that it does not experience any form of degradation such as erosion.

No respondents maintained any fodder crops for the same reasons that they did not maintain cultivated pastures. I have spoken to a few farmers in other vegetation types that maintain *Opuntia spp* and they commented that the fruits have contributed significantly to the feeding needs of their livestock and game species. They believed that they would have had much more drought related animal mortality if they did not have fodder crops. This drought preparation method should therefore also not be disregarded.

##### *5.5.2.3.2 Building a fodder bank*

Just under half of the farmers rested their rangeland as a drought preparation strategy and very few respondents used cultivated pastures. The remaining respondents would find themselves with a fodder shortage in drought periods and therefore needed to acquire fodder through other means, mainly in the form of buying hay.

Table 5.12 is a summary of the other methods used to acquire fodder.

**TABLE 5.12: OTHER METHODS USED TO BUILD UP A FODDER BANK**

| **Methods*** | **Number of respondents** (N=9) |
|---|---|
| Make hay from roadside reserves | 2 |
| Buy hay from Namibian sources | 7 |
| Buy hay from South Africa | 1 |
| Make hay on farm | 1 |

* More than one option could be chosen.

Most of the respondents bought hay, which would greatly increase their farm's input costs. One farmer in the study area commented that he has used all his savings to buy hay, but that the quality of the hay was often so poor that much of it could not be used. Farmers could rather use the money they would normally spend on hay and spend it on developing cultivated pastures or fodder crops. This way they would not be vulnerable to price increases and shortages of hay during drought and could build up a fodder bank during years of above average rainfall when supplementary feed would not be necessary.

Any drought preparation strategies that farmers had in place will greatly decrease their vulnerability to the negative effects of drought such as desertification and livestock death.

### 5.5.3 During and post-drought effects and management

Five (24%) of the respondents reported an average of 11 cattle deaths as a result of the drought. Data collection took place in May and June, which meant that there were still five to six months before the start of the rainy season and cattle deaths were expected to be much higher at a later stage in the dry season. Livestock die when their nutritional needs are not met by the grass sward (Rothauge 2007), which becomes diminished during periods of below average rainfall if no drought preparation strategies are practiced. Livestock deaths cannot be blamed on drought alone; it is the combined effect of drought and unsustainable rangeland management.

After a drought has occurred, farmers need to restock their farms by either buying cattle or allowing their herd to increase naturally through breeding. Rangelands are sensitive to degradation after a drought has occurred and restocking too quickly, as many commercial farmers do, could increase chances of desertification (Ward et al. 2004).

Table 5.13 is a summary of the ways that farmers restock their farms after drought.

**TABLE 5.13: METHODS USED BY COMMERCIAL CATTLE FARMERS TO RESTOCK POST-DROUGHT**

| Restock method* | Percentage (N=17) |
|---|---|
| Natural increase | 65 |
| Buying cattle | 59 |

* More than one option could be chosen.

The majority of the cattle farmers allowed their herds to increase naturally through breeding. This is more sustainable as the stocking rate increases gradually as opposed to buying cattle where the stocking rate could increase drastically from one day to the next. The productivity and fertility of individual cattle decreases when they do not get their nutritional requirements from the grass sward (Rothauge 2007). Therefore, allowing cattle to increase through breeding should also be a good indication whether rangelands would be able to support more cattle.

A Mantel-Haenszel correlation test was used to test if there was an association between farmers' experience in the study area and the methods used to restock (through breeding or buying cattle). The correlation was close to being statistically significant (P=0.0549), indicating that farmers with less experience tended to buy cattle more readily as a restock method than farmers with more experience.

Farmers should wait until sufficient rains have fallen and the vegetation has been given adequate time for growth before restocking (Rothauge 2001). Cattle farmers that buy cattle waited an average of 4,5 months before restocking. This could possibly not be enough time for rangelands to recoup after periods of below average rainfall. Farmers should wait even longer if they were not able to destock to optimal levels during drought.

### 5.5.4 Summary

Rainfall in the study area is highly variable and unpredictable. Without sufficient preparation farmers would find themselves vulnerable to the effects of drought.

The majority of cattle farmers practiced destocking as a drought coping strategy, the destocking rates were in line with the rates identified in the literature review. Whether farmers destocked to acceptable levels is unknown and depends on every individual farm's rangeland condition. Almost one quarter of the farmers did not practice destocking at all, this is worrisome as this means that one quarter of the study area was at high risk to degradation during the drought. Some reasons that prevented farmers from destocking were identified and recommendations were made.

Just under half of the respondents rested a portion of their farm. However, other drought preparation strategies would be necessary to sustain cattle through a drastic drought. Very few farmers used other strategies that would help to decrease their vulnerability in drought. It seems that some farmers dealt with the effects of drought on an *ad hoc* basis and fodder was rather bought to sustain cattle throughout the drought, which greatly increases farmer's input costs and vulnerability.

The majority of the farmers felt that they were prepared for the drought. However, the data showed that not all of the farmers were practicing drought preparation methods to the necessary levels, and the livestock deaths that had occurred were further proof of that.

Based on the high coefficient of variation of rainfall calculated, farmers in the Highland Savanna have a high likelihood of exposure to climate extremes. Farmers were not sufficiently prepared for drought and were therefore highly vulnerable to its affects. A high vulnerability to the effects of the drought would also translate into a high vulnerability to the effects of climate change as the climate in the study area is expected to become increasingly arid (Midgley et al. 2005).

## 5.6 Bush Encroachment Management

From the literature review it was clear that the problem of bush encroachment is a major environmental concern for the government and people of Namibia. It is also a problem for farmers in the Highland Savanna as 83% of the respondents reported that their farm is showing signs of degradation from bush encroachment. However, only 8% of the 160 303 ha covered in this study was being controlled for bush encroachment.

The results of this section will be presented as a summary; the different methods with their respective results will then be discussed under subsections. The factors that prevented farmers from practicing ideal levels of bush encroachment will also be discussed.

### 5.6.1 Summary of bush control methods and their success rate

Several methods of bush control were available to the farmers, each method having its advantages and disadvantages as discussed in the literature review. Table 5.14 is a summary of the methods that farmers used to control bush encroachment.

**TABLE 5.14: METHODS OF BUSH ENCROACHMENT CONTROL USED BY FARMERS***

| Method of control* | Percentage (N=17) |
|---|---|
| Manual (stumping/felling) | 41 |
| Mechanical | 6 |
| Chemical (aerial) | 29 |
| Chemical (manual) | 88 |
| Burning | 12 |
| Stem burn | 12 |

* More than one option could be chosen.

The methods that farmers had the most success with are summarised in Table 5.15.

**TABLE 5.15: BUSH CONTROL METHODS THAT RESULTED IN THE MOST SUCCESS**

| Method of control* | Percentage (N=14) |
|---|---|
| Manual (stumping/felling) | 17 |
| Mechanical | 0 |
| Chemical (aerial) | 29 |
| Chemical (manual) | 71 |
| Burning | 14 |
| Stem burn | 0 |

* More than one option could be chosen.

The methods that farmers had the least success with are summarised in Table 5.16.

**TABLE 5.16: BUSH CONTROL METHODS THAT RESULTED IN THE LEAST SUCCESS**

| Method of control* | Number of respondents (N=8) |
|---|---|
| Manual (stumping/felling) | 5 |
| Mechanical | 3 |
| Chemical (aerial) | 0 |
| Chemical (manual) | 2 |
| Burning | 1 |
| Stem burn | 0 |

* More than one option could be chosen.

### 5.6.2 Manual and aerial chemical control

As seen in Table 5.14, chemical control was the most widely used bush encroachment control method in the study area. The respondents preferred manual chemical control over aerial spray of arboricides, presumably because aerial spray is expensive and only viable for severely encroached farms (Smit et al. 1999). As seen in Table 5.15, farmers also had the highest success rate with manual chemical control, although some side-effects were reported.

The high use of chemical control in the study area indicated that farmers were desperate in their need to control encroacher bush, as arboricides are effective, but expensive. Arboricides also have known negative environmental impacts (Honsbein et al. 2012), some of which were observed by respondents, mostly in the form of non-target tree mortality. Respondents reported mortality of *Acacia erioloba* (3 out of 6), *Boscia albitrunca* (2 out of 6), *Ziziphus mucronata* (1 out of 6) and *Albizia anthelmintica* (1 out of 6). Non-target tree mortality is a side-effect of arboricide use (Smit et al. 1999). However, the mortality of non-target tree species reported in this study are worrisome as they are all protected tree species in Namibia (Mannheimer & Curtis 2009).

Respondents used arboricides that contain either Tebuthiuron or Bromacil, or a combination of both. Only non-target tree mortality as a possible side-effect was investigated in this study and further research is recommended to investigate other possible environmental effects of arboricide use in Namibia.

As seen in Table 5.16, a few respondents (2 out of 8) reported that they did not have success with manual chemical control. The reasons provided by the respondents for their disappointment with arboricide use was that a great percentage of the treated bush survived, even with overdosage. They also reported that unwanted species had established on chemically controlled areas. As discussed in the literature review, arboricide use is by no means a once-off control method for bush encroachment and follow-up treatments are essential (De Klerk 2004; Smit et al. 1999). Farmers might be expecting instant results, however, some forms of treatment could take a few years before being effective (Smit et al. 1999). and thereby applying more than the required amounts.

### 5.6.3 Mechanical and manual (stumping/felling) control

As seen in Table 5.14, the second most common method of bush control was manual removal through stumping or felling and one respondent reported that he used mechanical removal. It was not investigated which machines respondents used; however, a common form of mechanical removal is the use of bulldozers. Bulldozers can cause severe soil disturbance and often rangelands become more encroached after their use, and it is therefore not generally recommended as a bush encroachment control measure (Smit et al. 1999).

As seen in Table 5.16, the methods of control that resulted in the least success were manual removal (5 out of 8) and mechanical removal (3 out of 8). Only one of the 17 respondents (6%) indicated that they used mechanical control (Table 5.14). However, three respondents indicated that they had the least success with mechanical use (Table 5.16). It is assumed that two respondents previously used mechanical control, but as they did not have success with this method, they abandoned it. Nevertheless, the reasons provided for the failure rate with both methods were that these methods resulted in bush growing back even thicker than before. As Smit et al. (1999) have stated, this is a frequent occurrence after mechanical removal. According to De Klerk (2004) coppicing after manual removal is also common, it is therefore not considered as a sufficient method of removal without aftercare measures.

### 5.6.4 Fire

Fire is considered as the most economical method of control (Trollope 1980). The majority (81%) of the respondents agreed with the statement that a lack of fire contributes to bush encroachment. However, only two (12%) of the respondents used fire as a bush control method as seen in Table 5.14. The two respondents also reported that fire was the most successful method they used when controlling bush on their farms.

It is assumed that farmers do not use fire as often, because of behavioural customs created by past policies (De Klerk 2004), temporary loss of grazing, the perceived economic losses resulting from burning (Trollope 1980), and concern over legal implications from runaway fires (Joubert et al. 2014). One farmer reported that he had the least success when he used fire, because he regarded it as dangerous; it is therefore expected that farmers need training on how to use fire.

Two farmers commented that they would like to use fire, but they did not have enough grass for controlled burning. Fires need sufficient fuel in order to be effective against bush control which could be a dilema for commercial cattle farmers with high stocking rates. Fire will also not be effective in areas that are severly bush encroached (De Klerk 2004).

### 5.6.5 Factors that prevent bush encroachment control

The factors that prevented the farmers from practicing ideal levels of bush control are summarised in Table 5.17.

**TABLE 5.17: REASONS PREVENTING FARMERS FROM PRACTICING IDEAL LEVELS OF BUSH ENCROACHMENT CONTROL**

| Method of control* | Number of respondents (N=18) |
|---|---|
| Money | 56 |
| Time | 39 |
| Perception that bush will decrease with drought and disease | 22 |
| Farm is not bush encroached | 17 |
| Not enough fuel for burning | 11 |

* More than one option could be chosen.

The majority of respondents chose money and time as the main factors preventing them from practicing ideal levels of bush control. Bush densities are a major cause for concern and will not likely improve on its own as some respondents believed. Farmers are recommended to not give up and rather intensify their bush control measures. Once bush numbers are drastically decreased it would be much easier to control encroachment. Farmers need to be aware that controlling bush will be a lifelong issue as bush form new stands after a few successive years of above average rainfall (Holz & Bester 2007). However, if sustainable rangeland management is practiced the tree-grass balance will be much easier to maintain with inexpensive ways such as the use of fire (De Klerk 2004).

Farmers did not indicate that the need for training prevented their bush control measures. This might be true, but during critical analysis of data it was found that some farmers were expecting instant results such as immediate death of bush with arboricide use and manual removal. Farmers need to be aware of the available literature in order to gain maximum success out of their bush control efforts. One farmer also reported burning as dangerous. Burning should not be dangerous if proper precautions are taken and if it is done in the right way. Therefore, training in fire use is also considered necessary for farmers in the study area.

### 5.6.6 Summary

It is clear that bush encroachment is a cause for concern in the study area. Farmers were predominantly using arboricides as a control measure. Negative environmental impacts were observed in the Highland Savanna in the form of non-target tree mortality. These tree species are protected in Namibia and their mortality is therefore a conservation issue. Other environmental effects were not identified; however, it is advised that further research be done to determine if arboricide use could have other negative impacts on Namibia's fragile ecosystems.

The use of fire was not common in the study area, possibly because of the various reasons discussed. However, if farmers could intensify their bush control methods and get bush numbers down to ideal levels, rangeland maintenance through burning would be much easier and inexpensive. If optimum bush densities are reached, farmers would see a drastic increase in rangeland carrying capacity. It would also make a farm more aesthetically pleasing for tourists.

It is recommended that farmers welcome any training in bush encroachment control methods in order to get the most value out of their control efforts and to prevent further degradation.

## 5.7 Perceptions: Rangeland Condition and Function

Respondents were asked to judge some aspects of their rangeland condition. This was therefore by no means an objective assessment on actual rangeland condition, but rather a subjective opinion in order to determine the perceptions that farmers had of their rangeland condition. The opinion of farmers on some statements regarding rangeland function was also asked.

### 5.7.1 Visible signs of degradation

Table 5.18 summarises the results found on the perceptions of the visible signs of degradation on the respondents' farms.

**TABLE 5.18: VISIBLE SIGNS OF DEGRADATION ON RESPONDENT'S FARMS**

| Visible signs of degradation* | Percentage (N=18) |
|---|---|
| Bush encroachment | 83 |
| Low grass cover | 22 |
| Wind erosion | 16 |
| Water erosion | 16 |
| None | 5 |

* More than one option could be chosen.

As expected, bush encroachment is the most significant visible sign of rangeland degradation. Less than a quarter of the respondents reported low grass cover on their farms. It is not possible to determine objectively whether low grass cover is a visible sign of environmental degradation on farms in the study area without conducting a vegetation survey. However, the high stocking rates reported earlier in the results section would make it difficult to believe that less than one quarter of farms had low grass cover.

### 5.7.2 Trends of grasses

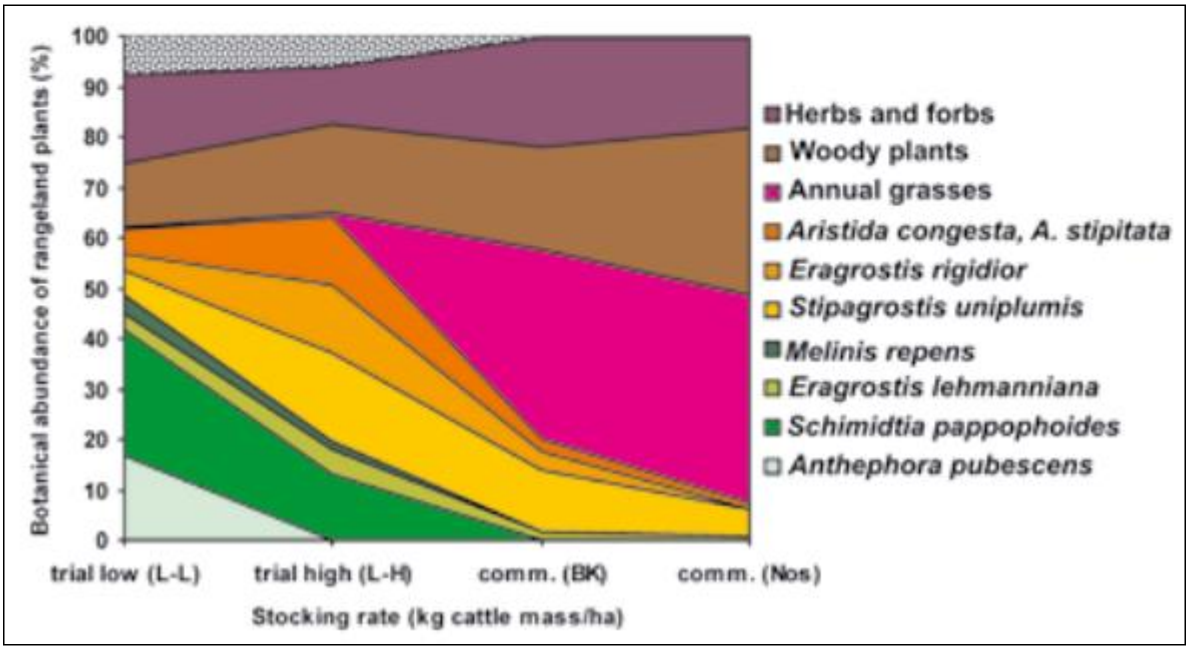
Table 5.19 is a summary of the trends of annual and perennial grasses in the time that the respondents have been farming in the Highland Savanna.

**TABLE 5.19: TRENDS OF ANNUAL AND PERENNIAL GRASSES**

| Grass type | Answer (%) (N=21) | | |
|---|---|---|---|
| | Increased | Decreased | Stayed the same |
| Annuals | 90 | 0 | 10 |
| Perennials | 81 | 14 | 5 |

The majority of respondents reported an increase in both annuals and perennials, but once again at the high stocking rates reported, this does not seem possible. Rothauge (2007) investigated the effect of different stocking rates on the botanical composition of rangelands in Namibia as seen in Figure 5.5.

As discussed in section 5.4.2.2, the respondents stocked at a mean rate of 38 kg live weight/ha in above average rainfall years and at a mean rate of 27 kg live weight/ha in below average rainfall years. A total of 48% of the respondents stocked between 21 and 44 kg/ha and 42% stocked over 45 kg/ha in above average rainfall years. The majority of the respondents stocked between 21 and 44 kg/ha in below average rainfall years. As seen in Figure 5.5, at these stocking rates reported by respondents, the majority of grass species would decrease, only *Aristida* spp increased, which are unpreferred grasses. At stocking rates over 45 kg/ha all grass species decrease and bush densifies and takes over (Rothauge 2007).




Note: Stocking rates indicated by trial varied from 15 kg (L-L) to 45 kg (L-H) cow mass per hectare, while those indicated by 'comm.' varied from 60 (BK) kg to 80 (Nos) kg cow mass/ha

Source: Rothauge (2007)

**Figure 5.5: Botanical composition of rangeland stocked by cattle at various stocking rates in Namibia**

It would be difficult for farmers to objectively judge the trend of grasses occurring within their rangelands over a long period. However, it would be dangerous for them to be under the impression that their rangelands are improving when in fact for some farms the rangelands might be degrading. Farmers might also lack knowledge on distinguishing between annual and perennial grasses.

It is possible that respondents have gradually decreased their stocking rate during the time that they have been farming with cattle in the study area. However, at the current high stocking rates reported for the majority of the farms, an increase in less preferred annual grasses might be observed and not perennials.

### 5.7.3 Perceptions of statements regarding rangeland function

Farmers were asked what their opinions were on a few statements regarding rangeland function in Namibia, the results are summarised in Table 5.20.

**TABLE 5.20: PERCEPTIONS ON STATEMENTS REGARDING RANGELAND FUNCTION**

| Statement | Answer (%) | | |
|---|---|---|---|
| | Agree | Disagree | Don't know |
| Bush control increases carrying capacity (N=21) | 90 | 0 | 10 |
| Lack of fire in a rangeland contributes to bush encroachment (N=21) | 81 | 14 | 5 |
| Overgrazing contributes to bush encroachment (N=20) | 85 | 5 | 10 |
| An increase in rainfall contributes to bush encroachment (N=21) | 48 | 38 | 14 |
| Droughts are not something that can be planned or prepared for (N=20) | 25 | 75 | 0 |

The majority of respondents agreed that bush control increases rangeland carrying capacity and a few did not know. It is well-known that bush encroachment negatively impacts rangeland carrying capacity in Namibia (De Klerk 2004). If farmers were aware of this fact they can address it, which as discussed in section 5.6, some are in the process of doing.

Almost all respondents agreed that a lack of fire in a rangeland contributes to bush encroachment. The fact that some disagreed or did not know, might still be remnants of past policies that created fire avoidance behaviour (De Klerk 2004). Farmers did not often use fire as a bush encroachment control method for the reasons discussed in section 5.6.4. Hopefully, farmers will be able to sufficiently control bush and then start implementing this age-old natural tool that shaped the structure of savannas and prevented bush encroachment prior to commercial livestock production (Trollope 1980).

The majority of respondents agreed that overgrazing contributes to bush encroachment and a few disagreed or did not know. It is well-documented that bush thickens on overgrazed rangelands (De Klerk 2004; Rothauge 2007; Zimmermann et al. 2008). Farmers need to understand the causes and drivers of bush encroachment in order to adjust their management methods accordingly.

Almost half of the respondents agreed that an increase in rainfall encourages bush encroachment. A large percentage of respondents disagreed with the statement and some did not know. Bush tends to form new stands after three consecutive years of rainfall (Holz & Bester 2007; Joubert et al. 2008). This fact did not seem to be common knowledge. However, it is important for farmers to be aware of this occurrence so that they would be able to intensify bush control measures after periods of above average rainfall.

The majority of respondents disagreed that droughts are not something that can be planned or prepared for. As discussed earlier in this dissertation, there are several measures available in order to prepare for drought. Some respondents agreed with the statement, which would lead to farmers dealing with drought on an *ad hoc* basis and thereby increasing their vulnerability to drought.

### 5.7.4 Summary

Farmers were aware that their rangelands are showing signs of degradation. However, not all farmers were aware of the drivers of rangeland degradation and can therefore not adjust their farming methods that could contribute to degradation in the study area.

It is recommended that farmers study the literature that has been referenced throughout this dissertation. They would, therefore, be able to understand the drivers of desertification in Namibia and make educated adjustments to their management methods where needed.

## 5.8 Conclusion

This chapter illustrated, summarised and discussed the results found for this study. The results provided insight on the rangeland management methods that commercial cattle farmers use in the Highland Savanna of Namibia. At the end of each section a summary was provided for the results that were found in that section. The next section will discuss an overall conclusion and highlight the most significant recommendations that farmers can use in order to decrease their vulnerability to drought and climate change.

*Chapter 6*

# CONCLUSION AND RECOMMENDATIONS

The overall aim of this study was to answer the research questions and to make recommendations based on the findings. In order to reach the aim, the objectives first had to be addressed. A questionnaire was used to determine whether farmers in the Highland Savanna were using some of the sustainable rangeland methods as prescribed by selected literature. The questionnaire was designed to investigate the objectives set out for this dissertation. Factors related to DLDD are often interrelated, therefore the results are frequently applicable to more than one objective.

Objective number 1 - to determine if farmers are using farming practices that could contribute to degradation - was addressed in the results and discussion chapter in the following ways:

- It was determined that some commercial cattle farmers in the Highland Savanna were contributing to degradation by overstocking their farms. Carrying capacities were on average much higher than recommended by the literature.
- Some farmers were not sufficiently prepared for drought situations and were therefore exposing their rangelands to degradation as the grass sward is particularly vulnerable during periods of water scarcity.
- Although the majority of farmers did destock, almost one quarter (19%) of the farmers did not destock at all during the current drought; the carrying capacity of rangelands drastically decreases during a drought and not destocking will cause long-lasting and possibly irreversible damage to a rangeland.
- It was found that experienced farmers allowed their herd to increase naturally after a drought has occurred and that inexperienced farmers were more likely to buy cattle after a drought. Restocking too quickly after a drought has occurred can be detrimental, as rangelands need time to recoup after a drought.

Objective number 2 - to assess if farmers are increasing their vulnerability to the effects of DLDD and climate change - was addressed in the results and discussion chapter in the following ways:

- Although there seemed to be a decreasing income dependence on cattle farming in the study area, there were still farmers that depended highly on cattle. Having a high dependence on cattle farming would greatly increase a farmer's level of risk to the adverse effects of drought and climate change.
- Farmers were not sufficiently prepared for drought and would therefore be vulnerable when a drought does occur and could incur great financial loss through cattle deaths and by dealing with drought on an *ad hoc* basis by buying fodder.

Objective number 3 - to identify factors that prevent sustainable rangeland management - was addressed in the results and discussion chapter in the following ways:

- Destocking was identified as the most significant drought management strategy. Some factors that prevented farmers from destocking during drought were identified and addressed. The most significant factors are the low weight of livestock and low price of beef.
- Factors that prevented farmers from using other drought preparation strategies such as resting of rangeland, planting cultivated pastures and fodder crops, were identified and discussed.
- The factors that prevented bush encroachment control were identified and addressed. The two most significant factors were lack of money and time.
- A lack of knowledge on some key principles of rangeland management were identified and addressed. These included unfamiliarity with some drought preparation strategies, inadequate methods of bush encroachment control and the use of fire. A lack of knowledge was also identified for some farmers when their opinions were asked on rangeland function.

Objective number 4 - to identify perceptions of farmers on land degradation and the condition of rangeland on their farms - was addressed in the results and discussion chapter in the following ways:

- The respondents' perceptions on visible signs of rangeland degradation were identified. The most significant sign being bush encroachment.
- The trend of carrying capacity of the farms and annual and perennial grasses were identified. The majority of the farmers were of the opinion that their carrying capacity had increased in the time that they had been farming in the study area. The majority

of the respondents also believed that the occurrence of annual and perennial grasses had increased.

The objectives have been reached and therefore the aim of the study could be addressed. The first aim of the study was to answer the research questions. The answer for the first research question is: Yes, the rangeland management methods used by some commercial cattle farmers in the Highland Savanna are contributing to land degradation/desertification. The answer to the second research question is: Yes, some farmers were increasing their vulnerability to the effects of drought and climate change.

The second aim of the study was to make recommendations based on the findings. Recommendations have been made throughout the study and would hopefully encourage farmers to practice sustainable rangeland management so that improved rangeland condition and productivity can be achieved. Once improved rangeland conditions have been reached, farmers will ultimately decrease their vulnerability to the effects of drought and climate change.

Although recommendations were made throughout the study, the following recommendations need to be highlighted:

- Farmers that have a high dependence on cattle farming should seek other on- or off-farm income-generating enterprises.
- Famers should use formal methods to determine the condition of their rangeland and to calculate their actual carrying capacity. Carrying capacity should be calculated and adjusted on a yearly basis.
- Farmers should drastically decrease their stocking rates in order to prevent further degradation.
- Farmers can decrease their vulnerability to the effects of drought by implementing the suggested drought preparation strategies.
- Farmers are advised to intensify their bush control efforts in order to get ahead of the bush encroachment issue.
- Farmers should also explore opportunities that could generate an income from encroacher bush and be open to alternative methods such as the Bush-to-Feed programme. The new permit system implemented by MAWF for bush control should not discourage farmers from their bush control efforts, but they should rather recognise the need for data on bush control efforts in Namibia.

- The most overriding recommendation is that farmers welcome any knowledge that comes their way. By staying up to date with literature, cattle farmers would be able to critically analyse their current rangeland management methods and adjust them wherever possible.

Further research is recommended on the rangeland management methods that commercial farmers use in the other cattle ranching areas of Namibia. This would enable a broad overview of management methods used in Namibia and allow government agencies and institutions to address the factors that prevent sustainable rangeland management. If the drivers of degradation are not addressed, the fight against the effects of degradation would be worthless. Climate change issues related to livestock farming would also not be addressed successfully unless degradation is halted and improved. Further research is also desperately needed to determine the effects of arboricide use in Namibia. The majority of respondents used arboricides (at times in excess) and some environmental effects were observed.

A limitation of this dissertation is that the broad scope of factors that contribute to land degradation prevented the researcher from delving deep into any given subject. Therefore, more research should be done to determine the specifics of certain methods, for example whether farmers practice complete eradication or follow advice from De Klerk (2004) that a certain amount of trees and bush should not be removed.

The Highland Savanna comprises only a small percentage of the total surface area of Namibia, but it has a high level of endemism and biodiversity compared to the other vegetation types of Namibia and it is therefore of conservation importance (Joubert et al. 2008). However, only 0.2% of the Highland Savanna is under government protection for conservation purposes, it is therefore of utmost importance that the freehold farmers maintain the biodiversity of this unique vegetation unit (Joubert et al. 2008).

A wealth of knowledge is available to farmers that will help them to adjust their rangeland management methods and halt the current degradation rates. The government of Namibia has shown its commitment to the issue of degradation and climate change by constructing the National Rangeland Management Policy and Strategy and the National Climate Change Policy. Continued dialogue between farmers, relevant institutions and the government of Namibia will assist to address the drivers of degradation. However, it is essentially up to the land user to decide to change and implement those changes.

*“I cannot change the direction of the wind, but I can adjust my sails to always reach my destination”*

– Jimmy Dean

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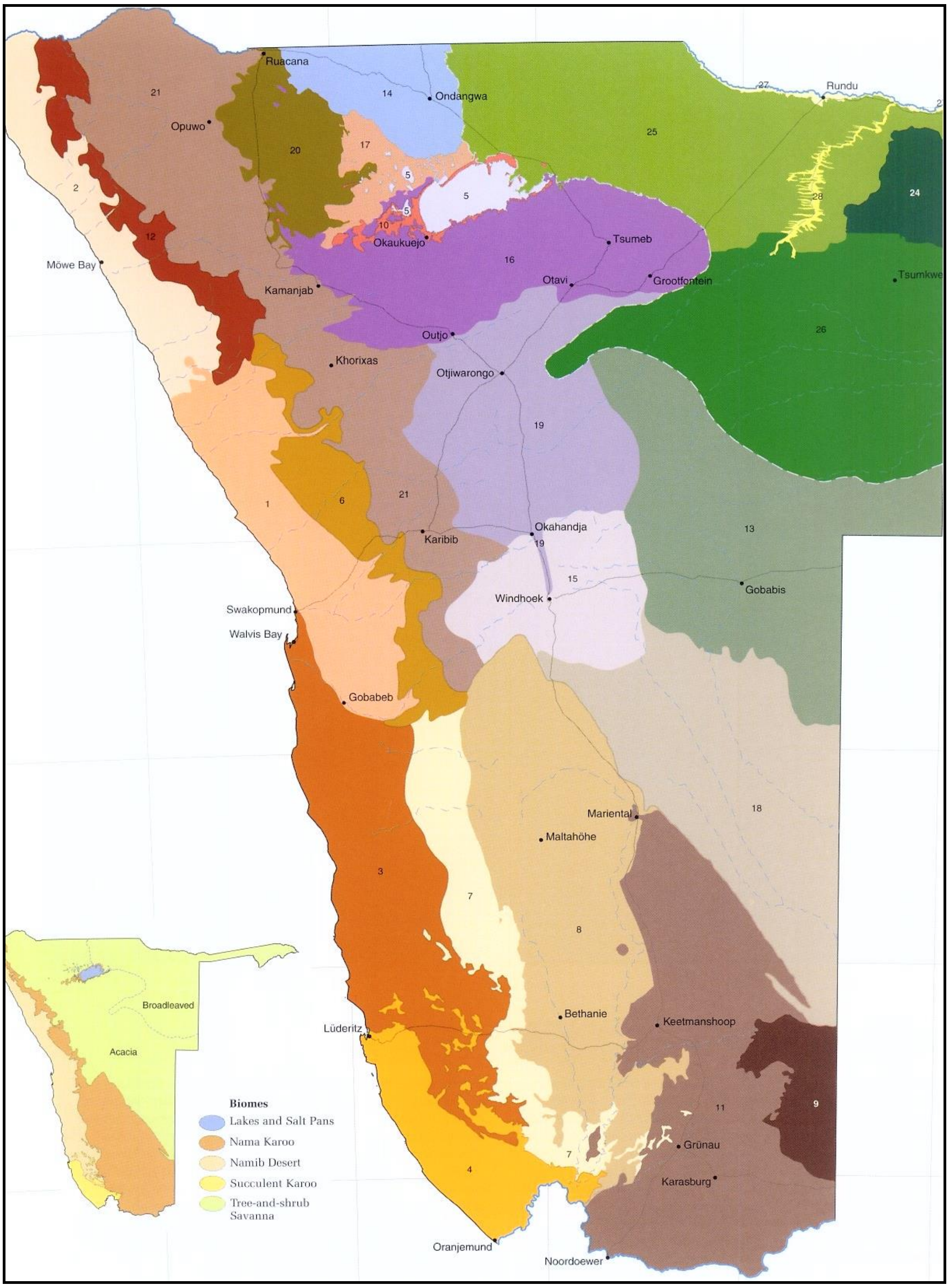
## *Appendix A*

# MAP OF VEGETATION TYPES IN NAMIBIA




Note: Type 15 is the Highland Savanna

Source: Mendelsohn et al. (2002).

*Appendix B*

# INTRODUCTION TO QUESTIONNAIRE

Dear participant,

I am a Masters student in Environmental Management with the University of the Free State, South Africa. I am conducting research on the management methods of commercial cattle farmers in the Namibian climate. I use a questionnaire to collect data on various management methods and other relevant factors. The questionnaire consists of questions where a number of potential answers are pre-printed and where the appropriate answer can simply be circled or ticked, sometimes with an 'other' option where you have the choice to enter text when the appropriate answer is not pre-printed on the questionnaire. If you think a question does not apply to you then you may leave it out, but please answer as many questions as possible.

I have asked you to provide your name, since this information will allow me to contact you if I need to ask any follow up questions or gain clarity on answers. I have also asked for your farm name and farm number; I need this information in order to determine the location of your farm, which will help me to determine the range of farms that I have covered. All your answers on this questionnaire will be treated as strictly confidential and will be used solely for the purpose of this study. The results from the study will be processed and analysed collectively and data summaries will be reported. The sources for the data and the names of the study participants and of their farms will remain strictly confidential.

By completing this questionnaire, you give consent for me to use your answers in my study. I will send an electronic copy of my final thesis to every participant with the hope that my research may be of some assistance to you.

I request that the most active farmer and decision maker in the family complete the questionnaire, preferably the person with the most farming experience. If you own more than one farm and they do not border each other, please choose your most economically productive farm. If your farms border each other and are managed as a unit, please answer questions relative to the whole area. I have provided a map of the study area, please mark your farm(s) (applicable to the questionnaire) with an 'x'.

I have included a few definitions of terms you may not be familiar with. Please feel free to contact me should you need any clarification on any questions that I have asked. I ask that you please scan and email the questionnaire to grunewald.thecha@gmail.com. Alternately, you can hand in the completed questionnaire at Permit Office in Windhoek. Please complete the questionnaire before 14 June 2016.

I thank you for your time and willingness to complete my questionnaire.

Regards,

Thecha Gericke

**Terminology:**

Cultivated pastures:

Indigenous perennial grass species such as *Cenchrus ciliaris* (buffalo grass) or *Anthephora pubescens* (wool-grass, borseltjiegras) are used for cultivated pastures. Exotic grass species are also used. The pastures provide extra feed to cattle and livestock when it is needed.

Fodder crops:

Drought resistant fodder crops such as exotic *Opuntia* spp. (prickly pear) and *Aloe* spp. (Agave) are planted and typically used during drought as supplementary feed for livestock. Indigenous plant species can also be used as fodder crops.

Fodder bank:

A fodder bank is supplementary feed that is stored for periods when grazing conditions cannot provide sufficient food to sustain or to improve cattle conditions.

*Appendix C*

# QUESTIONNAIRE

| | | | | |
|---|---|---|---|---|
| Name: | | | | |
| Surname: | | | | |
| E-mail address: | | | | |
| Telephone number: | | | | |
| Please list the name/s and farm number/s of the farm(s) you own, also include size: (**Only farms bordering each other**) | | **Farm name** | **Farm number** | **Size (Ha)** |
| | | 1. | | |
| | | 2. | | |
| | | 3. | | |
| | | 4. | | |
| | **Question** | **Answer**<br>Please circle your answer or tick where requested. | | |
| 1.1 | Sex | 1= Female 2= Male | | |
| 1.2 | Age | ____________ years | | |
| 1.3 | Ethnicity | 1= Afrikaans 2=German 3= Indigenous<br>4= Other:______________________ | | |
| 1.4 | What is your educational background? | 1= Completed primary school 2= Completed high school<br>3= Trade/apprenticeship 4= Diploma/Bachelor<br>5= Master/Doctorate | | |
| 1.5 | Years of farming experience in the Highland Savanna | 1= 0-10 2= 11-20 3= 21-30 4= 31-40<br>5= 41-50 6= more than 50 | | |
| 1.6 | Are you a weekend farmer? (Do you live elsewhere during the week?) | 1= Yes 2=No | | |
| 1.7 | What percentage did cattle farming contribute to your yearly income for these periods? | 2005-2010<br>____________% | 2010-2015<br>____________% | |
| 1.8 | Please indicate (tick) if you have any other on-farm activities that contribute to your annual income? (More than one may be chosen) | | 1= None | |
| | | | 2= Crop Farming | |
| | | | 3= Game farming (incl. Trophy hunting & other utilization) | |
| | | | 4= Charcoal Production | |
| | | | 5= Tourism | |
| | | | 6=Other:<br>________________________________________ | |

<table>
<tr><td>1.9</td><td>What percentage do these activities in 1.8 contribute to your yearly income? (Including off-farm income)</td><td colspan="5">__________%</td></tr>
<tr><td>2.1</td><td>How many camps does your farm consist of?</td><td colspan="5">________________Number</td></tr>
<tr><td rowspan="2">2.2</td><td rowspan="2">What is your average stocking rate (for livestock) during periods of above and below average rainfall? You can answer in kg (live weight)/ha or ha/LSU.</td><td colspan="3">Above average rainfall</td><td colspan="2">Below average rainfall</td></tr>
<tr><td colspan="3">________ha/LSU<br>or<br>________kg (live weight)/ha</td><td colspan="2">________ha/LSU<br>or<br>________kg (live weight)/ha</td></tr>
<tr><td>2.3</td><td>What factor has the most significant influence on how many cattle you keep on your farm?</td><td colspan="5">1 = Rainfall and grass growth 2 = Financial situation<br>3 = Market factors<br>4=Other:<br>______________________________________________</td></tr>
<tr><td>2.4</td><td>How many mm of rain do you consider as normal or average annual rainfall for your farm?</td><td colspan="5">_____________mm</td></tr>
<tr><td rowspan="25">2.5</td><td rowspan="25">Please tick during which seasons you experienced above and below average rainfall, also indicate where normal (average) rainfall was experienced.<br>Where possible please provide rainfall in mm.</td><td>Above</td><td>Normal</td><td>Below</td><td>mm</td><td></td></tr>
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| | | | |
|---|---|---|---|
| 2.6 | How do you determine your carrying capacity? | | 1=Carrying capacity maps from the Ministry of Agriculture (MAWF) |
| | | | 2= Advice from consultants |
| | | | 3=By monitoring rain |
| | | | 4= By monitoring available grass |
| | | | 5= I do not consider my carrying capacity |
| | | | 6=Other: ____________________ |
| 2.7 | In the time that you have been farming with cattle on your farm, has your carrying capacity on average.... | 1= Increased 2= Decreased 3= Stayed the same | |
| 2.8 | If your carrying capacity has **increased**, please tick the reasons for this occurrence. (More than one may be chosen) | | 1 = I rest a portion of my farm for a full growing season |
| | | | 2= I have de-bushed my farm |
| | | | 3= I decreased my stocking rate for several years (2 years or more) |
| | | | 4=Other: ____________________ ____________________ |
| 2.9 | If your carrying capacity has **decreased**, please tick the reasons for this occurrence. (More than one may be chosen) | | 1= My farm experienced over grazing in the past |
| | | | 2= My farm is bush encroached |
| | | | 3= My veld experienced degradation during drought years |
| | | | 4=Other: ____________________ ____________________ ____________________ |
| 3.1 | Were you to some extent prepared for the last drought before it occurred? | 1= Yes 2= No | |
| 3.2 | If "Yes", please tick the ways in which you prepared for drought. (More than one answer may be given) | | 1= Savings account to buffer losses |
| | | | 2= Rested a part of my farm |
| | | | 3= Supplementary feed stored |
| | | | 4= Able to destock quickly |
| | | | 5=Other: ____________________ ____________________ |
| 3.3 | Do you rest a portion of your farm for a full growing season (Jan to May)? (If 'no' proceed to question 3.5) | 1= Yes 2=No | |

| | | | |
|---|---|---|---|
| 3.4 | What percentage of your farm do you rest on average? | ____________ % | |
| 3.5 | If you **do not** rest a part of your farm for a full growing season, please tick the reasons preventing you from doing so. | | 1 = I am unfamiliar with this technique |
| | | | 2= It will put the rest of my grazing under pressure |
| | | | 3= I do not believe it helps |
| | | | 4= My farm is too small |
| | | | 5= Other: ____________ ____________ |
| 3.6 | Do you have any cultivated pastures of grass on your farm? If no proceed to question 3.10 | 1= Yes 2=No | |
| 3.7 | What specie/s do you use for your cultivated pastures? (Can be common name) | 1.____________Species name<br>2.____________Species name | |
| 3.8 | How many hectares does your cultivated pasture consist of? | ____________Hectares | |
| 3.9 | Are you satisfied with your decision to grow cultivated pastures? | 1= Yes 2=No | |
| 3.10 | If you **do not** have any cultivated pastures, please tick the reasons why. (More than one may be chosen) | | 1 = I am unfamiliar with this method |
| | | | 2= My farm is too dry |
| | | | 3= It is too expensive |
| | | | 4= I do not believe it is necessary |
| | | | 5=Other: ____________ ____________ |
| 3.11 | Are you growing any exotic or indigenous fodder crops on your farm? If no proceed to question 3.14 | 1= Yes 2=No | |
| 3.12 | What specie/s do you grow? (Can be common name) | 1.____________Species name<br>2.____________Species name | |
| 3.13 | How many hectares does your fodder crop consist of? | ____________Hectares | |
| 3.14 | If you **do not** have any fodder crops, please tick the reasons why. (More than one may be chosen) | | 1= I am unfamiliar with this method |
| | | | 2= They will use too much water |
| | | | 3= I am afraid they will encroach on my natural rangeland |
| | | | 4= I do not believe it is necessary |
| | | | 5=Other: ____________ ____________ ____________ |

| | | | |
|---|---|---|---|
| 3.15 | What other methods do you use to build up a fodder bank? (More than one may be chosen) | | 1= Make hay from roadsides reserves |
| | | | 2= Buy hay from Namibian sources |
| | | | 3= Buy hay from South African sources |
| | | | 4=Other: ______________________ ______________________ |
| 4.1 | At the **beginning** of the current/previous drought, did you remove some cattle from your herd? | 1= Yes 2=No | |
| 4.2 | What percentage of your herd were you able to remove immediately? | ______________Percentage | |
| 4.3 | During which month/s did you remove cattle immediately? | ______________Month/s | |
| 4.4 | Was it necessary for you to remove more cattle at a later stage in the current/previous drought? | 1= Yes 2=No | |
| 4.5 | What percentage of your herd were you able to remove at a later stage in the drought? | ______________Percentage | |
| 4.6 | During which month/s did you remove cattle at a later stage? | ______________Month/s | |
| 4.7 | What factors prevent you from destocking immediately during drought? (More than one may be chosen) | | 1= Low market prices |
| | | | 2= Low weight of livestock |
| | | | 3= Herd consists mainly of breeding stock |
| | | | 4= No immediate market available (For example Meatco needs notice in advance) |
| | | | 5=Believing that more rain will come |
| | | | Other: ______________________ |
| 4.8 | After a drought has occurred, what methods do you use to restock your farm with cattle? | | 1= I allow my herd to increase naturally through breeding |
| | | | 2= I buy cattle |
| | | | 3=Other: ______________________ |
| 4.9 | If you buy cattle, on average, how long do you wait before you restock your farm after drought? | __________Months | |
| 4.10 | On average, by what percentage do you allow your herd to increase during years of <u>above</u> average rainfall? | __________ % | |

| | | | |
|---|---|---|---|
| 4.11 | If you have experienced any cattle deaths caused by the last/current drought, please indicate how many cattle died. | ________________Number | |
| 5.1 | In the time that you have been farming with cattle on your farm, what have you noticed about the trend of annual grasses in your veld? | 1= Increased 2= Decreased<br>3= Stayed the same | |
| 5.2 | What have you noticed about the trend of perennial grasses in your veld? | 1= Increased 2= Decreased<br>3= Stayed the same | |
| 5.3 | What are the visible signs of environmental degradation on your farm? (More than one answer may be given, please tick) | | 1= Bush Encroachment |
| | | | 2= Low grass cover |
| | | | 3= Wind erosion |
| | | | 4= Water erosion |
| | | | 5=Other:<br>________________________________ |
| 5.4 | Have you undertaken any form of bush control on your farm? (If 'no' proceed to question 5.13) | 1= Yes 2= No | |
| 5.5 | If yes on how many hectares did you control bush? | ______________________Hectares | |
| 5.6 | What methods do you use to control bush?<br>(You may choose more than one, please tick) | | 1 = Manual removal (chopping) |
| | | | 2 = Mechanical removal (machine) |
| | | | 3 = Chemical control (aerial) |
| | | | 4= Chemical control (manual) |
| | | | 5 = Controlled veld burning |
| | | | 6 = Stem burning of target bushes |
| | | | 7= Other:<br>________________________________ |
| 5.7 | If you chose 'chemical control', name the arborcide that you use. | ______________________________________Name | |
| 5.8 | Using which methods, have you had the most success with controlling bush? (You may choose more than one) | | 1 = Manual removal (chopping) |
| | | | 2 = Mechanical removal (machine) |
| | | | 3 = Chemical control (aerial) |
| | | | 4= Chemical control (manual) |
| | | | 5 = Controlled veld burning |
| | | | 6 = Stem burning of target bushes |
| | | | 7=Other:<br>________________________________ |

| | | | |
|---|---|---|---|
| 5.9 | If any negative effects occurred, please tick what you have observed. | | 1= Observed grass mortality |
| | | | 2= Observed non-target tree mortality |
| | | | 3= Observed animal mortality |
| | | | 4=Other: ______ ______ ______ |
| 5.10 | If you have noticed tree mortality and are using an arborcide, which non-target trees have you noticed dying? | | 1= Camelthorn (*Acacia erioloba)* |
| | | | 2= Shepards tree/Witgat (*Boscia albitrunca*) |
| | | | 3= Buffalo thorn/Blinkblaar-wag-'n-bietjie (*Ziziphus mucronata*) |
| | | | 4=Other species: ______ ______ |
| 5.11 | With which methods did you have the least success? (You may choose more than one, please tick) | | 1 = Manual removal (chopping) |
| | | | 2 = Mechanical removal (machine) |
| | | | 3 = Chemical control (aerial) |
| | | | 4= Chemical control (manual) |
| | | | 5 = Controlled veld burning |
| | | | 6 = Stem burning of target bushes |
| | | | 7=Other: ______ |
| 5.12 | Why do you feel these methods did not work for you? (You may choose more than one, please tick) | | 1= They were too expensive |
| | | | 2= They were too labour intensive |
| | | | 3= They caused unexpected mortality in my veld and animals. |
| | | | 4=Other: ______ ______ |
| 5.13 | What factors prevent you from practising ideal levels of bush removal? (You can answer this question if you are already controlling bush, or if you are not controlling bush at all). | | 1 =Not enough money available |
| | | | 2= Not enough time available |
| | | | 3= I need training on how to remove bush |
| | | | 4= I believe bush numbers will decrease with drought and disease |
| | | | 5= I do not consider my farm as bush encroached |
| | | | 6= Other: ______ ______ |

| 6. What is your opinion of the following statements? (Please tick) | | | | |
|---|---|---|---|---|
| | **Statement** | **Agree** | **Don't agree** | **Don't know** |
| 6.1 | Bush control increases my carrying capacity. | | | |
| 6.2 | Lack of fire in a rangeland contributes to bush encroachment. | | | |
| 6.3 | Overgrazing contributes to bush encroachment. | | | |
| 6.4 | An increase in rainfall contributes to bush encroachment. | | | |
| 6.5 | Droughts are not something that can be planned or prepared for. | | | |

End of questionnaire.

Thank you for your time and contribution to this study!