AN EVALUATION OF SOCIO-ECONOMIC AND BIOPHYSICAL ASPECTS OF SMALL-SCALE LIVESTOCK SYSTEMS BASED ON A CASE STUDY FROM LIMPOPO PROVINCE: MUDULUNI VILLAGE

by

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Foreword

Livestock plays a central role in the livelihoods of small-scale farmers in Southern Africa and it also contributes to the human nutrition, traction, transport, income, and fertiliser needs of rural farmers, as well as to their financial security. In addition, livestock fulfils an important role at social and cultural functions. In essence, the world's poorest people − approximately one billion − depend on pigs, yaks, cattle, sheep, lamas, goats, chickens, camels, buffalos and other domestic animals for their livelihood (Maarse, 2010). There is also considerable evidence which shows that both the rural poor and the landless receive a higher proportion of their income from livestock than do the better to do. Freeman, Kaitibie, Moyo and Perry (2008) report that livestock is crucial to the livelihoods of many households in Southern Africa, although the role of livestock in terms of food security has not been either fully understood or exploited. As a result of both the dearth of information on livestock productivity and disturbing reports on the natural feed resource bases in the developing countries, a case study of the biophysical and socio-economic complexities of small-scale, communal, livestock farmers in South Africa has become necessary.

This dissertation is dedicated to providing a better understanding of the biophysical and socio-economic complexities within the communal farming systems with the hope that the study will help bring about an improvement as regards the livelihoods of small-scale, communal, livestock farmers through increased livestock productivity. In addition, it is hoped that the knowledge generated by this study will contribute to a sound scientific base for the launch of serious development at all levels.

DECLARATION

I declare that this thesis which is hereby submitted for the degree of Doctor of Philosophy at the University of the Free State is my own independent work, and has not been submitted for degree purposes to any other university. I hereby forfeit any copyright of this thesis to the University of the Free State.

Ek verklaar hierby dat die proefskrif wat hierby vir die graad Doktorandus van Filosofie aan die Universiteit van die Vrystaat deur my ingedien word, selfstandige werk is en nie voorheen deur my vir 'n graad aan 'n ander universiteit ingedien is nie. Ek doen voorts afstand van die outeursreg van die proefskrif ten gunste van die Universiteit van die Vrystaat.

………………………………………. ………April 2012……

Fhumulani Rachel Munyai **Date**

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LIST OF ACRONYMS

ADF	Acid detergent fibre
ADC	Agricultural Development Centre
AIDS	Acquired immune deficiency syndrome
Ca	Calcium
CGIAR	Consultative Group on International Agricultural Research
Co	Cobalt
CIS	Commonwealth of Independent States
CIFR	Centre for International Forestry Research
CP	Crude Protein
Cu	Copper
DoA	Department of Agriculture
DBSA	Development Bank of Southern Africa
DM	Dry matter
EE	Eastern Europe
FAO	Food and Agriculture Organisation
F	Frequency
GDP	Gross domestic product
GGP	Gross geographic product
HIV	Human Immunodeficiency Virus
HA/LSU	Hectare per livestock unit
H_2SO_4	Sulphuric acid
ILRI	International Livestock Research Institute
LPDA	Limpopo Province Department of Agriculture
MDGs	Millennium Development Goals
Mg	Magnesium
Mn	Manganese
Na	Sodium
N	Nitrogen
NH_3	Ammonia
NDF	Neutral detergent fibre
NPN	Non-protein nitrogenous compounds

OECD	Organisation for Economic Cooperation and Development
OF	Oesophageal fistulation
OM	Organic matter
P	Phosphorus
PS	Palatability score
PRSP	Poverty Rural Strategy Papers
PROLINOVA	Promoting local innovation
R&D	Research and development
RF	Rumen fistulation
RGC	Relative grazing capacity
S	Sulphur
SLF	Sustainable Livelihood Framework
SPSS	Statistical Package for Social Sciences
UN	United Nations
WPC	Weighted palatability composition
Zn	Zinc

CHAPTER 1

INTRODUCTION

This chapter contextualises the problem which this thesis aims to address. The chapter commences with discussion of the research motivation and justification for the necessity of the study and a description of the objectives of the study and ends with an outline of the subsequent chapters.

1.1 RESEARCH MOTIVATION

Despite the millennium development goals (MDGs) that the international community has pledged to achieve by the year 2015, poverty remains ubiquitous in many parts of the world. Poor rural households are constantly involved in a struggle to make ends meet with food security and family livelihood expenses constituting some of the major priorities of these households (Van Rooyen, 2008). It is reported that 864 million people worldwide are either undernourished or malnourished. Animal products account for an average of 33% of the protein in a daily balanced diet (Reist et al., 2007). The majority of the undernourished and the malnourished are found in the developing countries, namely, East Africa, South Asia, South East Asia, Central and South America, sub-Saharan Africa, West Africa and North Africa (Thornton et al., 2002).

Globally, agriculture provides a livelihood for more people than any other industry and, thus, since most of the world's poor live in rural areas and are largely dependent on agriculture, it plays a role in reducing the poverty in these rural areas. In addition, food prices determine the cost of living for both the rural and the urban poor (FAO, 2004b). However, we have also seen a decline in both the funding and the aid destined for the rural areas and this, in turn, has exacerbated rural poverty (D'Haese and Kirsten, 2006). The balanced use of the available natural resources helps combat poverty with farm animals being a resource which is the most readily available to the world's poor (Kirsten, 2006a).

Of the 1.3 billion people in the developing world, nearly a third lives below the poverty line. This situation is the worst in sub-Saharan Africa with more than half the population falling into this category, thus prompting the reviewers in the Third System Review of the Consultative Group on International Agricultural Research (CGIAR) to plead that special attention be given to this underprivileged region. Table 1.1 illustrates the extent of rural poverty in developing regions. The estimated 678 million of the rural poor who keep livestock in the developing countries represent approximately two-thirds of the rural poor, with this large proportion indicating the importance of animals to the livelihoods of this group (ILRI, 2000).

Table 1.1: The extent of rural poverty in developing regions ILRI (2000)

REGION	NO OF RURAL PEOPLE(M)	SHARE OF RURAL TO TOTAL POOR (%)
E Asia	114	80.9
South Asia	417	81.3
SE Asia	121	82.9
Latin America and Caribbean	76	42.0
W Asia and N Africa	40	49.6
Sub-Saharan Africa-	248	88.1
Total	1016	75.7

Of the 600 million poor livestock keepers in the world, two-thirds are women. However, despite the years of gender sensitisation in many research and extension organisations, the role of women both in livestock production and in marketing animals and their products continues to be underestimated and there is still a belief that the major actors in livestock (especially ruminants) are men. Accordingly, animal scientists working in the developing countries should be concerned about gender inequality and women empowerment because these issues are vital to improving animal production and, thereby, the livelihoods of millions of rural and urban households (Waters-Bayer and Letty, 2010). In Southern and East Africa and, indeed, in the whole of sub-Saharan Africa, the majority (up to 80%) of farmers are women (Kirsten, 2006b).

The United Nations describes the burden of this inequality as follows: “Women, who comprise half the world’s population, do two thirds of the world’s work, earn one tenth of the world’s income and own one hundredth of the world’s poverty” (Woldentensaye, 2007). This provides a clear indication that poverty has a gendered face and that women are poorer than men (Woldentensaye, 2007). Mupawaenda, Shingirai and Muvavariwa (2009) note that for mainly traditional and historical reasons, men continue to dominate livestock production, although this situation is gradually changing. However, men continue to eclipse women in terms of ownership of the more valuable stock, the making of decisions and the control of livestock production. This, in turn, suggests that gender is important in livestock production and must, together with other factors, be taken into account.

Nesamvuni et al. (2010) emphasises that it is essential that researchers working on gender issues in agriculture acknowledge that the empowerment of women in Africa must be accompanied by the empowerment of men and that, to avoid conflict, the traditional customs should not be disregarded.

The livestock sector in developing countries contributes more than 33% to the agricultural gross domestic product and is also one of the fastest growing agricultural subsectors, a major contributor to food and nutrition security as well as serving as an important source of livelihood for nearly 1 billion poor people in developing countries (Swanepoel and Moyo, 2010). In addition, it is anticipated that the livestock sector will become the world’s most significant agricultural subsector in terms of value add and land use (Van der Zijpp et al., 2010).

It is estimated that meat, milk and eggs provide about 20% of the protein in African diets while approximately 70% of the human population of sub-Saharan Africa is primarily dependent on livestock (Lenne and Thomas, 2006).The keeping of livestock is an important way in which poor people may diversify their livelihoods and also a way of ex-ante risk management − a deliberate household strategy to anticipate failures in crop yields or other income streams (D’Haese et al., 2008).

According to Herrero et al. (2010), livestock systems are the largest land-use activity on earth. In the developing countries, aside from the fact that livestock may be kept in the vicinity of the house or common land and fed with residue, there are also several other reasons why livestock is kept. These include, inter alia, the fact that livestock produces important food products and fertiliser, is source of income, provides draught power, fulfils banking and insurance functions, and so forth. Global livestock production was expected to double by 2010 and, hence, the greater emphasis on mechanisms to ensure that smallholders reaped benefits from the livestock revolution in a sustainable manner in order to realise the multifunctional nature of livestock in developing communities (Burrow, 2008).

The case for promoting increased livestock production is extremely pressing, especially in view of the rapidly growing demand for animal products in conjunction with the global aim to halve, by 2015, the proportion of the world population living in extreme poverty, most of whom are dependent, at least in part, on the food and income derived from livestock. In particular, the benefits from livestock development will accrue to both the landless and to rural women. Meeting the needs for promoting livestock production "while, at the same time sustaining the natural resource base (soil, water, air and bio-diversity), is one of the major challenges facing world agriculture today" (FAO, 2004b).

An increase in livestock productivity will result in primary benefits such as sustainable improvements in the livelihoods of livestock producers, many of whom are resource-poor, many of whom are women and some of whom are landless. These benefits will be reflected, inter alia, in improved levels of nutrition, while increases in market sales will provide income for other uses. However, increases in domestic production and the supply of livestock products may result in falling prices although these falling prices will benefit consumers and accelerate the growth in demand. Nevertheless, the fall in prices is unlikely to be significant enough to cancel out the benefits to the producers of the increases in productivity. The main effect for most developing countries will be the substitution of domestic products for imports and this, in turn, will bring additional benefits by saving scarce foreign exchange. Improvements in animal and veterinary public health will not only decrease farm costs and increase productivity and incomes, but also reduce the risks of animal losses and of human disease. In addition, those countries which are producing more than enough for domestic consumption will enjoy improved access to world markets. The social and economic contribution of livestock is widely recognised as representing a key element of sustainable agricultural development and household food security (FAO, 2002).

Poverty and food insecurity, as well as environmental degradation, are among the common rural phenomena in sub-Saharan Africa. The majority of the rural poor derive food and income from the use of natural resources, through agriculture, stock keeping, fishing, hunting, gathering of various goods and the like (Kirsten, 2006a). The location of the rural poor is characterised by certain constraints that contribute to both their vulnerability and their poverty. Some of the common constraints confronting the rural poor include, inter alia, hilly topography, poor soils, low and erratic rainfall, and poor infrastructure. In addition, the rural poor often lack financial and physical assets as well as the necessary resources with which to generate their livelihoods (Mtshali, 2002). Livestock accounts for 53% of the agricultural capital stock in sub-Saharan Africa and contributes significantly (30%) to agricultural products (Stroebel at al., 2010).

Mapiye et al. (2009) report that over 70% of the resource-poor farmers in South Africa are to be found in the harsh agro-ecological zones where cropping is unsuitable and, thus, they are forced to rely on livestock for their livelihoods. Musemwa et al. (2008) report that cattle production is the most important livestock sub-sector in South Africa, contributing approximately 25 to 30% to the total agricultural output per annum and with significant potential to alleviate household food insecurity and poverty in the communal areas of South Africa. In South Africa the rural poor households are found mainly in the previously communal homeland areas. After the democratic elections in 1994, South Africa was divided into nine provinces of which Limpopo is one. Limpopo includes three of the ten former homelands, namely, Venda, Gazankulu and Lebowa, which has, in turn, resulted in the highest concentration of poor rural households in the province.

The Limpopo Provincial Government (2011) reports that Limpopo is located at the northern tip of South Africa, bordering Zimbabwe to the north, Mozambique to the east, Botswana to the west. The Province covers an area of 125 701.86 sq km, which represents 10.2% of the area of South Africa. The 2001 Census has reflected a total population for Limpopo of 5.2 million, which represents 11.8% of the entire population of South Africa. The total population comprises 54.6% female, 45.4% male and 48% children under the age of 15 (SSA, 2001).

The Limpopo Province has five municipal districts, namely Vhembe, Capricorn, Waterberg, Sekhukhune and Mopane and 25 subdivisions of local municipalities.

Oni et al. (2003) report that Limpopo Province covers an area of 12.46 million hectares − 10.2% of the total land area of South Africa. In addition, Limpopo Province comprises three distinct climatic regions, namely, lowveld (arid and semi-arid) regions, middle veld, highveld, semi-arid region and the escarpment region with a sub-humid climate with rainfall in excess of 700 mm per annum. This diverse climate enables Limpopo Province to produce a wide variety of agricultural produce.

Oni et al (2003) report that 89% of the population of Limpopo Province is classified as rural, and agriculture plays a major role in the economic growth and development of the Province. The current structure of the Limpopo agricultural sector is dualistic and consists of two groups of farmers – large-scale white commercial farmers and small-scale previously disadvantaged black farmers[1]. For a full discussion, see the literature review in Chapter 2.

Statistics South Africa (2010) reports that there are 5 000 commercial farming units in Limpopo Province, operating large farms which are well organised and situated on prime land. Furthermore, these commercial farming units use advanced production technology and occupy 70% of the total land area of the Province. During 2000, there were 273 000 small-scale farmers operating in Limpopo Province, occupying 30% of the provincial land surface area. The majority of these smallholder farmers were

[1]*For a full discussion, see the literature review in Chapter 2*

women who produced food crops and livestock for their families' subsistence. Farming in terms of these smallholder systems is characterised by low levels of production technology and a farm holding of approximately 1.5 hectares per farmer. In addition, the low income and poor resource base of these smallholder farmers poses serious challenges to the agricultural growth and economic development of Limpopo Province. The IDP review 2011/12 report states that lack of access to initial support capital, lack of marketing and lack of infrastructure are key constraints faced by small-scale farmers in the Makhado municipal area within. Muduluni village forms one of the wards of this municipality.

Acheampong-Boateng et al. (2003) conducted a desktop study on livestock populations and livestock or allied projects in Limpopo Province and revealed that the land used for grazing in the Province comprises approximately 8 847 848 ha out of a total farming area of 10 548 290 ha, thus representing 83.9% of the total farming area in the province. In addition, the income from animal production constitutes more than half the total income that accrues to Limpopo Province from agriculture. The importance of animal production, especially grazing animals, in the agricultural economy is thus evident. The Limpopo Province communal areas will, increasingly, play a major role in the livestock economy of the province despite certain constraints which will be discussed in the following paragraphs.

The most important constraint is overstocking, as high stocking rates and low effective carrying capacity is prevalent. This, in turn, leads to low reproductive rates and low growth rates as well as low take off (amount of beef produced over a certain period) as it takes a long time for the animals to become marketable.

Secondly, there is winter die off as a result of the unavailability of feed. In addition, major losses may occur in the event of drought. Thirdly, there is a lack of herbage in winter. Fourthly, grazing management is conducted in an unsatisfactory manner. Fifthly, animals tend to be inbred and, sixthly, animals are lost as a result of stock theft and snares.

Cousins (1988) reports that a full understanding of the role of livestock in the economies of rural Africa remains one of the most challenging problems confronting researchers, development planners and practitioners, while Bembridge (1997) reports that the slow progress in the expansion and development of the livestock sector as regards the smallholders is a result of several complex factors, including ecological, biological and socio-economic aspects. On the other hand, Schawlbach et al. (2001) report that data on the socio-economic and management of communal systems is essential in order to plan and implement effective development strategies while Mapinye et al. (2009) report that previous efforts to address cattle production constraints in South Africa ignored farmers' perceptions, and prevailing sociocultural and economic conditions, thus making it difficult to design and implement sustainable development programmes based on the indigenous cattle resources and aimed at benefiting the resource-poor people. Nevertheless, there have been few, if any, studies that have shown linkages between constraints, production parameters and socio-economic factors affecting farmers in the smallholder areas of South Africa. This, in turn, justifies the first component of this study which is aimed at the socio-diagnostic aspect of the small-scale livestock systems of communal grazing system and all its complexities.

Recent analysis indicates that by far the largest number of poor people in the developing world live in regions where mixed farming systems predominate, with the result that these integrated crop-livestock systems provide livelihoods to most of the rural poor. Accordingly, research focused on improving the sustainable livelihoods of people in mixed farming systems may do more to reduce poverty than increasing productivity in intensive, industrialised systems (Stroebel, 2004). Livestock relies on poor quality, highly fibrous grass and fibrous crop residues during the dry season. However, these resources are inadequate to support optimum livestock productivity activities. Poor nutrition results in low rates of reproduction and production, as well as increased susceptibility to diseases. Approximately 40 million of the rural poor are involved in the arid and semi-arid grassland livestock production systems of the tropics and sub-tropics of sub-Saharan Africa (Stroebel, 2004). Cattle grazing on the natural feed resource base are subjected to a constantly changing feeding base, both quantitatively and qualitatively, as a result of variations in rainfall and temperature.

These variables affect botanical composition, dry matter production and the nutritive value of the natural feed resource base, all of which are of paramount importance in sustaining livestock production (Okello et al., 2005). Adequate amounts of good quality forage on a daily basis are essential if cattle are to meet the nutrient requirements for maintenance and production from such a natural feed resource base.

The livestock industry in South Africa is the dominant industry (40%) in the agricultural sector, followed by field crops (33%) and horticulture (27%) (Department of Agriculture, 2005/06).However, various factors exert increasing pressure on the natural feed resource base. These factors include an expanding human population [according to Palmer and Ainslie (2006) currently 44.2 million], increasing animal feeding costs, narrowing profit margins of the livestock industry, increasing demand on energy sources and the increasing demand for food production. These factors, inturn, constantly refocus the attention on the need for a more effective evaluation of the natural feed resource base in terms of its nutritive value for ruminants (Cilliers and Van der Merwe, 1993). According to Abdulrazak et al. (1997), the following factors are mainly responsible for poor livestock production in the tropics: a lack of feed as a result of overgrazing, poor quality feed and a reduced intake of dry-season feed from the natural vegetation. Willison and Macleod (1991) claim that overgrazing of the natural feed resource base all over the world affects the dry matter production potential. This situation, in turn, has a direct influence on livestock production and necessitates greater efforts to stop the further deterioration o fveld condition.

Numerous studies have been conducted with the aim of broadening the general perspective of grazing animals on the natural feed resource base. However, despite the valuable knowledge generated by these studies[2], there is still a remarkable paucity of information regarding the nutritional factors governing animal production from the natural feed resource base. This finding applies to livestock production in general, but it is especially true in the case of the communal rangelands of South African, which cover nearly 6 million ha and are home to approximately 2.4 million

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[2]*For a full discussion, see the literature review in Chapter 2*

rural households. These rangelands are used by the poor rural communities, not only for supporting livestock, but also for harvesting a wide range of natural resources (Twine, 2005). Accurate information on the nutritive value of the natural feed resource base is important to animal production while the conservation and proper utilisation of the natural feed resource base are two important variables in terms of both the sustainable utilisation of the natural feed resource base and the sustainable productivity of the livestock industry

The expected increase in the human population has resulted in grazing land being rezoned for residential and cropping areas, which results in both reduced grazing land being available for ruminant production and an increase in the human consumption of food from animal origin. Extensive literature has reported negatively on the quality of the biomass available to cattle grazing on communal land and, hence, the necessity of including a biophysical study in order to investigate different aspects of the natural environment, especially the biomass production under communal grazing, in order to quantify the nutritional factors affecting smallholder cattle production. The latter justifies the second part of this study.

It is evident that livestock is well positioned to continue contributing to social transformation as a strategic asset of poor populations (Randolph et al., 2007). This is related, in turn, to the concurrent need to support the poor by means of increasing productivity and protecting the environment, thus resulting in benefits linked to food security and sustainable livelihoods. However, in order to address these issues and to ensure an impact, the way forward will require a wider recognition of the following attributes: better use of the natural resource feed base, strong interdisciplinary approaches and institutional support to ensure the future contribution of livestock in developing countries (Stroebel et al., 2010). In addition, in view of the scarcity of information on the productivity potential of the livestock production of smallholders in South Africa, it is imperative that information on both the socio-economic and biophysical complexities of small scale ruminant livestock production system be made available to support agricultural initiatives in South Africa and, especially, to improve current livestock production. Clearly, the lack of resources and the inevitable question of sustainability should be one of the highest priorities for research.

It is against this background that it was decided to conduct a study of the socio-economic and biophysical complexities of small-scale livestock systems based on a case study from Limpopo Province: Muduluni village in Venda in an attempt to highlight the importance of livestock production as a means of both improving and sustaining rural livelihoods. For the purpose of this study, two adjacent sites were chosen, namely the Mara Agricultural Development Centre station (Mara ADC) as a site representing commercial farming and Muduluni as a site representing communal farming. Throughout this dissertation the Mara Agricultural Development Centre station will be referred to as Mara while Muduluni communal village will be referred as Mudu.

1.2 RESEARCH OBJECTIVES

Despite the important role that livestock plays in the livelihood of small-scale farmers, there is still a dearth of information regarding an understanding of these farmers' contribution to these small-scale livestock systems. However, it is evident that small-scale livestock systems are important both for South Africa itself and for the rest of the Southern African region. Accordingly, an improved understanding of the socio-economic and biophysical features of these systems may contribute to better focused development programmes in these regions.

This study intends to highlight the socio-economic and biophysical complexities of small-scale livestock systems and is based on a case study from Limpopo Province. The study will focus on Mudu village, situated in Venda, and compare it with the ideal situation on the adjacent Mara. Based on the two management systems the study will investigate the way in which the study impacts on the natural feed resource base by comparing the pasture yield and composition at Mudu to that of the Mara.

The study has a two-fold objective. Firstly, the study aims to evaluate the socio-economic complexities of small-scale, ruminant, livestock production under communal farming conditions in order to plan and implement effective development strategies. The sustainable rural livelihoods framework − see Figure 2.1 (Randolph et al., 2007) − will be used to provide an explicit focus on what is important to rural households in livestock production, thereby generating knowledge and practical recommendations to enhance the design and implementation of programmes and projects that will support rural livelihood security.

Based on this socio-economic scenario, the second objective of the study is to investigate the way in which the study impacts on the natural feed resource base by comparing the natural pasture at Mudu to that of the near ideal situation at the Mara. In addition, the study will also investigate how well the livestock farmer sin this area manage their natural pasture and also assess whether the natural pasture, on its own, has the potential to sustain their livestock farming. It is imperative to quantify the most important parameters of the natural feed resources in order to draw valid conclusions on the quantity and composition on livestock productivity. Accordingly, it was decided to express the grass material quantity in terms of dry material production per hectare, and the quality in terms of botanical and chemical composition, as well as *in sacco* degradability.

1.3 OUTLINE OF THE THESIS

A review of both the theoretical and the empirical literature pertinent to the topic of this thesis is presented in Chapter 2. Chapter 3 describes the research methodology, including a brief description of the study area, data collection procedures and analytical techniques. Chapter 4 reports the results of the study while Chapter 5 presents a discussion of the results. Chapter 6 is focused on the conclusion drawn from the study and, finally, the way forward is presented in Chapter 7.

CHAPTER 2

LITERATURE REVIEW

2.1 SOCIO-ECONOMIC ASPECTS OF SMALL-SCALE LIVESTOCK FARMERS

The research and development community faces the challenge of sustaining livestock productivity in order both to improve rural livelihoods and secure environmental sustainability in the developing countries. Current understanding of livestock productivity is incomplete and, hence, the need to update existing knowledge and to assess the role of livestock farmers in bringing about a significant improvement to their livelihoods. In addition, there is a need to pay more attention to the relative contributions of livestock farmers to the different sources of their livelihood and the way in which these vary between households, the extent to which people are constrained by their assets, changes in livelihood portfolios and, finally, to the options available in terms of poverty may be alleviated (Singh et al., 2007).

Living conditions in the rural areas are, to a considerable extent, reflected in the socio-economic factors pertaining to the households while, these, in turn, influence economic behaviour (Makhura, 2001). Despite the fact that considerable amounts of money are being invested in agriculture in an attempt to boost production and to alleviate hunger in the world; these efforts are unlikely to succeed unless they focus on the small-scale farmers who hold the key to ending the perennial hunger in the world (ILRI, 2010). Small-scale farming in developing countries is carried out mainly by small, autonomous family units, commonly known as “households”, and which operate within a defined production system.

2.1.1 DEFINITION OF CONCEPTS

Small-scale livestock keepers

There is no internationally agreed upon definition of the term small-scale, livestock keepers. The term “small-scale livestock production” is often used interchangeably with smallholder, subsistence and family farming, or with resource poor, low income, low external input, low output or low-technology livestock keeping. Smallholder farms constitute approximately 85% of all farms globally. Generic definitions for smallholders have been used, for example, dairy farmers with fewer than six milking animals, and/or less than 3 ha of land; pastoralists with fewer than 30 small ruminants or fewer than 200 poultry.

Smallholder livestock keepers are characterised by the following:

- They tend to operate with limited resources relative to other producers in the sector,
- They have low levels of formal education and training and they keep their animals on communal, rather than private, land or they may be landless.
- Smallholder livestock keeping is usually a family enterprise that practises either subsistence production or a mix of subsistence and commercial production. The family is the major source of labour, and livestock production is often the main source of income.
- They have limited access to input and output to markets and to services and credit with most of their market interaction taking place in informal local markets, for which they produce local or traditional products.
- They routinely face high transaction costs in respect of securing quality inputs and gaining market recognition for quality outputs (FAO, 2009a).

Smallholder livestock keepers tend not to purchase production inputs and the majority of these inputs come from the farm itself or from local grazing land as part of a closed nutrient cycle. These smallholder livestock keepers operate at the lower end of the production curve, where small additional inputs lead to substantial increases in productivity (FAO, 2009a).

Socio-economic characteristics of household

FAO (2004a) describes the household as a basic unit in respect of socio-cultural and economic analysis with most definitions of the term emphasising the issue of co-residence. The concept of the household is based on the arrangements made by persons for providing themselves with the food and/or other essentials they require for living. However, a household may be either one-person or multi-person. The household members may pool their resources. Households may consist of extended families who make provision for food or of potentially separate households with a common head, with the latter resulting from polygamous unions. Households may occupy more than one housing unit. A household may also include those persons who normally reside with the other members of the household but are temporarily away (period less than a year), for example, full-time students or those individuals engaged in seasonal migratory labour.

A study conducted by Makhura (2001) on the rural poor households in Limpopo Province revealed that the structure of the household, the asset structure, the physical location and access to information all comprise socio-economic characteristics of the household. These characteristics are explained below:

- Structure of the household: The size of the family, the participation of members of the household in various activities, the gender, size, age and education of the household members as well as the education level of the head of household are all important aspects to be considered
- Household assets: These include land, mobile assets and financial assets including non-farming income. Insufficient land constitutes one of the most significant constraints facing rural households. However, for any household, livestock is a source of social status and, hence, the majority of households own livestock. Households depend on a combination of agricultural and non-agricultural activities for their livelihood
- Physical location and information: Transaction costs also emanate from factors related to physical location and access to information. For example, those households located closer to market centres will experience lower transaction costs as they are able to obtain information easily. At the same time, better access to information will reduce transaction amounts.

As they attempt to meet and extend their livelihood needs households use a variety of resources as inputs into their production processes. As has been popularised in the Sustainable Livelihood Framework (SLF), these resources may be classified as financial, natural, human, social and physical. See discussion below (FA0, 2004a).

Sustainable livelihood framework (SLF)

The multiple objectives for keeping livestock suggest that it is misleading to consider livestock as a conventional, isolated production activity (Swanepoel et al., 2009). Instead, livestock activities are integrated within household production and consumption decisions, making the role that livestock play to minimize risk in household well-being, much more complex (Vandamme et al., 2010). Randolph et al. (2007) used the SLF (Carney, 1999) as a conceptual model to explain this complexity and to provide insights about the role of various types of household assets, with a focus on livestock in the well-being of the poor (Figure 2.1).

Human, financial, physical, natural and social capitals are all assets which are available to households. The livelihoods of people are based on these assets. A discussion of these five capital assets will ensure that all the components of the livelihood assets are addressed. For example, when households make choices about how to use their resources in order to further their livelihoods, the allocation of human capital, chiefly labour, is, arguably, the most important resource decision. Decisions regarding financial investments tend to be less important, as the scarcity of cash on the part of these households prevents frequent and large investments. Furthermore, the limited availability and transferability of natural capital prevents frequent and major decisions regarding land allocations (Campbell et al., 2002).

Carney (1999) reported that the SLF approach involves doing away with any pre-conceptions about what exactly rural people, in this case, the smallholder, are seeking and how they are most likely to achieve their goals. In addition, the SLF approach will help to develop an accurate and dynamic picture of the smallholders in their environment as well as providing a basis for identifying the constraints to both livelihood development and poverty reduction. Such constraints may be found either at local level or in the broader economic and policy environment. These constraints may relate to the agricultural sector − long-term focus of donor activity in rural areas − or they may have more to do with social conditions, health, education or rural infrastructure. This approach perceives sustainable poverty reduction as achievable, but only if the external support works with people in a way that is congruent with both their existing livelihood strategies and their ability to adapt. However, this approach entails an analysis of the following:

- The context in which (different groups of rural) people live, including the effects upon them of external trends, shocks and seasonality
- Their access to physical, natural, financial, social and physical assets and their ability to put these to productive use
- The institutions, policies and organisations which shape their livelihoods; and the different strategies they adapt in pursuit of their goals.

The goal of sustainable livelihood framework is both to learn from the rural poor about the often highly varied activities they undertake in order to sustain their livelihoods and also to identify their most pressing constraints and most promising opportunities, regardless of the context in which these occur. In short, the SLF is focused on the role which the various types of household assets play in mitigating risks and devising livelihood strategies, and the resultant wellbeing of the poor. In terms of the SLF, livestock is a critical physical asset that may improve the stock quality of each key household asset (see Figure 2.1), thus reducing vulnerability, broadening livelihood alternatives and improving outcomes.

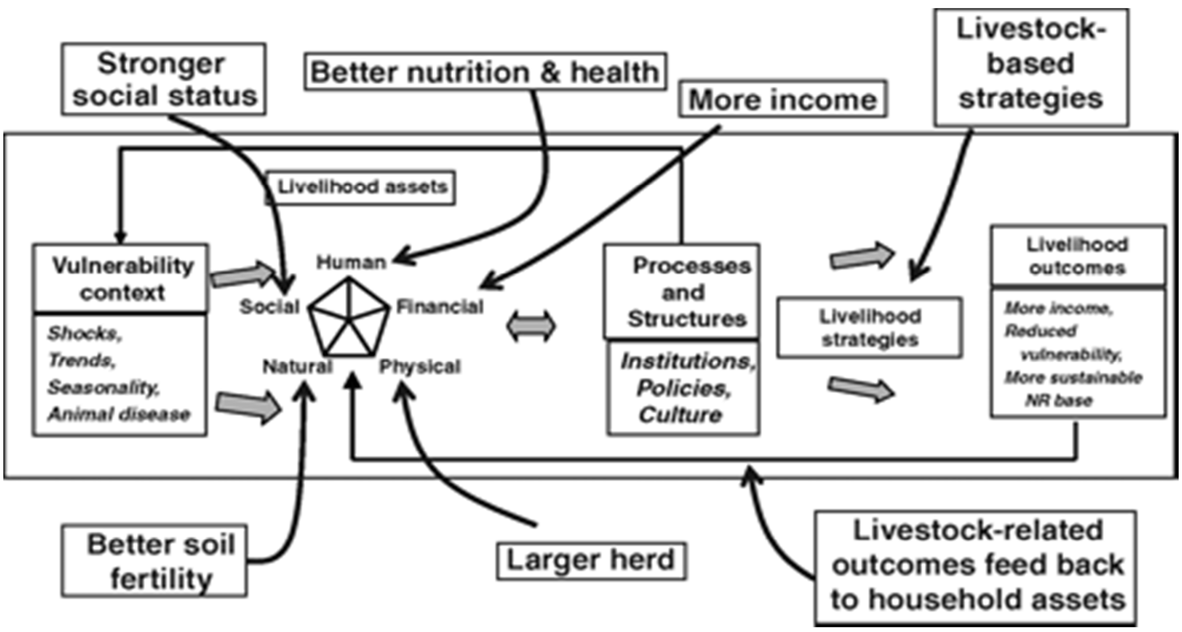

Figure 2.1: Sustainable livelihood frameworks with contributions of livestock in strengthening the asset-base (Randolph et al., 2007)

It is important to acknowledge that the SLF is not intended to be a sophisticated model for theoretical analysis and that it is also oriented towards a comprehensive, but practically focused, understanding of the ground realities that may, either directly or indirectly, inform development interventions. In an attempt to elucidate this statement, Baumann (2002) summarises the four important components within SLF as follows:

Livestock production systems

Across the world livestock production is undertaken in a multitude of ways and provides a large variety of goods and services, while using different animal species and different types of resources within a wide spectrum of agro-ecological and socio-economic conditions. Within this wide variety of ways in which livestock production is undertaken there are certain patterns that have been categorised into various livestock production systems. Most frequently, these systems have been defined as the basis of land use by livestock and, for this purpose, the distribution between grazing systems, mixed farming and industrialised (or landless) systems has been widely accepted.

In order for decision-makers to address the livestock-related food safety challenges in global markets, it is useful to conceive of livestock production systems as the building blocks of the livestock sector. Livestock production is undergoing rapid change, and this change is manifesting itself in the growing contribution that livestock is making to satisfying the increasing global demands for high-value food products, or high protein sources, and in the continuous adjustments at the level of resource-use intensity, size of operations, product orientation and marketing channels (Steinfeld et al., 2006).

Gill (1999) describes these livestock production systems as follows:

- Grazing: Livestock systems with a stocking rate of less than 10 livestock units per hectare and more than 10% of feed produced on the farm (animals obtain 90% or more of their feed from pasture).

- Mixed farming systems: More than 10% of feed crop residues and by-products produced on the farm and more than 10% of the total value of production derived from non-livestock farming activities.
- Industrial systems: Less than 10% of feed farm produced and annual stocking rate of greater than 10 livestock units per hectare of agricultural land.

Figure 2.2 depicts the different livestock production systems (Steinfeld and Maki-Hokkonen, 1995). Mixed farming is considered to be the largest animal production system in the world (Lungu, 2002). The majority of ruminants are kept in mixed systems in the developing world with crop residues and by-products constituting an important part of ruminant diets (Gill, 1999).

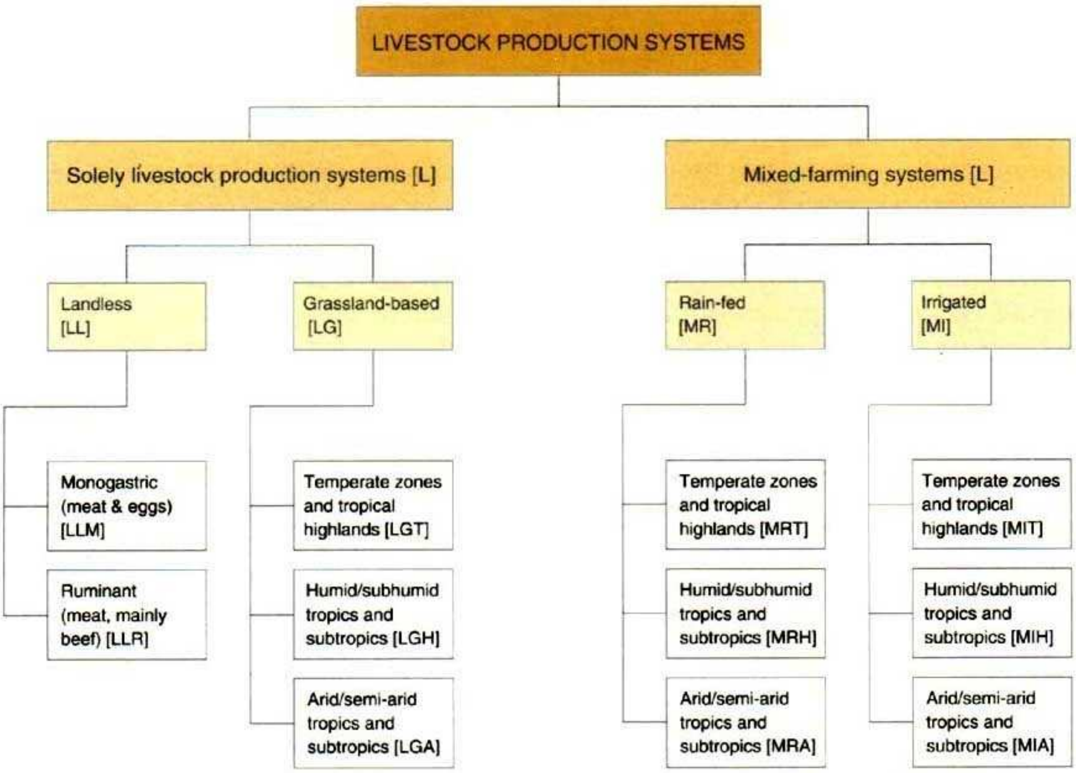

Figure 2.2: Livestock production systems (Steinfeld and Maki-Hokkonen, 1995)

As regards ruminants, mixed systems are most important in Asia and Africa, with grazing systems being the most important in Latin America. However, as regards pigs and poultry, industrial systems predominate in Asia. Slightly less than half of the world's usable surface is covered by grazing systems which support 360 million sheep and 600 million goats. Grazing systems in the developing countries vary from the productive pastures of South America to the deserts in the arid regions of Africa and Asia. Livestock represents an extremely significant source of income for mixed crop-livestock farmers in many countries of the world (Makhura, 2001).

2.1.2 SMALL-SCALE LIVESTOCK PRODUCTION IN DEVELOPING COUNTRIES

Rangelands comprise the largest land use system on earth and predominate in the arid and semi-arid areas of the world, where the majority of the poor and the vulnerable are found. Table 2.1 presents the human and livestock population found in the arid and semi-arid regions in different parts of the world (Sere et al., 2008). Over 65% of the world's cattle and small ruminants are found in the developing world although the distribution between countries and regions varies according to cultural, climatic and economic conditions (Gill, 1999).

Table 2.1: Human and livestock population of arid and semi-arid regions in different parts of the world (Sere et al., 2008)

Region	Area (km^2)	Total people(yr 2000)	CattleTLU total	SHEEP TLU total	GOAT TLU total	Buffalo TLU total
E Africa	39.286	517.388	142.511	136.593	78.475	9.161
N Africa	51.364	1.931.660	137.664	218.806	92.353	0
S Asia	44.078	5.821.210	642.833	187.932	150.070	283.456
LAC	1.006.230	8.886.420	9.976.930	447.039	413.432	0
SE Asia	38.750	386.390	221.684	729	4.768	138.949
W Africa	841.451	15.579.500	4.309.350	1.077.310	1.283.290	0
C Africa	572.019	3.228.620	1.636.200	123.222	284.505	0
E Africa	1.535.010	14.826.800	12.858.600	2.111.240	2.123.430	0
Southern Africa	2.051.810	12.739.900	5.735.070	280.616	488.221	0
Australia	1.672.811	311.839	7.054.910	2.252.895	5.529	0
Total	6.179.998	63.917.888	35.480.242	4.918.544	4.918.544	431.566

History tells us that, as the economic level of a given population improves, so does the consumption of foods from animal source increase. Growing populations and incomes, together with food preferences, are resulting in a rapid increase in the demand for livestock products, while globalisation is boosting trade in livestock inputs and products. The global production of meat is projected to more than double from 229 million tonnes in 1990/2001 to 465 million tonnes in 2050, and that of milk to grow from 580 to 1043 million tonnes (Steinfeld et al., 2006). Worldwide, the demand for livestock products is soaring because of changing food preferences, and, as already mentioned, income and population growth−income and population growt hwill be discussed below. This trend, which is being facilitated by the global trade in livestock inputs and livestock products, has resulted in livestock production becoming the fastest growing subsector of agriculture in many of the developing and transition countries (FAO, 2009b).

Driving demand for animal source

Income: Most households in developing countries rely heavily on income (cash and subsistence) from a number of sources, including dry land crop production, gardening, livestock production, and wages etc. Draught, transport and milk are the most significant income sources as derived from livestock (Campbell et al., 2002).

Income from livestock sales is an important component of household income in many parts of Southern Africa, contributing over 25% of the total incomes in all the food security categories (Freeman et al., 2008). The individual consumption of livestock products is closely related to per capita income. In other words, increased incomes result in people typically increasing their consumption of meat, milk and eggs until these products become fully integrated into their daily diet. The per capita consumption of meat in high income countries ranges between 80 to 130 kg per year. The economies of the developing countries achieved an annual growth of 3.8% (1.8% per capita) from 1991 to 2001, up from 2.9% during the ten preceding years. However, developing countries in East Asia have experienced extremely strong economic growth, with an annual rate of 7.4% (6.2% per capita) over the decade between 1991 and 2001, with the Republic of China leading as the world’s fastest growing economy. South Asia and the near East follow, with gross domestic product growth rates of 5.5% and 4.4 % respectively over the same period. Economic expansion has been more modest in Latin America, at 2.9% annually, and, in Sub-Saharan Africa, at 2.6%. Table 2.2 depicts economic growth rates, per capita (GDP) growth rates and human population growth rates (annual rates during the period 1991-2001) (Steinfeld et al., 2006).

Table 2.2: Economic growth rates, per capita (GDP) growth rates and human population growth rates (annual rates during the period 1991–2001) (Steinfeld et al., 2006)

REGION	GDP GROWTH RATE (%)	PER CAPITA GDP GROWTH RATE (%)	POPULATION GROWTH RATE (%)
East Asia and Pacific	7.4	6.2	1.6
South Asia	5.5	3.6	2.1
Sub-Saharan Africa	2.6	0.0	2.8
Near East and North America	4.4	2.3	2.6
Latin America and Caribbean	2.9	1.3	2.0
OECD countries	2.5	1.9	0.7
EE and CIS	0.0	-0.1	0.7
Developing countries	3.8	1.8	0.8
Developed countries	2.5	2.3	1.8
World	2.8	1.4	1.6

Where: CIS= Commonwealth of Independent States

EE= Eastern Europe

OECD=Organisation for Economic Co-operation and Development

Population growth**:** In addition to higher incomes, increases in human populations contribute to the demand for animal-source food products. The populations in most developing countries are still growing rapidly even though the percentage growth rates are below their peak in the 1970s. Each year the population in developing countries grows by 72 million, thus increasing the demand for food products (Steinfeld et al., 2006).

The predicted population increase percentage from the year 2000 (4.7 billion) to 2050 (7.6 billion) in the developing countries is illustrated in Table 2.3 and is a cause of concern (ILRI, 2000)

Table 2.2: Predicted population from 2002 to 2050 (ILRI, 2000)

COUNTRY	YEAR	
	2000	**2050**
East Asia	28	20
South Asia	28	2
South East Asia	11	10
Central and South America	11	10
Sub-Saharan Africa	13	20
West Africa and North Africa	8	2
Newly independent states	1	10

Table 2.4 provides an overview of the important changes that have occurred in the average diets of people in the various world regions. The changes have been the most dramatic in Asia, where the total protein supply from livestock for human diets increased by 131%, followed by Latin America, where the per capita animal protein intake rose by nearly a third. In contrast, there has been a decline in livestock consumption in sub-Saharan Africa, reflecting both economic stagnation and a decline in available incomes (Steinfeld et al., 2006).

Table 2.3: Overview of the important changes that have occurred in the average diets of people in the various world regions (Steinfeld et al., 2006)

REGION	TOTAL PROTEIN FROM LIVESTOCK(grams/capita)		TOTAL PROTEIN(in grams/capita)	
	1980	**2002**	**1980**	**2002**
Sub-Saharan Africa	10.4	9.3	53.9	55.1
Near East	18.2	18.1	76.3	80.5
Latin America	27.5	34.1	69.8	77.0
Developing Asia	7.0	16.2	53.4	68.9
Industrialised countries	50.8	56.1	95.8	106.4
World	20.0	24.3	66.9	75.3

It is estimated that, by 2015 approximately 45% of the world's total population of 1.1 billion will be living in the cities and large towns of the developing countries. This growing urbanisation will further amplify the growth in demand for livestock products, as urban populations generally have higher incomes than rural people. Total livestock production in sub-Saharan Africa will have to grow at an average rate of

4.2% per year in order to meet this growing demand for animal protein in the developing countries will provide an opportunity for the poor to improve their livelihoods. Within this context, sustainable increases in livestock production would, therefore, be desirable if the demands of the human population are to be met and, hence, the important role of livestock in smallholder farming systems (Swanepoel and Stroebel, 2009).

2.1.3 BENEFITS OF LIVESTOCK KEEPING FOR HOUSEHOLDS

The literature review revealed that livestock keeping is critical for many of the poor in the developing world, often contributing to multiple livelihood objectives and offering a way out of poverty.

Stroebel et al. (2010) report on both the benefits and the products derived from livestock by smallholders (Table 2.5). They further report that, in smallholder systems, the benefits from livestock are derived from products or activities usually not sold on the market. Various researchers have referred to these benefits as; inter alia, non-market functions, intangible goods and Z-goods.

It is important to take these non-market values into account when comparing the value of different livestock production systems within the livestock sector because, otherwise, the value of smallholder livestock production and local breeds will remain underrepresented (FAO, 2009b).

Table 2.4: Summary of benefits and products derived from livestock (Stroebel et al., 2010)

BENEFIT	PRODUCTS
Food	Milk; meat; eggs; blood; fish; honey; processed products
Clothing	Wool; hides; skins; leather
Work	Draught power cultivation; transport of goods and people; threshing; milling; pumping water
Monetary	Capital wealth; investment and savings; income from hiring working animals; sale of products and animals
Social	Lobola (bride price);ceremonial; companionship; recreational; status
Manure	Fertiliser (soil amelioration); fuel; flooring
Other benefits	Feathers; bone meal; soap production

Numerous researchers, including Van Rooyen (2008), Pell et al. (2010), and Vandamme et al. (2010), support the concept that livestock production fulfils a multipurpose role in developing environments. From an economic perspective, livestock contributes to food supply, cash income, traction and fertilizer. Furthermore, livestock constitutes a valuable asset portfolio and investment opportunity while, from a social perspective, livestock builds relationships, addresses gender imbalances and allows the distribution of benefits. Furthermore, the natural environment becomes increasingly relevant, as livestock owners are expected to fulfil an important stewardship role in sensible resource utilisation.

Randolph et al. (2007) highlight the fact that the livestock systems of the poor reflect the resource constraints which they face – financial access to information and services and landlessness − as well as their diverse reasons for keeping livestock. These reasons include, inter alia, producing food, generating income, providing manure, producing power, serving as financial instruments and enhancing social status.

Producing food and nutritional security

The livestock kept by the poor is able to produce a regular supply of nutrient-rich animal source feed that provides both a critical supplement and diversity to staple, plant based diets (Ndlovu, 2010). These animal source foods are obtainable only when animals became sick or unproductive or for exceptional occasions such as ceremonies or hospitality. ILRI (2003) reported that animal food products, such as meat and milk, are concentrated sources of high quality proteins as well as certain vitamins and minerals. When children consume even modest amounts of these products these help alleviate poor growth, poor mental development and general ill-health.

Generating income

Freeman et al. (2008) report that livestock is kept mainly as a safety net, and sold during times of hardships only. In addition, livestock plays an important role in managing risks (McDermott et al., 2010). Many households reported that they often sold livestock to meet emergency cash needs, such as purchasing food or meeting health expenses, or when shocks occur. The income from livestock sales is an important component of household income.

It would appear that livestock makes a greater contribution to the income of lower income farmers as compared to higher income farmers (Gill, 1999).

Providing manure

In Africa in particular, but also in Asia and some countries in Latin America, livestock also makes a major contribution to food production, albeit indirectly, through increasing crop yields (Pell et al., 2010). The actual increase in crop yield in response to the application of manure is highly variable, and is dependent on several other factors such as the basic nutritional status of the soil, the type of soil, and the way in which the manure is collected and applied (Gill, 1999). Dung is used for maintaining soil fertility, thereby contributing to increased crop production for food and income. In certain areas, dung is also used as a fuel. The utilisation of fertiliser and building materials made from dung is considered an important motivation for keeping animals in the developing countries (Steinfeld et al., 2006).

Providing traction power for transport and crop production

This reason for keeping livestock refers to the use of animals for the purposes of ploughing, harrowing, ridging, carting, logging, pumping, threshing, planting and pulling sledges. In cases where motorised mechanical farm implements are either unavailable or expensive, animal traction is often the alternative to back-breaking human labour (Stroebel et al., 2008). The livestock may also become a source of additional income for farmers through the hiring of traction services (Kumwenda, 1999). Simalenga and Joubert (1997) reported that animal traction is a viable option for small-scale farmers as it is affordable, sustainable, profitable and environmentally friendly.

Domestic work animals still exist in all regions of the world. Animal traction is particularly important as regards the issue of food security in smallholder farming systems. Animal power saves household women and children the time and effort they would have expended by having to carry water and fuel wood themselves and is a renewable energy source that is suited to family-level farming. Cattle (oxen, bulls and cows), buffaloes, horses, mules, donkeys and camels are all used in animal traction. The use of animal power is expanding in Africa and is also widespread in both Asia and Latin America. In sub-Saharan Africa, the use of work animals for agriculture is increasing every year and it is especially true in South Africa where many small-scale farmers and local transporters continue to use animal power (FAO, 2004b).

Simalenga (2003) reports that power sources for tillage and transport in the smallholder-farming sector include tractors, oxen, donkeys, horses, mules and hand labour. In the past, farming in the rural communities was highly skilled at using animal traction and this, in turn, constituted an indigenous technology in South Africa. However, the introduction of the policies of subsidised tractor hiring services meant that animal traction development was discouraged. Bembridge and Tapson (1993) report that the pulling of carts, sledges and firewood outside of the farming season is considered an important function of cattle in rural life. Likewise, cattle are borrowed or hired for draught and ploughing in exchange for work.

Large animals are also used as a form of equipment, providing traction power for transportation and crop production. In addition, they may also be hired out (Randolph et al., 2007).

Serving as financial instruments

Livestock offers an alternative for either savings or accumulated capital in the form of a “living savings account”. Although not without risk, this “living savings account” provides a reasonably robust hedge against inflation and, in most instances; livestock may be sold and transferred into cash, as needed (Swanepoel and Moyo, 2010). Accordingly, livestock keeping is considered as an alternative form of insurance, providing the family with assets insurance by providing the family with assets that may be sold in times of crisis.

Reist et al. (2007) report that poor rural livestock keepers refer to their livestock as a bank account on legs that pays interest in the form of products such as milk, meat, fertilizer, wool, leather and draught power. The growing demand for animal products represents an opportunity for poor farmers to increase their bank accounts and earn more interest.

Enhancing social status

The issue of social status is based mainly on the size of a family's livestock holdings, or in their sharing of livestock with others and may strengthen social bonds. In addition, livestock may be used as a dowry or bride price. Higher social status may, in turn, translate into access to, or authority over, broader base resources in the community (Stroebel et al., 2010).

Smallholder livestock keepers have developed strategies to help them to survive and to make the best use of their environment. They often keep mixed herds of cattle, sheep, and goats of several breeds. Some of these breeds are high producers under good conditions; while others do not perform as well although they do produce under difficult conditions. In order to survive and make the best use of an area, it is often more important to own large numbers of animals than to own highly productive animals (Gura, 2008).

For many poor farmers owning livestock means that, not only do they possess assets, but they also enjoy social recognition and they are culturally anchored. Accordingly, these people strive to obtain as many large animals as possible (Reist et al., 2007) although this often results in the overexploitation of the natural resource, i.e. the grazing, to which there is open access. This has been termed "the tragedy of commons". Inevitably, the livestock keepers tend to take care of the private costs but disregard the social costs (e.g. effect of overgrazing on the long-term, sustainable stocking rate) (Frazer and Hendricks, 2003).

2.1.4 LIVESTOCK AS A SOURCE OF LIVELIHOOD FOR SMALL-SCALE FARMERS

Most households have a rich and varied livelihood portfolio, and display infinite resourcefulness in making ends meet. However, patterns of livelihood change overtime, with these changes reflecting concomitant changes in institutions, thus illustrating both the responsiveness of farmers and the community to external signals, and their resourcefulness despite the low levels of capital costs. It is important that we acknowledge that the main objective of small-scale, communal cattle farmers is a sustainable livelihood. Small animals require minimal investment on the part of poor livestock keepers because such animals are kept either in the vicinity of the house or on common land and are fed with the residue from agricultural production. In the developing countries, crop failures are common and many farmers depend on livestock in order to survive. Worldwide, 29% of all cattle and 46% of all sheep and goats are found in these developing countries (Campbell et al., 2002).

According to Kirsten (2006a), livelihood comprises the capacities, capital (human, social, economic/financial, and natural) and activities needed for sustaining life. A livelihood is regarded as sustainable when it is capable of answering and recovering from abrupt changes and stress, and also is able either to maintain or to improve its capacities and capital without undermining the natural resource base. These are five key elements in this definition:

- Generation of employment: This is related to the capacity of a combination of life strategies to generate employment, whether on farms or beyond in the formal or informal system. Employment encompasses the following three aspects: income (salaried employment for employees, production/employment producing consumables goods), and recognition in terms of which employment recognises for having participated in something of value). Generally, 200 days of employment per year has been estimated as the required minimum needed for generating livelihoods.
- Reducing poverty: The level of poverty is a key criterion in evaluating livelihoods. Various indicators may be used to develop an absolute measure of the “poverty line” based on, for example, levels of income, consumption, and access to services.
- Well-being and skills: This concept goes beyond the material needs for food and income, and includes the notion of capacities (i.e. what people are able either to do or to be, given what they possess). Accordingly, the people themselves should determine the criteria that are relevant to the concept of

wellbeing, for example, self-esteem) safety and happiness, low levels of stress, vulnerability, increased power, reduced exclusion, as well as other more conventional elements.

- Adaptation, recovery and vulnerability: This refers to the ability of a livelihood both to respond to and to recover from abrupt changes and stress .Those livelihoods that are either not able to respond (i.e. make temporary adjustments as a result of change) or to adapt (i.e. make long-term changes in life strategies) are, inevitably, vulnerable and there is, thus, a low probability that a sustainable livelihood will be achieved.
- Sustainability of natural resources: Most livelihoods depend on a natural resources base. Accordingly, the concept refers to the system's ability to maintain productivity when faced with disturbances, including stress or abrupt changes. This, in turn, implies preventing natural resource reserves from diminishing to a level that may result in the effective and permanent reduction of the products and services generated by these natural resources.

Livestock revolution

It is difficult for smallholders to access international and regional livestock markets. The demand for animal food products is rising sharply in many of the developing countries, thus resulting in a pronounced reorientation of agricultural production, in general. Experts have termed this trend the "livestock revolution". The reason for this livestock revolution is a growing urban middle class, which is increasingly supplementing its diet with meat products. This trend is evident primarily in countries which are in transition and in certain developing countries − especially China and India.

Reist et al. (2007) summarise the characteristics of the livestock revolution as follows:

- Global production and consumption of livestock products are increasing rapidly.
- Developing countries are rapidly expanding their share of production and consumption.

- Livestock production is evolving from a multifunctional activity, independent of markets, into a globally integrated market activity.
- Meat products are increasingly replacing cereal products in the human diet.
- Fodder is increasingly based on cereals.
- Claims on grazing land are growing, and production in urban areas is intensifying.
- Industrial production and processing are subject to rapid technological changes.

Livestock and fodder production have expanded markedly in these developing countries in order to meet the growing demand. The concomitant increase in the number of livestock for poor livestock keepers in developing countries is resulting in additional income and employment. However, intensified production is also accompanied by problems such as emissions (source of environmental pollution); risks of overgrazing; increase in diseases with the rise in the density of animal populations and, lastly, the genetic diversity of the livestock tends to decline. In addition, the marked expansion of the production in animal fodder may be responsible for the degradation of landscapes such as forests, and may also compete with the production of food for human beings. Finally, the industrialised production concentration of distribution channels increasingly threatens to exclude small-scale producers from the markets (Reist et al., 2007).

Livestock production and poverty alleviation

The demand for livestock products is rising noticeably in developing countries while, at the same time, a large proportion of the poor rural population in these countries already keep livestock (Reist et al., 2007).

The potential of livestock to reduce poverty is enormous based on the fact that livestock contributes to the livelihoods of more than two-thirds of the world's rural poor and also to a significant minority of the peri-urban poor. Despite the fact that the very poor often do not own livestock, if they are able to acquire animals, their livestock may offer a way out of poverty.

An understanding of poverty is crucial if poverty is to be reduced in a sustainable way. ILRI (2003) defines poverty as pronounced deprivation in human well-being, encompassing not only material deprivation but also poor health, illiteracy, poor nutrition, vulnerability to shocks and changes, and little or no control over key decisions. A widely accepted gauge of poverty is being forced to live on an income of less than the equivalent of US$1 per day, something which is endured by an estimated 1.3 billion of the world's poor.

Campbell et al. (2002) maintain that rural poverty is a result of a combination of interacting social, economic and environmental factors and processes operating at the following range of scales:

- adverse biophysical conditions, resulting in low agricultural potential and disastrous declines in livestock numbers
- insufficient high-quality land; labour scarcities (exacerbated by the global HIV/AIDS pandemic); economic remoteness with its concomitant higher transaction and input costs, and few investments because returns on investments are low compared to other areas
- lack of credit market as result of little or no collateral;
- few employment opportunities and low level of education and skills
- low incomes and, hence, an inability to purchase certain basic needs, for example, medicines, secondary school education
- poor macroeconomic conditions
- HIV/AIDS pandemic, leading to loss of breadwinners, labour scarcities and increased costs
- low level of empowerment.

ILRI (2003) summarised the following three livelihood strategies in terms of which livestock may be used to assist households out of poverty:

Securing the current and future assets of the poor: Focus on the way in which livestock may help to secure the asset base of households by providing access to more reliable flows of the benefits, as discussed above. This capacity may help buffer the household, enabling it to shoulder the risks associated with developing other income generating strategies.

***Sustainable livestock intensification*:** Represents the livestock development scenario in terms of which specialisation and intensification increase the productivity of the livestock, in turn increasing household incomes and assisting the accumulation of other assets.

Encouraging participation of the poor in livestock related markets: Involves improving access to market opportunities, for example, opening new markets, and obtaining better prices. This, in turn, will increase the profitability of livestock activities and create incentives to increase production and sales.

2.1.5 SMALL-SCALE LIVESTOCK SECTOR IN SOUTHERN AFRICA

According to Statistics South Africa (2010), less than a quarter of South African households (22%) are involved in agricultural production, with those involved in agriculture engaged mostly in the production of food and grains (43,4%), fruit and vegetables (30.1%), poultry (43.9%) and livestock (49.4%). Most crop production takes place in backyard gardens (87.6%)

The livestock sector contributes up to 49% of agricultural output while approximately 80% of agricultural land in South Africa is suitable for extensive livestock farming. The numbers of livestock vary according to weather conditions**.** By mid-2007, there were 13.5 million cattle, 24.9 million sheep and 6.4 million goats in South Africa. South Africa produces 85% of its meat requirements, while 15% is imported from Namibia, Botswana, Swaziland, Australia, New Zealand and Europe (SAO, 2012).

South Africa has a dual agricultural economy, namely, a well-developed commercial sector and a predominantly subsistence sector. The majority of the subsistence farmers are not part of mainstream agriculture and they practise subsistence agriculture in the overcrowded, semi-arid areas in the former homelands (Sebopetji and Belete, 2009). The literature review (Mbeki, 2003; van der Merwe, 2006; Pote et al., 2007) has revealed that the legacy of the apartheid regime – a regime characterised by discriminatory policies and extreme disparities in income distribution − has resulted in the majority of the population becoming trapped in a vicious circle of poverty, while the minority owns the greater proportion of the wealth in the country.

This, in turn, has resulted in the dualistic structure of the South African agricultural sector. On the one hand, the modern, highly capitalised commercial sector operates on large farms which are well organised and situated on prime land, occupying 83% of the total farming area of the country. On the other hand, there is the traditional, low technology and small-scale communal sector which is characterised by small size farm holdings (approximately 1.5 ha per farmer) which produce primarily for subsistence purposes with little marketable surplus. This sector occupies 17% of the total farming area of South Africa, and is located mainly in the former black homelands (e.g. Ciskei, KwaZulu, Transkei and Venda). The Department of Agriculture (2005/6) indicates that these traditional farmers are in the majority and that they use their livestock in order to sustain their livelihoods. In addition, lack of the necessary finance to acquire supplementary feeding during droughts or dry seasons adds to the difficulty of sustaining animal production within the communal livestock area. Furthermore, declining pasture production and the loss of sustainable grazing systems threaten both the productivity of the grazing livestock industry and the sustainability of natural resources.

Livestock production on communal natural pasture in Malawi (Matita, 1999), Zimbabwe (Chakoma et al., 1999), Namibia (Els, et al., 1999); Botswana (Maphane and Mutshewa, 1999); Mozambique (Uaila, 1999) South Africa (Raats, 1999) and Zambia (Mukumbuta et al., 1999) has been extensively reviewed and found to be inadequate in terms of providing sufficient animal feed. This is especially true during the dry season, when the quantitative nutritive value of the natural pasture is both drastically reduced and poor as a result of overgrazing (affects dry matter production), thus leading to poor quality animals.

Smet and Ward (2005) maintain that South Africa comprises three main types of rangeland management systems, namely, commercial livestock ranching, communal livestock ranching and game ranching. The management system differences are summarised in Table 2.6.

Table 2.5: The differences between management systems as regards management structure and product production, and also animal diversity and grazing resource (Smet and Ward, 2005)

MANAGEMENT SYSTEMS	MANAGEMENT STRUCTURE	ANIMAL DIVERSITY	MANAGEMENT OF GRAZING RESOURCE	PRODUCTS
Communal livestock	Multiple managers	Several different species	Continuous grazing, diverse vegetation	High quantity, significant diversity of products, mostly for personal use
Commercial livestock	Single manager	Single species	Rotational grazing, uniform vegetation	High quality, single product for domestic and international markets
Game	Single manager	Several different species	Continuous grazing, diverse vegetation	High variety, strong, healthy, large animals for trophies or eco-tourism

According to Smet and Ward (2005), commercial livestock and game farming are managed by persons with secondary education and others with tertiary education, while both these management systems also enjoy the support of South African agricultural research institutes. On the other hand, communal livestock farming has been based mainly on traditional management systems which are managed by individuals without any formal training in either animal husbandry or veld management. This situation is further complicated by no one person actually being in charge. Comparative findings relating to the commercial ranching, communal livestock ranching and game ranching management systems indicated that communal livestock ranches are expected to have a more detrimental effect on rangeland condition than the other management systems because the stocking densities and, consequently, herbivore impacts, are usually far higher than under the other two management systems.

It emerged from the literature review that communal livestock production has received little media coverage. This, in turn, highlights the importance of studying small-scale communal livestock production.

There have been studies carried out across Southern Africa on communal livestock farming with many of the researchers coming to contrasting conclusions regarding communal livestock farming. These views are discussed briefly below:

Birch (2001) states that, in recent years, there has been much debate around the issue of the deterioration and loss of productivity of the natural rangelands, specifically those under communal management. Forbes and Trollope (1991) carried out a study on veld management in the communal areas of Ciskei based predominantly on a communal land tenure system. They found that the stocking rates were excessively high and, consequently, that veld degradation was severe, resulting in turn in a lowered carrying capacity and low efficiency indicators such as weaning percentages. They recommended that any solution to the continued degradation of the veld would depend on the commitment of the government to a development strategy which would address factors such as freehold tenure, education, and the provision of incentives for profitable production.

Peden (2005) reports that the democratisation in 1994 resulted in a shift in the state focus from commercial farmers to small-scale and subsistence black farmers living in communal areas in South Africa. The Landcare Programme of the Department of Agriculture was aimed both at improving productivity and promoting sustainable land-use practices. However, agricultural officials have remained reluctant to tackle the issue communal rangeland management and this, in turn, has resulted in a need for greater financial support and law enforcement on the part of the state in the area of communal grazing.

A descriptive study of rangeland on commercial and communal land conducted by Kiguli et al. (1999) report that, based on species forage factors for commercial livestock production, the commercial grassland were in a significantly better condition than the communal land. Both the vegetative field survey data and the satellite imagery showed that the communal land had been transformed as compared to the commercial land. This difference may be attributed to differences in the land-use.

Du Preez et al. (1993) report that up to 90% of the grazing in developing areas is communally owned and managed with communal land use often being cited as a major reason for the poor veld condition in these areas. They further indicated that two types of farmers prevail, namely, the stock owner who keeps livestock on communal lands and may not have individual grazing rights on the land, and stock farmers who live in the community and receive most of their incomes from their livestock.

There have been several grazing systems identified in the communal areas. However, Du Preez et al. (1993) classified four types:

- Traditional zero-camp system: This system prevailed before the fencing of grazing areas. In terms of this system the cattle are kraaled at night and grazed during the day. This system worked well with low human population and low stock numbers. The livestock was rotated as the herdsmen moved the livestock to new areas, thus allowing previously grazed areas to rest. However, as human and stock pressure increased, this rotational system failed and the veld became progressively overgrazed. Population pressure, continuous grazing, lack of proper supervision of livestock, increased stocking rates, no rest for the veld during the growing season and a lack of planning all contributed to the failure of this system;
- Early systems with three or four very large camps: This system involves three to four camps per community rather than per herd with one of the camps being used for crop growing and grazed in the winter only. The other camps are grazed for fixed periods during the year. However, these systems often fail as a result of the camps being large, thus resulting in large distances between grazing and water resources, veld type not separated, poor herd management and, despite camping, the cattle still requiring herding.

- High utilisation grazing multi-camp systems: This system involves a wagon wheel design with 16 camps, one central watering point and a cattle handling facility. Three-strand barbed wire fences were used in order to reduce costs. However, shortcomings of this system included the following: veld variation was ignored; camps were long and narrow, thus promoting area-selective grazing and large distances to watering points and, thus, severe overgrazing near the watering points, with underutilisation at the extremes of camps.
- High production multi-camp systems: In terms of this system the basic principle applied was that management be adapted to the available grazing in order to ensure maximum production per animal. Despite the fact that this approach appeared to be complicated, the farmers quickly grasped the principle and this, in turn, led to improved sward vigour.

Tongway (2003) reports that heavy or inappropriate grazing has resulted in changes in the resource state in certain rangelands, thus resulting in lowered animal production. However, appropriate intervention to initiate recovery may be the answer. Nevertheless, existing rehabilitation techniques within the prevailing socio-economic context are limited and are often prejudiced as a result of a lack of fundamental understanding of ecosystem dynamics.

In his study, Erskine (1993) concluded that there are two important dimensions to the challenge involved in creating the right conditions for both the optimal management of grazing livestock and the sustainable use of rangelands in the less developed areas of Southern Africa, namely, gaining a clear understanding of the reasons why farmers in these areas have adopted, and are continuing with, certain land use systems and practices, and designing alternative land use management and farming systems that are both sustainable and satisfy the socio-economic needs of those rural communities which are in transition from subsistence to commercial agriculture.

Shackleton (1993) reports that the communal lands in South Africa are heavily stocked, often supporting livestock at levels of up to four times the recommended stocking rate. In other words, the veld has often been exposed to heavy grazing for a long period of time. In addition, the areas close to villages are usually more heavily grazed as a result of to higher densities of livestock and the greater numbers of goats, which do not usually forage far from human settlements.

Twine (2005) reports that understanding both the socio-economic drivers and the consequences of vegetation change in communal natural veld is important. According to Twine (2005), factors such as changes in institutional control, levels of unemployment and local perceptions of rights and responsibilities since the democratic elections have resulted in a dramatic increase in the harvesting of tree resources within communities.

Shackleton et al. (2005) researched both the contribution and the direct-use value of livestock to rural livelihoods. Their findings reveal that cattle are used for a greater variety of goods and services than are goats. The savings from livestock represented the most important use, followed by milk and then manure. In addition, non-owners of livestock benefited through donations of manure, milk, draught and meat for free, or at a cheaper rate than alternatives. Booysen (1993) reports that, for an ecologically stable agriculture in rural communities, it is essential that the agricultural systems and practices implemented be designed to provide maximum sustainable support for the limited resources and that they also be appropriate to the operator's criteria for success and capable of optimising production in terms of the most limiting resource in these capital poor circumstances.

Scoones (1992) conducted a study focusing on an economic assessment of the value of cattle and goats in the different ecological zones of an agro-pastoral farming system in Southern Zimbabwe and reported that the relative returns of different stock types in different ecological zones illustrate that investment in livestock is, in the main, a good option and that choices between cattle, goats and donkeys are mediated by the factors of risk and uncertainty which relate to the contrasting ecological dynamics and sandy soil savannah areas. In conclusion, he recommended that an understanding of the economics of communal area production systems would be helpful in terms of informed policy decisions in relation to both livestock production support (technical and marketing measures) and land-use and resettlement policy.

Mahabile et al. (2005) report on factors affecting the productivity of livestock in southern Botswana. The results showed that those respondents with secure land tenure (private farms) and larger herds make use of more agricultural credit than do those who rely on open access communal grazing to raise cattle. In addition, secure tenure and higher levels of liquidity from long-term credit and off-farm wage remittances promote investment in fixed improvements to land, liquidity from short-term credit and wage remittances support expenditure on operating inputs while herd productivity increases with a greater investment in operating inputs and fixed improvements. Duvel and Afful (1996) carried out a study analysing the socio-cultural constraints on cattle production in communal areas in South Africa. The results indicated that there has been no decrease over time in the need for cattle, but that, increasingly, it would seem that cattle are being kept for financial reasons. However, there appears to be no immediate and acceptable solution to the problem of overstocking and, thus, agricultural development should focus on alternatives ways of improving stock reduction. There is also a need for more research, especially as regards range management.

Masiteng, et al. (2003) evaluated the needs and aspirations of farmers in communal grazing systems. They revealed that the integration of environmental planning into communal grazing systems in the Free State is essential for the best cattle performance and land use.

De Bruynand Kirsten (2001) tested the hypothesis that a cattle producer’s choice between alternative marketing is influenced by transaction costs. Their study showed that a number of transaction cost variables (herd size, distance from auction points, information and risk) have a significant effect on the proportion of produce sold to the government-owned parastatals and, thus, indirectly on the choice of marketing channels.

Kadzere (1996) reports that, despite inherently ideal climatic vegetational conditions, the productivity of the smallholder systems is low. At the same time, the multiplicity of livestock functions in smallholder systems distorts any direct comparison with privately owned, large-scale, commercial properties. “Survival” is the smallholder’s prime objective. This in turn means that smallholder agriculture is usually mixed, thus maximising the spread of risk. In addition, smallholder communal farmers tend to see their livestock in terms of numbers and not quality and, under communal land tenure, this practice leads to overgrazing and land degradation.

Barrett (1992) studied the economic role of cattle in communally grazed pasture and found that despite, the commercial off take from communal cattle being low, communal farmers are both productive and rational in their cattle herd management. In addition, the economic rationale for cattle ownership is, firstly, to provide draught power and manure for tillage and, secondly, to provide milk and meat for local consumption. However, these uses vary from one part to another.

Chawatama et al. (2005) focus on the way in which to characterise low-input smallholder livestock production systems, diagnose the problems and constraints and identify which gender-sensitive development programmes may best alleviate poverty in Zimbabwe. The study revealed that the main constraints in livestock production include diseases, access to capital, grazing, access to markets, gender imbalances, and draught power. On the other hand, the farmers needs were related mainly to marketing, training, animal health and capital.

Duvel and Afful (1997) highlight the fact that the problem of overstocking has been generally accepted as the major cause of the degradation of natural resources in the communal farming areas of South Africa. However, this problem has remained unresolved for decades. Their findings were based on empirical surveys conducted in three districts in the North West Province. The study showed that the number of cattle owned remains an important indication of status and that it is this factor that causes communal farmers to continue overstocking.

The Limpopo Provincial Department of Agriculture believes that farmers are ready to commercialise. This is, however, in contrast to the findings of Paterson (1994) and Grwambi et al. (2006), who found that the majority of communal farmers have no interest in developing into commercial farmers. Constant cattle numbers and constant off-take at a low level have resulted in sustainability in this subsistence sector for many years with cattle being kept for milk, traction, lobola and ceremonies, but not usually for beef. Accordingly, increased beef production is not an objective and, consequently, has neither been striven for nor attained.

Tapson (1990) reports that communal areas were heavily stocked but not overstocked, effective in utilising their scarce resources and not unproductive, and that their subsistence existence has been sustained for many years, despite the growth in population.

Most researchers tend to underestimate the contribution of agriculture to rural livelihoods as the full economic value of multi-purpose livestock systems on communal rangeland is often not appreciated. The emerging literature on resource valuation within Southern African reveals that the full economic value of these contributions may be considerable and may also help to explain why more people are not leaving the apparently impoverished rural areas to work in the towns and cities.

However, it is important to note that many policy-makers and government agencies appear to have accepted the fact that neither stock reduction nor limitation programmes are not even an option and should, thus, not be contemplated. This is as a result of the fact that the political costs are likely to be extremely high, and also because the implementation of any such programmes is likely to poison the relationship between communal area livestock owners and any outside bodies that wish to affect a positive intervention in this sector (Duvel and Afful, 1996). The other side of the perceived ‘overstocking’ problem is that there is insufficient land available to the large numbers of people and livestock in the communal areas. However, despite the fact that this aspect is being addressed, to some extent, by land reform programmes, it is likely to remain a contentious issue. There are vast tracts of good grazing which is not being optimally utilised − mainly because of limitations in access to water, or else few watering points, with this distance from drinking water making it impossible to graze the livestock.

A review of the successes and failures of rangeland/livestock development in Africa was conducted by Squires et al. (1992). They reported that many livestock developments failed because they addressed the technological problems without considering the socio-economic factors, while the absence of modalities to incorporate scientific knowledge into the local knowledge and traditions resulted in the lack of effective interventions.

In view of the scarcity of information on the comparative productivity potential of communal livestock production in South Africa, it is, thus, imperative that this type of information be made available in order to support agriculture initiatives in South Africa and, especially, to improve current livestock enterprises. Clearly, the lack of resources and the inevitable question of their sustainability should be accorded the highest priority.

2.1.6 GENDER ANALYSIS AND LIVESTOCK PRODUCTION

Both gender equality and empowering women are of concern to scientists working in developing communities as both these aspects are vital if animal production is to be improved and, thereby, the livelihoods of millions of rural and urban households in these developing communities. Despite the fact that gender sensitisation has been the main focus of several research and extension organisations for some years, is it of concern that the role of women in both livestock production and the marketing of animals and their products continues to be underestimated. It is, nevertheless, interesting to note that there are some encouraging initiatives which are focusing on women livestock-keepers, although most projects still tend to assume that the major actors in livestock (especially ruminant) systems are men. This practice, thus, strengthens the position of men versus women in households and communities, and may also deprive women of the traditional realms of responsibility, social recognition and income. Waters-Bayer and Letty (2010) summarise their findings on key lessons for promoting gender equality and women's empowerment through livestock as follows:

- Gender analysis is imperative and must not be confined to a once-off exercise, as the situation changes over time.

- Focus on women as they need the most support in order to attain equality with men.
- Strengthen local women's organisations.
- Improve the access of both women and girls to education and training.
- Recognise dynamism and openings for positive change in resource-poor households.
- Seek gender equality in livestock services and organisations.

If women are to be empowered it is essential that the powerful images of their success stories be disseminated. In addition this would support an organisation known as Promoting Local Innovation (PROLINOVA) in Ecologically Oriented Agriculture and Natural Management which is working in various countries in Africa, Asia and the Andes region. This organisation encourages agricultural research and development (R&D) staff both to recognise and to stimulate women's innovativeness in livestock keeping. This, in turn, raises the women's self-esteem in their own eyes as well as in the eyes of their communities, it also sends out strong messages to women and men at all levels about the actual and potential contributions of women to livestock production and it also assists in changing perceptions and attitudes at all levels. It is strongly recommended that these messages be conveyed in educational institutions from primary school up to university level. In addition, it is crucial that R&D institutions include women in their structures and policies and day-to-day practices so as to enable women to make a greater contribution to livestock R&D and be able to reap the benefits from this.

There are two cases of innovation by women livestock keepers in South Africa that are worth mentioning. Firstly, Mrs Muyisa developed a system of raised grass baskets in which her hens lay eggs, thus making it easier and quicker for her and her children to find the eggs. Secondly, Mrs Mbila found a way of ensuring that her goats return to the homestead every evening of their own accord by offering them various palatable leafed branches and water when they return to the kraal. In the livestock sector, it is essential that the spotlight be placed on local women and women's groups who are innovating, taking collective action in order to solve their problems, openly expressing their views about the changes they seek and on incidences of women taking an active part in the decision-making bodies in their communities, in project planning, as partners in livestock research and development and as members of related advisory groups (Waters-Bayer and Letty, 2010).

In Africa, the predominance of the patriarchal system induces gender power relations which downgrade women to an inferior position. In addition, gender disparities in terms of rights constrain women's choices in many aspects of life and limit their opportunities to participate in the economic activities of society The patriarchal system also influences socio-economic and political structures, government policies and strategies and this, in turn, impacts on accessing, managing and controlling resources. For example, in any agricultural development, be it either livestock or crop production, land is of primary importance and women have limited control over land.

2.1.7 CONSTRAINTS OF SMALLHOLDER LIVESTOCK FARMERS

An extensive literature review conducted by various researchers highlighted the constraints encountered by smallholder livestock farmers. These constraints are summarised below:

Livestock feed and nutrition

The quantity and quality of feeds may be regarded as the first limiting constraint to livestock productivity in developing countries. The under-nutrition of livestock limits the yields of meat and milk to a fraction of the genetic potential and increases the animals' susceptibility to diseases and parasites. Monogastrics are particularly sensitive to nutrient quality and balance, especially under intensive confinement production systems. The significant increase in monogastric meat production projected in the Livestock Revolution will depend on balanced concentrates of rations of starchy staples, proteins and, essentially, micronutrients. These ingredients are, in essence, the same as those required by humans, so there is potential competition, especially for coarse grains, with poor consumers.

As regards ruminants, the major constraints arise from seasonal shortages and from poor digestibility of fibrous feeds, including forages and crop residues. Many tropical plants have evolved phytochemical and structural protection against pests and predators, including wild and domesticated herbivores. These anti-nutritional factors include toxins and indigestible structural materials. There has been considerable research conducted in the tropics into supply and utilisation of feed. Nevertheless, adoption by smallholders of the resultant technologies has been limited. The reasons for this non-adoption include the lack of a holistic approach linking the farmers' circumstances with alternative solutions, the lack of systematic research effort in seeking alternatives and inadequate knowledge of the physiological response of animals to seasonal fluctuations in feed supply (ILRI, 2000).

Stock theft

Khoabane and Black (2009) report that livestock theft is a contributory factor to poverty. Livestock theft is mainly attributable to the increased poverty of both the unemployed and drought stricken crop farmers. It reduces the affected households' own consumption of both the returns on their wealth, for example milk, and, in addition, it restricts the ability of households to sell their returns on their wealth in the marketplace and use the proceeds to acquire other food and non-food products.

Access to water

Amede et al. (2009) are of the opinion that the threat of water scarcity in sub-Saharan Africa is very real and is a result of expanding agricultural needs, climate variability and inappropriate land use. In addition, besides the economic benefits, increasing livestock production may also deplete the water resources and aggravate the water scarcity at both local and global levels. The insufficient understanding of livestock-water interactions tend to lead to low productivity, impede sound decisions on resources management and also undermine the realisation of positive returns on agricultural water across sub-Saharan Africa. Innovative methods are necessary in order to improve water productivity and reverse the growing trends of water scarcity, which are a cause for concern.

Veld fires

Mengistu (2008) reports that, in Ethiopia, fires are started deliberately by local people for various reasons. These reasons include removing dry grass and initiating new flushes of grass, eradicating ticks, tsetse flies and other insects or pests harmful to livestock, clearing agricultural land and harvesting forest honey. However, this practice may lead to negative impacts on the local environment, including degradation of the forest vegetation, reduction in the population of wild animals, loss of farm properties such as houses and perennial crops and a critical shortage of cattle feed until the first shower of rain.

In South Africa, veld fires result mainly from land use activities such as land clearing, pasture management and crop production. However, these veld fires contribute to a significant proportion of land degradation and emission of greenhouse gases to the atmosphere. Furthermore, fire destroys the resources needed for immediate use during the dry season (Nkomo and Sussi, 2009).

Poisonous plants

Merill and Schuster (1978) reported that death losses from poisonous plants are caused by overgrazing. The presence of a poisonous species in a plant complex will generally not cause livestock poisoning until the relative palatability of the poisonous species or some other factor causes it to be consumed by the animals. Poisonous plants are classified into the following three categories, according to their palatability and toxicity relationship:

- those that are relatively palatable and comprise an important portion of the forage consumed, but cause poisoning during certain growth periods or forage conditions only
- those that are relatively palatable and poisonous at all times
- those that are relatively unpalatable and poisonous at all times.

Hunter (undated) reports that poisoning may also occur when the veld has been burnt or when new animals, that are unfamiliar with the local plants, are introduced. Various poisons may be identified, inter alia, prussic acid (galsiekte), nitrate, urea, lead, copper, water, etc.

Bush encroachment

Bush encroachment refers to the process which transforms a grass-dominated vegetation type into a woody species-dominated vegetation type. This is recognised as a serious problem throughout sub-Saharan Africa as it leads to large areas of grazing lands being either lost or reduced in capacity, while it also transforms habitats and reduces species diversity. Despite the fact that a few species of plant only are regarded as problematic, bush encroachment may be both rapid and costly to control. In South Africa, the worst affected areas are in the Northern Cape, Eastern Cape and Limpopo Province (Department of Environmental Affairs, 1999).

Moore (2010) reports that controlling bush encroachment is expensive, while the majority of farmers are not able to afford bush clearing. In addition, bush encroachment is viewed as the most devastating threat to both sustainable livestock and acceptable standards of living in rural areas.

Animal diseases

Animal diseases constitute one of the principal constraints to smallholder livestock production in the developing world. High incidences of diseases may dramatically reduce productivity, while the risk of disease restricts both further investment and intensification in livestock production. Smallholder livestock keepers fail to manage livestock diseases effectively either because existing disease control technologies are not appropriately designed or have not been made available or because the appropriate technologies have yet to be developed. Epidemic and endemic diseases continue to represent major constraints to livestock productivity in large parts of the developing world in the tropical regions.

While many of the epidemic diseases have been controlled through vaccines that are now available, nevertheless they continue to cause severe economic losses through morbidity and mortality. These diseases include infections caused by vector-borne haemoparasites and helminthes. In addition, live vaccines that were previously successful in controlling diseases are no longer effective because of either acquired resistance or weakened delivery services while appropriately designed alternatives are often lacking. In addition, the situation is exacerbated by a lack of interest in both the developing world and the private sector in supporting research into diseases specific to the tropics. The further globalisation of the livestock trade and trade regulations will mean that many of these diseases will also, increasingly, block opportunities for developing countries to exploit their trade potential (ILRI, 2000). FAO (2002) reported that animal diseases constitute the major constraint to income generation and asset acquisition by the poor, as poor people have limited cash resources with which to pay for animal health.

Livestock genetics and genomics

Of the world's animal genetic resources, which comprise 40 species and 3500 breeds, one-third are at risk of extinction with 60% at risk of extinction being found in the developing countries. Breeds that may, potentially, make important contributions to sustainable livestock production continue to be underutilised and are increasingly at risk of being lost. In general, indigenous livestock in the developing world yields less per head of milk, meat and other products than in the developed world, where annual genetic gains of 1% or more of the breed average in the milk production in dairy cattle and approximately 0.5% in growth to one year of age in beef cattle have been achieved over the last two decades through genetic improvements focused on a small number of breeds.

Transplanting genetic improvement programmes from developed to developing countries, especially in the tropical regions, has not often been successful and, frequently, imported exotics have either not reproduced or survived as well as locally adapted breeds (ILRI, 2000). Locally adapted indigenous breeds are better adapted to specific local conditions and also better able to tolerate heat, drought, a scarcity of fodder or disease (Reist et al., 2007). These breeds contribute to the livelihoods of a large proportion of the world's poor. However, despite good adaption to their production environments and the livelihood strategies of their keepers, they continue to face threats. The sustainability of production systems may be affected by either the degradation of natural resources, or by inappropriate policy measures and development interventions. Furthermore, indigenous breeds may possess valuable genes with commercial potential, especially breeds kept by pastoralists, which are regularly exposed to stressful conditions such as excessive heat or shortages of feed or water. In addition, they are rich in survival and fitness traits, which have disappeared from the high performance breeds (GTZ, undated).

Livestock policy

Too often policies and regulations actually discourage the development of safe, sustainable livestock production systems and practices that benefit the poor. Subsidies and price controls imposed on input and output markets may favour large-scale or developed country producers at the expense of smallholders in the developing countries and also urban consumers at the expense of rural livestock producers. Inadequate or inappropriate property rights and environment policies are disincentives that work against protecting the natural resources base supporting animal agriculture and, in addition, they may fail to take adequate account of the societal costs of environmental degradation. The dearth of policies and institutions that reduce risk, improve market access, provide credit, and encourage part investment in livestock services (feeds, health, and breeding) and support livestock research and extension deters sustainable livestock development (ILRI, 2000).

Livestock and the environment

The increased demand for livestock products means that there will be increased pressure on the natural resources supporting livestock production. In addition, population pressure and both human and livestock needs will bring about increased competition for land use, thus resulting in pollution, erosion, degradation and the loss of plant and animal biodiversity. In the more extensive systems of grazing and mixed livestock, the competition for resources affects the crop-livestock land use choices of smallholders and increases the pressure to convert forested lands to pasture and crops (ILRI, 2000).

Global environment

The increasing demand for animal products in the developing countries will continue to grow in the coming years. However, as regards the conditions of international trade, global markets are not usually accessible to the smallholders in developing and transition countries. The export of both animals and animal products is greatly limited by sanitary restrictions, tariffs, and non-tariff constraints on trade and, thus, smallholders are not able to compete in the international arena. In cases of disease outbreaks, governments usually instruct all livestock farmers to kill all the animals affected while not giving any compensation. This is an unfortunate situation for smallholder livestock farmers who do not usually have insurance against such losses.

Environmental impacts, for example, the much debated global warming, leads to extreme weather events which have a major impact on poor populations, for example, desertification and water shortages are increasing in both subtropical and tropical regions. Shortages of water and fodder render livestock production difficult and more expensive, and especially so for the poor livestock keepers, who are rarely able to afford to buy fodder and water. As regards the Millennium Development Goals, there are numerous measures which are required in order to achieve these MDGs with livestock improvement being one of the possible measures which may be implemented among rural poor populations to alleviate poverty through the provision of animal feed resources. HIV/Aids have resulted in the loss of family members who were part of the workforce as well as the additional costs of caring for family members stricken by AIDS. These are heavy burdens for the remaining family members and may force families to sell the animals they own (Reist et al., 2007).

National environment

Despite the fact that livestock may make a significant contribution to alleviating poverty, livestock continues to receive scant attention in respect of most rural strategies, for example the Poverty Rural Strategy Papers (PRSP) However, governments do promote livestock production by promoting subsidies for the expansion of infrastructure and services. However, these measures are directed at commercial farmers only, while ignoring the plight of the poor livestock keepers in rural areas. In addition, stock theft results in subsistence farmers losing their immediate source of livelihood (Reist et al., 2007).

Access to information and services

Market access and infrastructure

Once a livestock farmer has decided to earn income from livestock rather than merely producing for home consumption, the issues of market access and market conditions arise. In view of the fact that animal products spoil rapidly and smallholders, in particular, are not in a position to expose themselves to risk, they become dependent on reliable transportation, pricing information, and customers. However, the state tends to favour large-scale producers who, thus, benefit from more beneficial tax and customs rates, receive support in obtaining access to credit, and are not held accountable should they violate environmental standards. In addition, smallholders are hardly in a position to comply with the restrictive sanitary regulations that apply to exports (Reist et al., 2007).

The ability of the poor to explore diverse marketing opportunities is limited because they do not possess the know-how, business contacts, and capital or credit facilities. Nevertheless, participation in livestock-related markets does offer the poor, especially women, a possible route to better livelihoods by, inter alia, presenting them with an opportunity to benefit from the increase in the demand for meat and other livestock products. Improved market access may secure better incomes and promote the welfare of smallholder livestock producers. By creating demand, markets promote economic growth and also help the beneficiaries to accumulate material assets. However, there are usually far more livestock producers and consumers of the products as compared to the fewer few traders or market intermediaries with this situation arising from the small-scale and scattered distribution of producers, and inadequate transport and communications. The existence of economies of scale in marketing activities, including transport, processing and retailing, means that large-scale operations are most likely to be cost-effective. Consequently, markets are likely to be dominated by a few large-scale traders as a result of the lack of market competition and the inequality of bargaining power in respect of the few large traders who control the market and the many small producers. In addition, the producers lack experience and the necessary skills for negotiating contracts which would ensure that the terms were fair and equitable. Producers may also be forced to sell as a result of an emergency, such as drought, or to clear a debt. Accordingly, small-scale livestock are forced to accept whatever terms are offered because of their inability to negotiate a good offer (Small Stock in Development, 2012).

ILRI (2003) reports that smallholders encounter several obstacles which limit the opportunities for the poor as regards employment in livestock–based enterprises or for them to create enterprises with, the access of women to markets being even more restricted in many societies. Obstacles include poor roads to the markets, inadequate communication systems, overwhelming competition from large–scale producers, and an inability to afford to comply with animal disease control measures, such as movement controls and quarantines, or with public health legislations. Transport rates are a decisive factor in marketing options, particularly in the case of perishable products and livestock.

The availability of better information to livestock farmers would reduce uncertainty, thus enabling farmers to make more informed production decisions (Gura, 2008). Timely and relevant information may, fundamentally, alter people's decision making capacity and is critical to increasing agricultural productivity. Information on animal management practices, pests and diseases, transport availability, new marketing opportunities and the market prices of farm inputs and outputs is fundamental to an efficient and productive agricultural economy. Nevertheless, poor information is still common in the rural areas in Africa with the distances to information sources, poor transport and communications infrastructure making access to information even more difficult. In addition, the information is often in written form, limiting its access to the majority of poor livestock farmers who are illiterate. Equally important is the fact that indigenous knowledge is seldom documented and stored and, thus, this information is ultimately lost (Kachoro, 2007).

Extension officer and veterinary services

The extension and veterinary services in many countries, especially in the developing countries, have been severely affected by public sector budgetary constraints, leaving many workers with their salaries paid but without the necessary funds to visit farmers. In South Africa the goal of the new agricultural policies is to provide an analysis that will assist in changing apartheid strategies and create an environment conducive to the development of an efficient and competitive agricultural sector, both regionally and internationally, and a sector that will contribute to economic growth with equity, capacity building in disadvantaged communities and employment expansion (Van Rooyen, 1998). In line with this focus, the South Africa Department of Agriculture (DoA) acknowledges the challenges faced by the extension and veterinary services. Accordingly, the DoA has profiled the state of extension and advisory services in all nine of the provinces in South Africa. The report indicated understaffing by 5490 extension officers and a need to intensify training and visibility. To this end, an Extension Recovery Plan has been adopted and approved to be rolled out in all nine provinces in order to address capacity deficiencies and create a more visible and accountable Extension Service. In addition, the Green Book will be introduced to monitor the visits of extension officers and all field officers, including the animal health technician (Department of Agriculture, 2008).

Drought

United Nations Report (2007) reported that drought is at the core of the serious challenges and threats facing sustainable development in Africa. Drought has far-reaching, adverse impacts on human health, food security, economic activity, physical infrastructure, natural resources and the environment, and national and global security. Drought may be defined as an extended period − a season, a year, or several years − of deficient rainfall relative to the statistical multi-year average for a region. This deficiency results in water shortages for certain activities, groups, or environmental sectors.

In other words, drought is a temporary or prolonged shortage of rainfall in a geographical region. Seasonal or annual droughts spells, which are common in arid and semi-arid zones, may have serious impacts on natural rangelands and, consequently, on livestock. With decreased rangeland resources, livestock then becomes more vulnerable to disease (Wardeh, 1999).

The main effects of drought on livestock include:

- A decrease in the natural feed resource base as a result of low rainfall is the first major effect of drought on livestock production systems. During a drought year, animals suffer a lower rate of conception because of a tardy and incomplete return to the peak body weight during rains, and also higher rates of miscarriage and stillbirth in the subsequent period of pregnancy and calving because of the high level of stress experienced by the animals as the dry season proceeds. Accordingly, drought in one year will lead to lower calving rates in the following year. This decrease in the number of new calves entering the herd is further aggravated by high mortality rates among the young stock.

- Milk production decreases as a result ofthe limited access of the female animals to the natural feed resource base and, below a certain level of intake, lactation ceases completely. This decline in milk affects both the nutritional status and consumption level of those households which rely on off take of milk from their animals to meet part of their requirements
- Animal live weight decreases as grazing becomes scarce, thus reducing the value of the livestock as meat animals. This loss of weight also directly affects the use of animals for transport and power.
- Livestock death rates increases with the decrease in live weight and increased susceptibility to diseases. Within any particular species young animals, elderly stock and pregnant females are the most vulnerable.
- Sales from herds rise sharply as livestock keepers seek to salvage some value from their animals before they die and to obtain the necessary funds to buy food for their households.
- Drought affects herd-owners differently, depending on the level of their livestock wealth and their access to other resources. In general, large herd owners suffer proportionately fewer losses than small livestock owners (ILRI, 1985).

Lack of land ownership

Equality of access to grazing land and water is a basic prerequisite for keeping grazing animals such as sheep, goats, cattle and camels. The control of grazing land and grazing rights, however, is frequently not in the hands of poor livestock keepers, families or villages, but in the custody of wealthy farmers, tribal chiefs, urban residents, or the government. Accordingly, poor, landless farmers are forced to graze their animals on marginal land (roadsides, remote grazing land) (Reist et al., 2007).

The loss of rights and access to resources is an important factor affecting smallholder livestock keepers (Gura, 2008)

In developing countries, especially Asia and Africa, most pastures are used as common property and this further complicates attempts to intensify production (Steinfeld et al., 2006). In addition, there are no rules or institutions to govern the allocation or management of natural resources.

Communal grazing prevails in most of Central and Southern Africa, India and South East Asia. Communal lands grazed by animals are usually associated with adjacent croplands with animals grazing the communal pastures in the growing season and the cropping lands in the dry season. The availability of crop residues and crop by-products in the dry season enables high numbers of animals to be kept, with corresponding high pressure on the communal lands (Jones and Jones, 1997).

2.1.8 SMALL-SCALE LIVESTOCK MANAGEMENT

Breeding management

The breeding in goats or cattle in most developing areas is not controlled (Wilson, 1986). Breeding management consists of selecting breeding animals, mating control, the removal of unwanted animals from the herd through culling or selling, and decisions as to how many animals are needed to cover all the females. FAO (2009b) reported that poor farmers do not have the same concept of an ideal animal as exists in formal breeding societies. Instead, they seek to maintain an optimal herd composed of different lineages representing continuous functional traits and of course, as many as possible animals, regardless of quality. However, breeding goals are more concerned with adaptive traits than with productive traits and, in most instances, breeding goals are guided by aesthetic preferences, religious requirements and behavioural characteristics such as good nature, good mothering ability, herd ability to walk long distances and loyalty to the owner.

Generally, there are no specialised and managed breeding systems to be found in most of the developing countries. Cows run with the bulls throughout the year with little reference as to which bull serves which cow or heifer. In addition, the selection and culling of any breeding animal is the sole responsibility of the individual owner. As a result of the communal grazing system most farmers often find themselves with unplanned for cross breeds. The farmer is, thus, often forced to handle an ever-changing genotype he/she has not planned for, nor has the experience to manage. The introduction of these new strains has eroded the indigenous genotype base, which is known to be adaptable to the communal area environment. Calving is also unpredictable. There is no specific time for calving because of the fact that the bulls remain in the company of the heifers and the cows and it is not possible to control mating with any cannot be easily controlled.

It is also possible that a farmer may own a bull, but be unable either to see the impact of the bull on the production of his/her herd. In addition, in view of the fact that the farming practices are communal it would be relatively easy for the bull to mate with a neighbour's cow, thus contracting venereal diseases which cause infertility and occasional abortions in cows and heifers.

Routine operations

Routine operations such as records keeping, castration, dehorning and branding are all practised in livestock management systems, but with varying degrees of modification and adaptation. Castration is carried out mainly to ensure docility in oxen and is usually carried out on animals of up to two years and sometimes older. The most commonly used method of castration method involves cutting the vas deferens with a burdizzo. On the other hand, dehorning is not a practice that has been widely adopted. In most cases dehorning is carried out at the age of less than six months old (FAO, 2009a). Vaccinations and inoculation are important tools in herd management health programmes for protecting animal health but, in most developing countries, programmes of vaccination and inoculation are being used less as a result of the exorbitant cost, as well as the lack of animal health technicians to assist in implementing such programmes.

Grazing management

Grazing management is an important tool in the efficient utilisation of the pasture resource. Appropriate choices of stocking or height of grazing and rotational or continuous stocking are critical to the success of a grazing system (Sollenberger et al., 2009).

Grazing management refers to the utilisation of a specific area of pasture by grazing animals in order to achieve specified objectives. However, the vast majority of grazing animals in the tropics are managed extensively on native pastures with limited inputs to intensify production. Forage in the tropics is utilised in a wide variety of ways, for example, cut and carry systems, animals being penned and never choosing their own feed; tethering on roadsides, under trees or in fields by day and in pens at night; grazing in the day only and confined to pens at night; grazing in the day only and in pens at midnight (many parts of Africa); grazing throughout the day and the night (Australia, the United States of America, Southern Africa and South America (Jones and Jones, 1997).

Supplementary feeding is not a very common practice although some household salt or salt of another type may be provided during the dry season with young animals not being allowed to graze out until they are three to four months of age. In addition, the young animals may be prevented from suckling if the milk from their dams is required for human consumption (Wilson, 1986).

There is the view that grazing management in the developing world is not ever likely to be realised. The ratio of people to animals tends to be higher in subsistence, pastoralist societies than in ranching economies. Community well-being depends on a healthy economy which, in turn, depends on a productive resource base (Jones and Jones, 1997).

Overgrazing is a common problem leading to the rapid degradation of natural resources. The main purpose of managing forages on communal grazing land is to ensure grazing persistency as well as to maintain or improve grazing quality in order to provide better nutrition for the livestock. In essence, effective fencing, proper grazing management and current carrying capacity are all necessary. However, both overgrazing and managing communal grazing land are complex issues as they involve the farmers while their cooperation and commitment to forage management are vitally important (Chin, 1995).

The grazing system entails grazing animals in designated grazing areas during the growing season and kraaling them at night. Schoolchildren are usually in charge of herding these animals after school with the herds being allowed to graze freely away from the homesteads. As a whole, this system of management tends to lead to abuse of the grazing and difficult decision making as regards the proper management of the resource base (natural pasture). In addition, this system of management tends to lead to high stocking rates and, consequently, most of the areas become degraded, thus resulting in a reduced availability of feed and subsequent, depressed animal performance. Continuous grazing is practised because most of the land is still under the communal system of land tenure.

Insufficient feed supply in terms of both quantity and quality is the major cause of poor livestock production in the communal area. Winter or dry season is the time when the feed is in shortest supply. After harvesting, animals are allowed to forage randomly on crop residues in the arable areas. Cattle are often sold in an unfinished state straight from the veld and this, in turn, results in a reduced income, often below cost.

Drought management

Despite the fact that drought is a natural phenomenon it would, unfortunately, appear that farmers have not yet learnt to live with it or to plan for it with every occurrence of drought being viewed as a disaster as farmers panic and seek drought mitigation strategies. The course of action chosen depends on the farmer’s circumstances, i.e. the resources at his/her disposal, severity of the drought, market availability and veterinary movement restrictions. Nevertheless, a “do-nothing” approach continues to a common strategy employed by all farmers.

Production risks management

Production risk refers to those factors that affect the quantity or quality of livestock yields. When livestock is sold at varying weights, the production risks may impact either on the number of animals or else affect the quality of the animals, making them less desirable and, therefore, less valuable in the market. Both the quest for improved yields and reduced yield variability has been major drivers of improvements in technology and production practices over the years. The risks associated with production agriculture are substantial compared to the risks in other industries. For example, too much or too little rain may ruin crops, cause animals to become sick, and damage grazing lands. In addition, cold and heat may have a huge impact on livestock throughout the year and, especially, during times of breeding and birthing. Diseases impact on both animal numbers and animal weights. It is, thus, essential that this uncertainty be managed properly in order to realise successful, viable and on-going farming operations (undated report). Freeman et al. (2008) report that drought, widespread crop failure, animal diseases and declining access to livestock services delivery increase vulnerability to food insecurity and affect all households in different ways.

2.2 NATURAL PASTURE

Numerous studies have been conducted on communal livestock farming, highlighting the plight of these generally poor, but proud livestock owners. De Bruyn (1998) reports extensively on the socio political and institutional aspects, vegetation dynamics and livestock related matters within the communal rangelands in Southern Africa. The literature is silent on research on the nutritive value of the natural resource base which is both the main and a cheap source of animal feed in these areas. Duvel and Afful (1996) cite the need for more research, especially on range management. Pell et al. (2010) recommend investigating different aspects of the natural environment, for example, water, soil fertility; biomass production, to ensure that farmers’ livelihoods are not being improved at the expense of long-term damage to the environment. This study will focus on the biophysical aspect of small scale livestock operations with the main emphasis on biomass production.

Both declining pasture production and the loss of sustainable grazing systems threaten both the productivity of the grazing livestock industry, and the sustainability of the natural resources (Donaldson, 1998).

The South African veld types are extremely diverse in terms of botanical composition, dry matter production potential and, therefore, nutritive value, that is, the ability to sustain animal production/performance. The nutritive value of a feed depends largely on its chemical composition, the digestibility of the ingested nutrients and the voluntary intake/unit of time by the animal concerned. Animal performance (in terms of growth, milk and wool production) is determined by the change in nutrient requirements, physical environments, the quantity and quality of available pasture and, also, the health and genetics of the animal concerned. This performance, in turn, is governed by the complex relationships between the pasture and the animal – relationships which are influenced by climate, soil, pasture composition, the type of animal and the management of both land and animal., Factors that influence the carrying capacity and feeding value of a pasture include the climate (temperature and rainfall) and soil fertility, in addition to the characteristics of the plant species present.

2.2.1 IMPORTANCE OF NATURAL PASTURE

According to Erskine (1993), natural pasture comprises two thirds of the world's agriculturally useful land. At national level, the Department of Agriculture (2003) reports that 80% of the land available for agriculture in South Africa is utilised as natural pasture for livestock production. Acheampong-Boateng et al. (2003), on the other hand, report that land used for grazing in the Limpopo Province comprises approximately 83.9% of the total farming area. It is clear from these statements that natural pasture forms the dominant feeding source for ruminants both in South Africa, as well as worldwide.

Snyman (1998) conducted an excellent review of the dynamics and sustainable utilisation of the rangeland ecosystem in arid and semi-arid climates of Southern Africa. He reported that approximately 65% of South Africa's rangeland is to be found in the arid and semi-arid areas. These areas have a mean annual rainfall of 500 mm or less. Although rangeland is the cheapest source of animal feed special expertise is required for its sustainable utilisation and management.

In neighbouring countries natural pasture also constitutes the basic feed resource for livestock production in the arid areas, with these areas experiencing a highly variable rainfall − within the range of 100 to about 650mm per year. These neighbouring countries include Botswana (Maphane and Mutshewa, 1999); Namibia (Els et al., 1999), Malawi (Matita, 1999), Mozambique (Uaila, 1999), Zimbabwe (Chakoma et al., 1999) and Zambia (Mukumbuta et al., 1999).

As a result of variations in both rainfall and temperature, cattle grazing on natural range pastures are subjected to a constantly changing feeding base, both quantitatively and qualitatively. These variations, in turn, affect botanical composition, dry matter production and the nutritive value of natural pastures – all of which are of paramount importance in sustaining animal production (Okello et al., 2005). Adequate amounts of good quality forage on daily basis are vital if cattle are to meet the nutrient requirements for maintenance and production from such pastures.

The conservation and proper utilisation of natural pastures are two important variables as regards both the sustainable utilisation of these pastures and the sustainable productivity of the livestock industry in Southern Africa. The livestock industry, in turn, is the dominant industry (40%) in the agricultural sector, followed by field crop (33%) and horticulture (27%) (Department of Agriculture, 2005/06). However, various factors may exert increasing pressure on natural pasture as a resource base. The most important of these factors include expanding human population [according to Palmer and Ainslie (2006), currently 44.2 million], rising animal feeding costs, narrowing profit margins in the livestock industry, increasing demands on energy sources and the increasing demand for food production. These factors, in turn, constantly refocus the attention on the need for a more effective evaluation of forage in terms of its nutritive value for ruminants (Cilliers and Van der Merwe, 1993). According to Abdulrazaket al. (1997), the following factors are mainly responsible for poor livestock production in the tropics, namely, lack of feed as a result of overgrazing, poor quality of feed and reduced intake of dry-season feed from the natural vegetation. Overgrazing claims, constantly cited in respect of natural pastures throughout the world (Willison and Macleod, 1991), affect the dry matter production potential. This situation, in turn, has a direct influence on animal production and necessitates greater efforts to prevent the further deterioration of the veld condition.

Numerous studies have been conducted to broaden the general perspective on grazing animals on natural pasture. A brief discussion of the available literature follows. This discussion will cover, inter alia, botanical and dry matter composition; grazing capacity and nutrient content/chemical composition − the most important aspects considered by this study.

- Botanical composition and dry matter composition

A good knowledge of botanical composition is helpful in planning production systems (Van Niekerk and Schoeman, 1993). Fourie et al. (1984) report that changes in botanical composition are more apparent where veld deterioration is more advanced. Tainton et al. (1993) conducted research on two well-managed sites in order to ascertain the patterns of grazing of *Themenda triandra, Tristachya leucothrix* and *Hyparrhenia hirta* by cattle at two stocking rates. The results showed that no clear species selection patterns were evident although *Themenda triandra* was the most preferred species during winter, with immediate selection for Hyparrhenia hirta and little selection for *Tristachya leucothrix*.

In their research, Smet and Ward (2005) compared the effects of different rangeland management systems on plant species composition, diversity and vegetation structure in semi-arid savannah. They concluded that grazing hada significantly negative effect on these rangelands, although the differences in the degree of degradation may have been compounded by factors other than grazing. Rothauge et al. (2004) report on the way in which veld condition is affected by the frame size and stocking rates of free-ranging beef cattle. Their results indicated clear-cut compositional changes occurring in the grass sward as a result of the systematically increasing stocking rate. Nevertheless, in some instances, this was as a result of a reaction to the different cattle frame sizes utilising the plots.

O’Connor (1991) investigated the influence of heavy grazing by cattle over a period of three years and rainfall interception over a period of one year on the herbaceous composition of a sandveld savannah in Gazankulu. The trial results show that the trend of rainfall − initially wet and then successively drier −apparently had an influence on compositional trends.

- Grazing capacity

Rowe-Rowe (1999) describes the grazing capacity of the veld as the area of land required to maintain a single animal unit without causing deterioration in either the vegetation or soil condition (a decrease in basal cover or a change in species composition or the vigour of the veld plants). According to Du Toit (2003), grazing capacity is used in instances in which the goal is the sustainable management and use of natural veld utilised by grazing domestic livestock. However, grazing capacity varies from farm to farm and even from place to place on one farm. It also varies according to the weather conditions during the different seasons. Grazing capacity is expressed as hectares per animal unit (ha/LSU). Knowledge of the grazing capacity may assist farmers to formulate a sound veld management plan that will provide for the needs of livestock and also ensure the sustained productivity of the veld plants.

It is interesting to note that veld plant composition varies to such a degree that it would be unrealistic to expect a detailed and accurate assessment of grazing capacity. Nevertheless; a methodical approach to grazing capacity estimation would yield estimates sufficiently accurate for the purposes of sound veld planning and management (De Beer, 1990). This method was adopted in this study.

In their research on the quantification of grazing capacity from grazing and production values for forage species in the semi-arid grasslands of Southern Africa, Van der Westhuizen et al. (2001) revealed that there is a plethora of factors influencing the determination of grazing capacity. When one of these factors change, the grazing capacity changes to either a greater or a lesser extent, while these factors differ in the different ecological areas. For example, rainfall is more important in arid areas than in areas of high rainfall. The factors influencing grazing capacity include rainfall, available soil moisture depending on soil type, soil depth and evapo-transpiration, rangeland condition, topography, stock type, management factors and climatic variation.

Rethman and Kotzé (1986) studied veld condition in the South Eastern Transvaal and its effect on grazing capacity. Their results indicate that it is unrealistic to strive for the realisation of the long-term, potential grazing capacity with an ideal botanical composition over the whole area, but that it might be a realistic objective to stabilise, both ecologically and economically, livestock production in the region and conserve soil and water resources for continued development.

Smith and Rethman (1992) reported that, since the introduction of domestic livestock, large areas of natural veld in South Africa have undergone radical changes. In addition, these changes have been detrimental as they have resulted in lower grazing capacity, soil erosion and the general degradation of the environment.

Barnes (1992) has shown that the grazing value of the veld in the South-Eastern Transvaal is well below the estimated potential. However, efforts aimed at rectifying the situation have been unsuccessful as a result of the fact that most of the recommendations are not acceptable to the producers.

Rethman and Kotze (1986) report widespread concern over the condition and deterioration of the natural pasture. This deterioration has been caused by the expansion of arable areas and a rapid increase in both the human and livestock population. An overestimation of grazing capacity and incorrect management result in overgrazing, erosion and the deterioration of natural pasture (Fourie et al., 1984), with this being especially true as regards the communal areas (Duvel and Afful, 1997). The communal rangelands in South Africa are known to be heavily stocked, supporting livestock at levels of up to four times the recommended stocking rate .The stocking rate in communal rangelands is double that of commercial farms (Peden, 2005). It must also be borne in mind that stocking rate is the most important factor in terms of grazing management and that it affects animal production (Dekker, 1997).

Twine et al. (2002) report on the long-term effects of sustained high stocking rate in a comparative study of communal vs. commercial in Bushbuckridge, Limpopo. The results of this study indicate that the re-growth capabilities of grass tufts may be related to distance from a village and the grazing pressure to which a site has been exposed over time.

- Nutrient content/chemical composition

A minimum crude protein of 7 to 8% is required for ruminants, 13 to 14% for high producing animals (Boyazaglu, 1999), crude protein of 13 to 18% and crude fibre of 15-20% for feeder cattle (Meissner et al., 1999) while, for dairy cows, crude protein of 9 to 14.5% and crude fibre of 7 to 10% are required (Smith et al., 1993). Aregheore (2001) reports that, in order to facilitate favourable, ruminal, physiological function in ruminant diet, crude protein of 13 to 16%, crude fibre of 18%, ADF of 19% and NDF of 25% are required. The crude protein requirements of an animal depend on the animal's species, age, the physiological functions being undertaken, for example, growth or lactation, and its level of production. Mineral content declines with age, although it is not possible to predict the rate and extent of the decline as a result of variations in seasonal conditions, soil type and nutrient levels. South Africa generally is deficient in phosphorus minerals, and it is advisable to avoid inadequate amounts and imbalances of these minerals in forages so as to avoid physiological disorders and suppressed animal performance (Tainton, 1999).

Faure et al. (1983) found crude protein and the digestibility of oesophageal samples of sheep grazing on natural pasture on two veld types were within the range of 5 to 20%; 50 to 67%; 6 to 28% and 55 to 67% respectively. However, these parameters were not consistent and showed no clear seasonal trend.

Working on the composition of the diet selected from the veld by fistulated steers, Sibanda (1984) found that crude-protein content declined from approximately 15% in early December to 5.3% at the end of June, while ADF increased from 50.7 to 59.4%. After 48 hours, degradable matter increased from 50.7 to 59.4% within the same period. These results suggest that the degradability of the dry-matter increased with time of incubation, irrespective of season, and it was, therefore, recommended that samples using nylon bags in the rumen not be incubated for more than 48 hours, as other factors besides dietary composition determine the performance of growing steers.

Kavana et al. (2007) report that the crude protein of natural grasses ranged between 32.2 g/kg to 9.8 gin 1kg/DM in inland Tanzania. The distribution of rainfall, uneven seasonal growth and the availability of pasture are considered to be major limitations as regards the constant supply of forage for ruminants. However, experience has shown that low quality and quantity of grass pastures are so common that it was not possible to meet the minimum requirements for the maintenance and production of animals. Nevertheless, Fourie et al., (1986) found that crude protein of 7 to 9% in herbage is sufficient to sustain beef production

According to Van Niekerk and Schoeman (1993), the nutritional value of the natural grazing of Southern Africa is still relatively unknown, in spite of well documented research. Most of this research was based on the chemical analyses of hand cut samples, leading to the misconception that grazing ruminants ingest herbage which is deficient in nutrients and thus that the herbage warrants supplementation in order to support reasonable levels of animal production (De Waal, 1990). Oesophageally collected pasture samples differed chemically from the hand-cut pasture although it is not possible to use the chemical analysis based on hand-cut samples as an indication of the nutritive value of feed (Coffey et al., 1991, Brand et al., 1991; Fourie et al., 1986). In view of the fact that hand-cut pasture does not take into account the effects of selective grazing it tends to provide a relative, rather than an absolute, measure of the changes taking place in the nutritive value of the veld (Sibanda, 1984). The nutritive value of a feed depends on chemical composition, digestibility of the ingested nutrients, the voluntary intake of the feed by the animal (Fourie et al., 1986), and the nutritive value of the veld in terms of its ability to support animal production. Accordingly, it is recommended that the role of supplementary feeding be studied under both realistic and practical conditions (De Waal, 1990).

Aregheore (2001) maintained that, for cattle grazing on natural pasture to meet the nutrient requirements for maintenance and production, it is essential that they obtain adequate amounts of good quality forage on each grazing day. To obtain adequate quality forage depends on both dietary and animal factors and may best be described by the in Sacco disappearance of ingested feed incubated in the rumen. The results of his study reported seasonal variations in the disappearance of the Sacco dry matter with the dry matter disappearance being 26% during the dry season and increasing to 30% at the end of the rainy season. This increase was as a result of the active herbage growth triggered by the rains and leading to improved dietary quality and digestibility. Working with steers, Playne, Khumnualthong and Echevarria (1978) reported 48 hours dry matter disappearance of three grasses − Heteropogon contortus, Chloris barbata and Stylosanthes humilis − of 36.1, 42.1 and 51.3% respectively. Aregheore (2001) argued that a 48-hour dry matter disappearance of less than 40% has little potential for supporting growth and milk production and that, even at 45 to 50%, the potential is still very low. Working with sheep, De Waal (1990) reported winter and summer dry matter disappearance at 24 hours of 26 and 49% respectively. The crude protein level was within 60 to 100g/kg, with the highest level reached during the wet season and falling during the dry season.

Good pasture is slowly fermentable and has fair crude protein and intake. Chenost and Sansoucy (undated) and Teferedegne (2000) report that tough texture, poor digestibility and deficiency in nutrients of the natural pasture leads to low productivity. However, the value of good quality grass for ruminants depends on its nutrient concentration as well as its intake by animals (Aregheore, 2001).

Cilliers and Van der Merwe (1993) report on the relationship between the chemical components of veld herbage and in vitro digestibility, and estimated intakes of dry matter and digestible dry matter by sheep and cattle at the Noyjons Experimental Farm. Their findings revealed that the contents of crude protein of the herbage selected by sheep was highly significantly ($p < 0.01$) and, in fact, higher than that selected by cattle, while the contents of ADF and NDF were lower ($p<0.01$). Gunter et al. (1991) researched the chemical composition of the diets consumed by cattle grazing on native range or plains bluestem pasture. Their results showed that the crude protein of plains was higher than that of the native pasture.

Licitra et al. (1997) studied three field sites for their forage quality, botanical composition and chemical analyses. Investigations included chemical analysis of dry matter, ash, neutral detergent fibre, acid detergent fibre, lignin, total nitrogen, NPN, soluble nitrogen and degradable protein. The research results showed that the quality of forage varied over the growing season and declined with forage maturity.

2.2.2 DESCRIPTIVE TERMS OF GRAZING VALUE

The relative sweetness of the pasture and carrying capacity are two popular terms which are used to describe the grazing value of natural pasture. The following brief discussion will explain the relevance of these two concepts to the study.

Sweetness of natural pasture

The sweetness of natural pasture relates to the impact of certain soil and climatological characteristics of an area on the naturally occurring plants. This influences the species composition, chemical composition and the ratio of structurally soluble and insoluble carbohydrates of the plant. These influences make it possible to classify natural pasture into sweet-, mixed- and sourveld. According to Ellery et al. (1995), a basic distinction in grassland management in South Africa is between sweetveld and sourveld, with mixed veld as an intermediate.

Sweetveld refers to veld which remains palatable and nutritious, even when it matures in the dormant season. Sourveld, on the other hand, provides palatable material during the growing season only while mixed veld is intermediate between these extremes and ranges from sweet-mixed veld, which provides grazing for about 9 to 11 months of the year, to sour-mixed veld, which provides grazing for between 6to 8 months of the year. In general, the distinction between sweetveld and sourveld is reasonably clear in the summer rainfall regions where growth is restricted to the spring and summer seasons. The subtropical grass species, which dominate the grasslands in these areas, mature in mid to late summer. Sourveld provides nutritious grazing material in spring and summer but becomes, relative to sweetveld, unpalatable and of low feeding value during autumn and winter (Tainton, 1999). The current study was conducted in the arid sweet Bushveld of Limpopo. Natural pasture of this veld type maintains its palatability and nutritional value throughout the entire year. The feeding value of natural pasture in this area is capable of maintaining the physical condition of livestock through the dormant season and is also able to support high growth rates during the spring and summer (rainy season) (Tainton, 1999).

According to Meissner et al. (1999), both preferred and principal foods, and the determination of acceptability and palatability are also important as a result of their effect on the palatability of feed grazed by animals. The palatability of the feed itself determines the attractiveness of the feed to an animal, whereas acceptability refers to the attractiveness of feed to animals, as determined by factors relating to the forage and in the environment.

- Preferred and principal foods: Of interest is the choice the animal will make between the various feeds on offer. This choice has important consequences for veld management because the choices made control selective grazing. An animal shows a preference for a particular food when the animal consumes that particular food in a larger proportion than another food which is also presented to the animal, irrespective of the extent to which that food contributes to the total diet of the animal. Principal foods are determined by the circumstances, for example, if an animal is presented with forage from a single species only then, assuming that the animal is prepared to consume that food, then that species will automatically serve as the principal food species (Tainton, 1999).

- Characteristics determining acceptability according to Tainton (1999):

    - Acceptability is positively correlated with the concentration of protein, energy, mineral, anthocynins, ether extract and water content and negatively correlated with the fibre and lignin content.
    - Acceptability is strongly influenced by the physical properties and structure of the plant, for example, thorns and spines, presence of awns,

    hairs or stickiness, as well as by the coarseness or harshness of the leaves.

  - The presence of tannins and alkaloids in woody plants significantly depress the acceptability of such plants to browser species.
  - The situation in which the plant grows also affects the acceptability of the plant.
  - Selective abundance and the associated preference of other species growing in the same area influence acceptability.

- Determination of acceptability and palatability: A number of plant and animal factors interact in determining the extent to which a particular food item will be selected. The relative importance of the different factors will vary according to the circumstances prevailing at any one time.

However, the determinants of acceptability and palatability are poorly understood and they are difficult to ascertain. Vanton (2001) reports that, when a veld is overgrazed, cattle often pick out the palatable bits only and leave the rest. Eventually, the unpalatable grass only is left.

Carrying capacity

According to Tainton (1999), the carrying capacity (potential stocking rate) may be described as the potential of an area to support livestock through grazing and/or browsing and fodder production over an extended number of years without resultant deterioration of the overall ecosystem. Carrying capacity is expressed in terms of hectare per animal unit (ha/LSU).

Stocking rate affects both animal performance and the profitability of livestock systems. Stocking rate is regarded as of primary importance in rangeland management. Conservative stocking rates are recommended in order to maintain long-term animal production and veld condition (O'Reagan and Turner, 1992). There appears to be a threshold stocking rate above which veld degradation occurs. This implies that a range of stocking rates may be applied without causing range degradation provided the critical stocking rate for a particular vegetation type is not exceeded. Veld condition appears to be dependent on stocking rate, whereas the relationship between veld condition and carrying capacity is often indirect (Du Toit, 2003).

As regards humid grassland, Morris (2002) found that the grazing capacity limits of the veld constitute one of the most important grazing management principles and, furthermore, failing to stock correctly will lead to veld deterioration. Regular and careful monitoring of animal and veld productivity and condition is needed to enable a continual refinement of management practices, such as stocking rate. In contrast, Vanton (2001) found that increasing stock density may actually restore overgrazed and desertified areas, if combined with good timing.

O'Reagan (1994a) and Speedy (1991) considered both stocking rate and the grazing system as the most important factors influencing animal performance. Grazing pressure increased with an increase in stocking rate, while veld condition deteriorated at high stocking rates, under both rotational and continuous grazing. This, in turn, may influence the crude protein content and digestibility of animal diets. It is, therefore, important to gain information as to the extent that these two components of nutritional value are influenced by stocking rate and grazing system.

Barnes and Denny (1991) studied a comparison of continuous and rotational grazing on the veld at two stocking rates and the effect on animal performance. Their study was conducted at the Matopos Research Station. They found that, although floristic composition changed over the period of the trial, no differential effects of either grazing procedure or stocking rate were detected on the composition. Gains per steer on average during the growing season were virtually identical with all treatment combinations except with continuous grazing at the low stocking rate while, during the dormant season, steer performance was similar in all treatments. The poor performance in the dormant season was as a result of the unpalatable supplement offered in that year. In addition, the gains per hectare were directly proportional to the stocking rate.

Stocking rates vary considerably between the different veld types in South Africa. The table below (Table 2.7) illustrates the carrying capacity which may normally be expected in the different regions and significant variations between the major veld types.

The reasons for these variations include a complex set of climatic, soil and biological variables that result in different vegetation architectures for each major veld type. The variation in carrying capacity within a veld type is also significant, for example 8 to 30 ha/animal unit/annum in Valley Bushveld. The same set of variables is responsible for this variation, but on a limited geographical scale only and within a narrower range of absolute variation per variable.

Table 2.6: Carrying capacity of the different types of grazing lands in South Africa (Tainton, 1999)

VEGETATION	CARRYING CAPACITY (ha/animal unit/annum)
Grasslands	
Climatic climax grassland at low elevations	1-5
Climatic climax grassland at high elevations	3-5
Fire climax grassland of potential forest areas	1-2. 5
Fire climax grassland of potential savannah areas	2-3
Savannah	
Kalahari thorn and bushveld	10-35
Transvaal sour bushveld	4-6
Transvaal mixed bushveld	4-7
Transvaal sweet bushveld	5-8
Eastern mixed bushveld	6-15
Valley bushveld	8-30
Karoo	
Western desert Karoo	>35
Succulent Karoo	12-25
Upper, non-succulent Karoo	7-35
Northern karroid bushveld	20-35
Forest	
Tropical lowland forest	>35
Subtropical coastal forest	>35
Montane forest	>35
Fynbos	
True fynbos	6-20
False fynbos	4-20

However, management practices represent one variable not included in the variations illustrated in the above table is. This variable, which is caused by human intervention in the ecosystems, also impacts significantly on carrying capacity. However, this variable of management practices is not fully quantified in the literature and, thus, represents a void in the knowledge base of natural pasture science. The results of this study will contribute to quantitative values for the arid sweet Bushveld.

Forage quality

The term forage quality refers to the production response of the animal to specific forage. It may also be termed the feeding value of forage. Feeding value refers to the potential of the feed to supply the nutrients required by an animal, both quantitatively and qualitatively, in order to support a desired type of production (Mlay et al., 2006). Both forage quality and production are influenced by growing season, amount and distribution of precipitation, elevation and composition of the vegetation (Cheeke, 2005). Meissner et al. (1999) report that chemical composition of feed intake and digestibilities are the main factors which determine animal performance. However, these factors are, in turn, influenced by a number of factors related to both the animal and the forage, and they interact between themselves. The factors are briefly discussed in the following section.

Chemical composition

Chemical composition refers to the chemical constituents that serve as nutrients for herbivores and are divided into cell wall constituents and cell constituents, and also into digestible, indigestible or poorly digestible fractions. In general, cell contents are highly digestible while cell wall contents (commonly referred to as fibre) are either indigestible or poorly digestible and are soluble in acid detergent. Major chemical constituents found in forages include proteins, carbohydrates, minerals, structural components of the plant cells, vitamins, and anti-quality and toxic substances.

- Proteins: The amount of protein and its chemical form constitute the main nutrients that limit animal performance on natural pasture. Crude protein (CP) refers to natural proteins as well as non-protein nitrogen (NPN). Crude protein is calculated by multiplying the N content of the forage by 6.25. This figure provides a useful indication of the need for protein supplementation. The protein requirements of an animal depend on the species, age, reproductive phase and level of production of the animal. As a general guideline, it may be assumed that 7% to 8% crude protein is sufficient for the maintenance requirements of ruminants, while high producing animals may require a crude protein level of up to 13–18%. However, certain game species and livestock breeds appear to have a lower requirement than the levels cited above. When a large proportion of the crude protein is in the form of NPN, animals may respond to supplementation even if the crude protein levels are well above the levels shown above. Crude protein varies widely among forage plants. However, in all species and in all seasons it declines with increasing age and the level of maturity of the forage.

- Minerals: Both inadequate levels and imbalances of minerals in forages may lead to physiological disorders and suppress animal performance. The balance of minerals in the forage is critical to livestock. De Brouwer et al. (2000) report that phosphorus is invariably in short supply in grazing throughout most of South Africa and, thus, phosphorus supplementation has become common practice. This has had a marked effect on the reproduction and growth of cattle in some areas. It is important to note that responses to phosphorus supplementation vary substantially from one area to the next. Other minerals recommended in livestock feeding include Na, Ca, P, Mg, S, Zn, Co, Cu, Mn, molybodenum, iodine and selenium. The concentration of minerals in forages declines with age, although it is not possible to predict the rate and extent of this decline because it varies with the time of year and is also influenced by soil type, soil nutrient level and seasonal conditions.

- Structural constituents: The structural constituents (cell wall constituents or fibre) of plant material include polysaccharides, lignin and some proteins, and may be divided into matrix polysaccharides (hemicellulose and pectic substances) and fibre polysaccharides (cellulose, lignin and proteins). These constituents have been termed fibre and may be either incompletely or partly digested by the animal. The stems of most forage have a larger proportion of structural polysaccharides and lignin than do the leaves with this proportion increasing with maturity in both temperate and tropical species. Variations in the total content of structural constituents or their components are apparently less significant in herbivore nutrition than the interactions between the constituents, i.e. once lignin has been removed; the polysaccharides of the cell wall become significantly more digestible. The lignin in plant fibre resists microbial attack, reduces digestibility through its linkage to specific points on polysaccharides chains and prevents the physical attachments of rumen bacteria to plant cell walls.

- Vitamins: Vitamins are normally required in small amounts only. The most important vitamin is vitamin A. Vitamin A is usually deficient in dry veld but is well provided for by green roughages and leafy lucerne hay.

- Anti-quality and toxic substances: These comprise the secondary metabolic substances of plants and are often produced for the protection of the plants. These substances include polyphenolics, such as tannins, toxic amines, amino acids, saponins and cyanides. Certain legumes, such as lucerne, white clover and red clover, contain substances which cause bloat, whereas others contain tannins which reduce the digestibility of the forage. Meissner et al. (1999) reported that the tree legume, Leucaena leucocephala, contains mimosine, which causes hair loss and liver damage in livestock. In addition, alkaloids cause gangrene in the hooves of animals while prussic acid poisoning is a problem associated with some sorghum varieties, although little is known of this aspect of toxicity as regards the indigenous species.

Intake

Intake refers to the physical capacity of the digestive tract and the rate at which food passes through the rumen. Intake determines the extent of rumen fill which, in turn, controls the appetite. The rate of passage is determined by the digestibility of the feed (both physically and biologically), while the latter is influenced by the quantity and composition of fibre (cell wall) in the feed. Animal growth is dependent on feed intake. The feed intake of pen-fed animals is well documented, but relatively little is known of the factors controlling herbage intake under extensive grazing conditions as a result of the complexity of the factors involved in the grazing situation. Regulation of intake, prediction of intake, voluntary intake and models of dietary selection are all factors influencing the feeding value of roughages and they determine the performance of grazing livestock (Meissner et al., 1999).

Digestibility

Digestibility is estimated as the difference between the amount of feed ingested and the amount excreted and, therefore, assumed to be absorbed by the animal. Grazing management, plant age, high temperature and fertilizer influence on growth rate and stage of maturity of the material are all factors affecting digestibility.

Accurate information about the nutritive value of feed is of great importance in animal production. However, the chemical analyses of feed samples do not provide sufficient information on the evaluation of animal feeds and should be supplemented by digestion studies. Selective grazing by ruminant livestock and other herbivores causes difficulties in either measuring or estimating the chemical composition and functional properties (digestibility and intake) of the diets of free grazers (Boval et al., 2004). Apart from large-scale feeding trials, which are both expensive and time-consuming, two approaches of biological significance are commonly used for ruminant feeds; namely, the in situ and the in vitro systems. Both these methods have proved to be highly reliable and to correlate closely with digestion in vivo.

In vitro methods of estimating digestibility are the most commonly used method worldwide for the routine analysis of large numbers of samples. These methods attempt to simulate in vivo digestion in the laboratory (Tainton, 1999).

The most commonly used in vitro procedure is the "two-stage in vitro” of Tilley and Terry (1963). During the first stage, a finely ground sample of the food is incubated for 48 hours with buffered rumen liquor in a tube under anaerobic conditions. In the second stage the bacteria are killed by acidifying with hydrochloric acid to pH2 and are then digested by incubating them with pepsin for a further 48 hours. This is followed by filtering off, drying and igniting the insoluble residue, while the insoluble organic matter is subtracted from that present in the food to provide an estimate of the digestible organic matter.

Briefly, these methods involve the anaerobic fermentation of small feed samples in digestion flasks which contain a synthetic saliva solution and appropriate rumen inoculums. The methods are limited to the reactions which take place, the end products, the microbial population and several other factors, which may differ when occurring in vivo. It is essential that these factors be considered when interpreting the results obtained from in vitro digestibility determinations.

In addition, there are two in vivo methods which may be used to collect samples. Both methods involve the surgical alteration of the animal. In the one method fistulation is carried out in the oesophagus (oesophageal fistulation (OF). This is the most readily accepted representation of the forage consumed by grazing ruminants although it is demanding in terms of animal care, maintenance and extrusa processing (Coffey et al., 1991). In terms of the other method fistulation is carried out in the rumen (rumen fistulation).However, these methods do need to be discussed at length.

According to Coffey et al. (1991), a precise estimation of forage intake depends on the accurate determination of the forage components consumed. However, the chemical composition of the forage consumed may differ from that of the available forage as a result of animal selectivity and other processes involved with ingestion and mastification. Samples collected without the use of oesophageal fistulated animals should be regarded as estimates of the available forage only, and not of the forage selected and consumed.

Recently much attention has focused on the more direct method of measuring the rumen degradation of feeds. This method involves placing a small amount of feedstuff in an undegradable porous bag and suspending both the bag and its contents in the rumen. This technique (variously termed the nylon/dacron polyester bag, or the in sacco or in situ rumen degradability technique) had been adopted by the Agricultural and Food Research Council (1992) as the standard method of characterising the rumen degradability of nitrogen (Huntington and Givens, 1995). The method was originally developed for use with forages (Dewhurst et al., 1995). However, it is unsuitable for soluble feedstuffs and feedstuffs with a high proportion of starch and other particles that disappear, undergraded, from the nylon bags (Cone et al., 1999). This nylon bad technique has been utilised in several species of animals, including cattle, sheep, goats, and horses and also in wild animals. Nevertheless, the technique provides a powerful tool both for the initial evaluation of feedstuffs and for enhancing the understanding of the processes of degradation which occur within the rumen (Orskov et al., 1980; Vanzant et al., 1998).

The in situ technique has been extensively evaluated. According to Michalet-Doreau and Ould-Bah (1992), its usefulness lies in its ability to standardise. However, despite its widespread use, a standardised method has not yet been adopted as a result of the large number of variables that are involved (e.g. bag pore size, ratio of sample to particle size, animals' diet, incubation time, and so on (Marinucci et al. 1992; Van der Merwe et al., 2005). Trinacty et al. (2003) and Holtshausen and Cruywagen (2000) maintain that no single technique or experimental design is totally satisfactory at the present moment.

The strongest criticism of the in situ technique is its low repeatability, as is suggested by the diversity of values obtained by different researchers for a similar feed sample. In addition, considerable differences exist between various laboratories as regards the application of this technique (Michalet-Doreau and Ould-Bah, 1992) with Huntington and Givens (1995) highlighting many sources of variation in the application of this in situ technique. The same differences as regards the application of the technique were found to explain some of the variations in nitrogen degradability values observed in the European ring test, and as cited by Huntington and Givens (1995). It must also be pointed out that considerable differences exist from one laboratory to another in the application of the technique. Vanzant et al. (1998) report that interactions involving feed stuff characteristics suggest that no single standardised procedure will ever be applicable across all feedstuff, processing techniques or plant nutrition. However, in order to provide a meaningful and logical progression in the in situ procedure, it is imperative that there be some well defined starting point (i.e. standardised procedure).

There is substantial information available on the factors influencing the measurement of in situ degradation of dry matter and crude protein in the rumen with these factors including bag characteristics, influx of microbial populations, undergraded particle losses, retention of solubilised products, sample characteristics, sample size to bag surface ratio (Michalet-Doreau and Ould-Bah, 1992), period of incubation (Marinucci et al., 1992), sample preparations prior to rumen incubation, post-rumen incubation processing of in situ bags and their residues, type of cloth used to fabricate bags, bag pore size, bag mobility in the rumen with respect to cord length (11-105 cm), anchor weight, the sequence in which the bags are incubated, ratio of sample size to bag pore size, the possible need for the co-incubation of highly proteinaceous feeds (Huntington and Givens, 1995); bag location in the rumen, type of bag attachment to the weight (Trinacty et al., 2003); sample particle size, animal's diet, animal characteristics, substrate characteristics, bag characteristics, temporal characteristics, other procedural aspects, mathematical components (Vanzant et al., 1998), as well as several other factors. Several writers have made recommendations concerning the standardisation of in situ procedures. These recommendations are summarised in Table 2.8.

Table 2.7: Comparison of standardised procedures or recommendations for measuring ruminal degradability (emphasis on protein degradability) (Vanzant et al., 1998)

ITEM	ØRSKOV (1982)	LINDBERG (1985)	NOCEK (1988)	AFRC (1992)	MICHALET-DOREAU AND OULD-BAH (1994)	MADSEN AND HVELPLUND (1994)	WILKERSON ET AL. (1995)
Diet	Similar to diet of application	50:50 hay to concentrate	Similar to diet of application	60:40 hay to concentrate	Similar to diet of application	66. 7:33. 3 hay to concentrate	All forage
Feeding level	Unspecified	Maintenance	Ad libitum	Maintenance	Unspecified	Maintenance	Unspecified
Bag							
Material	Polyester	Polyester	Polyester	Polyester	Polyester	Polyester	Polyester
Pore size	20–40 µm	35–40 µm	40–60 µm	40–50 µm	40–60 µm	30–50 µm	53 µm
Sample size: surface area	12–20 mg/cm²	10–15 mg/cm²	10–20 mg/cm²	12 mg/cm²	15 mg/cm²	10–15 mg/cm²	12. 5 mg/cm²
Sample grind size							
Concentrates	2. 5–3 mm	1. 5 mm	2 mm	2. 5 mm	1. 5–3 mm	1. 5–2. 5 mm	2 mm
Roughages	2. 5–5 mm	1. 5 mm	5 mm	4 mm	1. 5–3 mm	1. 5–2. 5 mm	2 mm
Animal	Sheep or cattle	Cattle	Animal of application	Unspecified	Unspecified	Cattle, sheep, goats	Cattle
Replication							
Number of animals	2 – 4	3 – 4	Unspecified	3	Unspecified	3	1–4
Number of days	1 – 2	Unspecified	Unspecified	1	Unspecified	1	1–4
Number of bags	1 – 4	Unspecified	Unspecified	1	Unspecified	2	1–8
Pre-incubation	Unspecified	Unspecified	Pre-soak	None	None	Unspecified	Pre-soak
Incubation conditions							
Ruminal location	Contact with liquid and solids	Ventral sac (free movement)	Unspecified	Liquid (free movement)	Unspecified	Unspecified	Ventral sac (free movement)
Insertion/removal order	Simultaneous insertion	Unspecified	Simultaneous removal	Either approach	Simultaneous insertion	Simultaneous insertion	Simultaneous removal
Times	2, 6, 12, 24, 36 (? for roughages)	2, 4, 8, 16, 24 (48 for roughages)	6–12 points up to 24 h; others > 25 h	2, 6, 8, 24, 48 (72 for roughages)	Adequate to describe curve	0, 2, 4, 8, 16, 24, 48	16 h for test, times for rate unspecified
Rinsing	Hand	Hand	Hand	Machine	Unspecified	Machine	Hand
Microbial correction	Correct	Unspecified	Correct	Unspecified	Unspecified	Unspecified	Unspecified
Standard feed	Unspecified	Unspecified	Use	Unspecified	Use	Use	Unspecified

Table 2.9 reveals that, of all the nylon bag technique reviewed in this study, only a few offered by Sibanda (1984); Manyuchi et al. (1997) and Okello et al. (2005) were carried out on natural pasture using rumen fistulated steers on different veld types. This emphasises the paucity of literature on this topic.

Table 2.8: Review of research carried out on Dacron bags

RESEARCH REVIEW RESEARCHER	DIET USED	ANIMAL USED	VELD TYPE	INCUBATION PERIOD
Sibanda S, 1984	Natural veld	Rumen fistulated and oesophageal fistulated steers	Loamy sandveld	48 hrs
Huntington and Givens, 1995	Planted	Rumen fistulated cows and sheep	Not specified	2, 4, 8, 16, 24, 48 and 66 hrs
Beck et al.,2007	Planted	Rumen fistulated steers	Not specified	6, 12, 24, 36, 48, 72, 96 and 120 hrs
Trinacty et al.,2003	Planted	Rumen fistulated cows	Not specified	2, 4, 8, 16, 24 and 48hrs
Coblentz et al.,2002	Planted	Rumen fistulated steers	Not specified	3, 6, 9, 12, 24, 36, 48, 72 or 96 hrs
Gralak, 1997	Planted	Rumen fistulated sheep	Not specified	0, 2, 4, 6, 24 and 48 hrs
Holtshausen and Cruywagen, 2000	Planted	Rumen fistulated cows	Not specified	12 hrs
Ogden et a.l, 2005	Planted	Rumen fistulated steers	Not specified	3, 6, 9, 12, 24, 36, 48, 72 OR 96 hrs
Van der Merwe et al., 2005	Planted	Rumen fistulated cows	Not specified	24 and 72 hrs
Manyuchi et al., 1997	Natural pasture	Rumen fistulated steers and sheep	Not specified	6, 12, 24, 48, 72 hrs
Lopez et al., 1998	Hay	Rumen fistulated sheep	Not specified	6, 24, 48 and72 hrs different length of time
Dewhurst et al., 1995	Planted	Rumen fistulated cows	Not specified	2, 4, 8, 12, 18, 24, 48 and 72 hrs
Okello et al., 2005	Natural pasture	Rumen fistulated steers	Not specified	6, 12, 24, 36, 48 and 72 hrs

2.2.3 MANAGING THE VELD

According to Stevens (1999), it is essential that veld management systems be both economically viable and ecologically stable. Van der Merwe (1998) cites poor management practices such as overgrazing, as well as low and erratic rainfall, as possible factors resulting in the fact that large parts of Southern Africa are threatened by the degradation and deterioration of the natural rangeland in both the arid areas (Karoo) and also in large parts of the grasslands.

O'Reagan and Turner (1992) maintain that veld management procedures/practices are critical in rangeland management. Tainton et al. (1993) are of the opinion that veld management is aimed at ensuring continued vigour among the main forage producing plants, that as much as possible of the available forage is consumed by the animals, and that the basic resources of soil and water are conserved. The shorter the period of occupation and the longer the period of absence in rotational grazing systems, the greater will be the production of individual plants in the sward.

Rainfall variability has been identified as a primary determinant of compositional change in the Southern Savannas (O'Connor, 1995). Tainton (1999) defines veld condition as the state of health of the veld in terms of its ecological status, resistance to soil erosion and its potential for producing forage for sustained, optimum livestock production. Different researchers have worked with various veld conditions assessment techniques. For example, Van der Westhuizen, et al. (2006) used the degradation gradient method and determined that veld condition constituted the most important aspect of sustainable rangeland management systems. Tongway and Hindley (2004) worked on the landscape function analysis; Palmer and Fortescue (2004) used remote sensing, while Dörgeloh (1999) and Van der Westhuizen et al. (2006) reported that the monitoring of the trend and validity of the various assessment techniques is still subject to serious debate. Tainton (1999) provides a brief review of these methods according to the major vegetation types used for livestock production in Southern Africa, viz grassveld, Karoo and savannah (Van der Westhuizen et al., 2006). The veld condition assessment is carried out for the following reasons:

- To evaluate veld condition relative to its potential in that ecological zone. This would assist graziers in making decisions, for example the need to adjust stocking rate;
- To evaluate the effects of current management practices on veld condition and to monitor changes over time; and
- To classify the different vegetation types on farms and quantify their condition.

In his research Stevens (1999) found that there appeared to be a lack of objective veld monitoring techniques with those that are available being of little practical use for stock farmers, and also contributing to veld deterioration in South Africa. However, veld monitoring is essential and, at present, it is moving from its theoretical and academic base to a more practical stage. The natural pasture has an inherently low capacity for animal production while the grazing systems applied on the veld, the method of grazing, recommended resting period and stocking rate are all critical for good veld management. Du Toit (2003) reported that farmers and researchers continue to be confused about the meaning of veld management concepts, particularly stocking rates, grazing capacity, carrying capacity and biomass. However, despite these limitations, veld management will be discussed based on the information available.

Grazing systems

- *Continuous:* This is a type of management system in terms of which growing animals are placed in a camp when the forage is first ready to graze /browse, at the start of the growing season. These animals, or their replacements, are left in that camp for the entire grazeable/ browseable period of each year. O'Reagan (1994a) reports that continuous grazing has been widely condemned as it deemed to be responsible for widespread veld deterioration and soil erosion. The system allegedly allows area and species selective grazing, thus leading to a decline in the vigour and the eventual death of preferred species. Initially, animal performance may be high, but production allegedly declines with time owing to the inevitable range deterioration associated with this system.

- *Rotational:* This type of management system requires that the grazing allotted to either a group or groups of animals for the entire grazeable period be subdivided into at least one enclosure more than the number of animal groups. This system involves the successive grazing of these enclosures in rotation so that not all the veld is grazed simultaneously. Consequently, rotational grazing involves a greater animal concentration than is characteristic of continuous grazing. O'Reagan (1994b) reports that it is the only system capable of maintaining long-term veld and animal production, and it is recommended for all veld types. However, according to Stevens (1999), the principles underlying rotational grazing are contradictory. Forbes and Trollope (1991) recommend that the rehabilitation of the veld through the implementation of rotational grazing and resting systems is the best option in the communal areas
- *Multi-camp system*: This system is defined as a system involving eight or more paddocks per group of animals. The system has been used as a means of vastly improving the vegetation productivity and associated animal production normally achieved under pauci-camp systems, while avoiding the perceived shortfalls of the latter. The logic behind this system is that, by increasing camp numbers, the period of occupation is minimised and the grazing of regrowth is avoided, while the period of absence is maximised, thus giving desirable grass species an extended rest period (O'Reagan and Turner, 1992)

O'Reagan and Turner (1992) report that continuous and rotational grazing or pauci- and multi-camp systems differ slightly in terms of their effects upon range condition or animal production.

Kreuter et al. (1984) reviewed rotational, continuous and multi-camp grazing systems and indicated that each grazing systems would be expected to have its own optimum stocking rate. Barnes and Denny (1991) report that continuous grazing leads to veld degradation. However, in the long term, the poor placing and distribution of watering points, faulty alignment of fences and overstocking may have deleterious consequences which are independent of continuous grazing. In addition, heavier stocking rates may be applied under rotational grazing without veld deterioration occurring.

Continuous grazing is responsible for widespread range deterioration, while rotational grazing is reported as the only system capable of maintaining long-term range and animal production (O'Reagan and Turner, 1992). There is a general belief that the rotational grazing of the veldand, more especially, multi-paddock rotational grazing, is invariably advantageous in comparison with continuous grazing (Barnes, 1992).

Morris (2002) reported that research has not demonstrated beyond doubt the superiority of any grazing system (continuous grazing or rotational grazing) over another. In addition, the type of grazing system that is applied is of less importance for the maintenance of veld and animal productivity than other management factors, such as time of grazing after a burn and stocking rate. Vanton (2001) is of the opinion that leading experts advised livestock farmers that continuous grazing with a light stocking rate is the best option.

O'Reagan (1994b) examined and reported on grazing systems in order to determine whether the numerous claims about rotational and continuous grazing are supported by experimental findings. However, the research findings showed that there is no conclusive evidence to show that continuous grazing (as opposed to, for example, not resting) is necessarily inferior to rotational grazing in terms of its effect on the veld. In addition, conflicting research results have been reported on veld management. O'Reagan and Turner (1992) offer the following recommendations concerning future rangeland research in Southern Africa:

- More basic or component research should be conducted in order to enhance the understanding of rangeland systems.
- A stringent peer review process should be conducted throughout the planning, implementation and interpretation of research results.
- All funding should be linked to the publication of the research in an independent, peer reviewed journals.

Resting: This is essential in order to maintain veld condition. Accordingly, resting to allow seeding, seedling establishment and/or the restoration of stored carbohydrate reserves in desirable grass species is recommended for all veld types (O'Reagan and Turner, 1992; O'Reagan, 1994b). The effects of resting are summarised in Table 2.10. According to Tainton and Danckwerts (1999), the resting objectives may be broadly classified into two types, namely, resting based directly on short-term animal performance, without any consideration as regards the effect of these animals on the veld, and that designed to benefit the veld, in the short term, have little benefit on the animal production.

Kirkman (2005) researched resting veld and the way in which it affects subsequent growth. The results showed that rotational grazing treatments are the most stable, even at high stocking rates, while resting for a full growing season may enhance vigour. Du Toit (2005) and the Central Bureau (1990) are both in agreement with the suggestion to rest or to move cattle off the veld every few years to allow the grasslands to regenerate. Billet (2002) stresses the importance of periodic resting of veld from grazing in order to ensure optimal palatability. Morris (2002) reported on recommendations for the management of fire in the humid grasslands. In terms of these recommendations judicious burning is considered to be vital for maintaining the composition and vigour of the veld, and also necessary in order to boost animal production. He further discusses how to use effective grazing systems and stocking rates to manage cattle and sheep on the veld. According to Morris (2002), dense concentrations of livestock in smaller camps for shorter periods, followed by rest periods of up to 12 months, improves the veld and increases its carrying capacity. O'Reagan and Turner (1992) evaluated the empirical basis for grazing management recommendations for the rangelands in South Africa and concluded that stocking rate has a major impact on both range condition and animal production and that either regular seeding, vigour rests, or rests in order to accumulate fodder, appear to be essential.

Table 2.10: Summary of effects of resting on different veld types (O'Reagan and Turner, 1992)

TYPE OF VELD	RESTING
Semi-arid sweetveld	A third of the veld must be given a full season's rest on an annual basis as a result of the extreme intra- and inter-seasonal variability in rainfall in South Africa.
Sourveld	Resting significantly improved root and shoot growth in the subsequent season.
Semi-arid savannah	Veld condition following a drought recovered more rapidly under resting than under grazing because of the large scale seedling establishment and a reduction in tuft mortality.
Karoo	Prolonged or seasonal resting improved veld condition.

2.2.4 METHOD OF GRAZING

Stevens (1999) reports that researchers are in disagreement about the methods of determining grazing capacity; he believes that there is limited scientific validity as regards the supposed advantages of the periodic resting of veld. Such methods are being propagated extensively in terms of two schools of thought, namely, controlled selective grazing and non-selective grazing, although neither of these has been tested scientifically.

- *Non-selective grazing*: Aims to improve veld condition by forcing animals to graze unpalatable species through the use of heavy stocking densities, while allowing for extended rest periods between defoliation. Grazing is less detrimental to the palatable than to the unpalatable species. In addition, this system improves veld condition and herbage production which, in turn, allows two- to three-fold increase in carrying capacity. However, this statement is in contrast to the viewpoint of Hoffman (2003), who reported that non–selective grazing reduced plant cover and increased erosion, thus leading to further widespread degradation if implemented.

- *Controlled selective grazing*: Aims to maximise the grass production through frequent light defoliations while avoiding the grazing of undesirable species, thus allowing them to became moribund and die. This system is a recommended form of management for most veld types.

The method of grazing (non-selective and selective) is considered to be an important factor influencing the conversion of herbage to animal products (Kreuter et al., 1984). O'Reagan and Turner (1992) also identified non-selective and selective grazing as methods of grazing. Non-selective grazing aims to improve range condition by forcing animals to graze unpalatable species through the use of heavy stocking densities, while allowing for extended rest between defoliations. In addition, non-selective grazing is assumed to be less detrimental to the palatable than to the unpalatable species. Controlled grazing aims to maximize grass production through frequent, light defoliations while avoiding the grazing of undesirable species, thus allowing them to become moribund and die. This system has been recommended as a form of management for most veld types.

The literature review revealed that smallholder livestock owners in communal areas face numerous challenges as regards sustaining livestock productivity in order to improve their livelihoods. It is against this background that a case study of the socio-economic and biophysical complexities of smallholder communal livestock farmers within South Africa has been deemed necessary. The experimental procedures followed in executing this study are outlined below.

CHAPTER 3

EXPERIMENTAL DESIGN AND PROCEDURES

3.1 DESCRIPTION OF THE STUDY AREAS

Two separate sites, adjacent to each other, were chosen, namely, Mara Agricultural Development Centre (Mara ADC) (used as a control) and Muduluni village[3] were used for the purposes of this study. Both these sites fall under the Makhado Local Municipality in the Vhembe District Municipality in Limpopo Province. The mean annual rainfall recorded at Mara reflective of Mudu is 452 mm (measured over a period of 60 years from 1937/38 to 1997/98). Mean daily maximum temperatures vary between 22.6^0 C in June to 30.4^0 C in January. On average, the daily maximum temperature exceeds 20^0 C for 337 days of the year. The vegetation is classified as arid sweet bushveld with *Acacia tortilis* being the dominant species. *Eragrostis rigidor, Schmiditia pappophoroides* and *Urochloa mosambencis* are conspicuous in the sub-habitat between the trees while *Panicum maximum* occurs in association with the canopied sub-habitat under the trees. The dominant soil types include flutter and glenrosa (Dekker et al., 2001). The area is capable of providing nutritious grazing when the veld is in good condition (Tainton, 1999).

The Mara ADC is a government institution administered by the Limpopo Province Department of Agriculture (LPDA) and situated 54 km west of Louis Trichardt (Makhado). It covers an area of 11 000 hectares. Since 1934, research has been conducted into veld management and livestock production. The Mara ADC has a proud history as it played a central role in the development of the Bonsmara cattle breed in the period 1937 to 1954 (Bonsma, 1980).

For the purposes of this study Mara ADC and Muduluni village will be referred to as Mara and Mudu, respectively. Figure 3.1. and Figure 3.2 present maps of Limpopo province and South Africa respectively and indicate the position of the study site.

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[3] *For a full discussion, see the overview of Mudu village in Chapter 4*

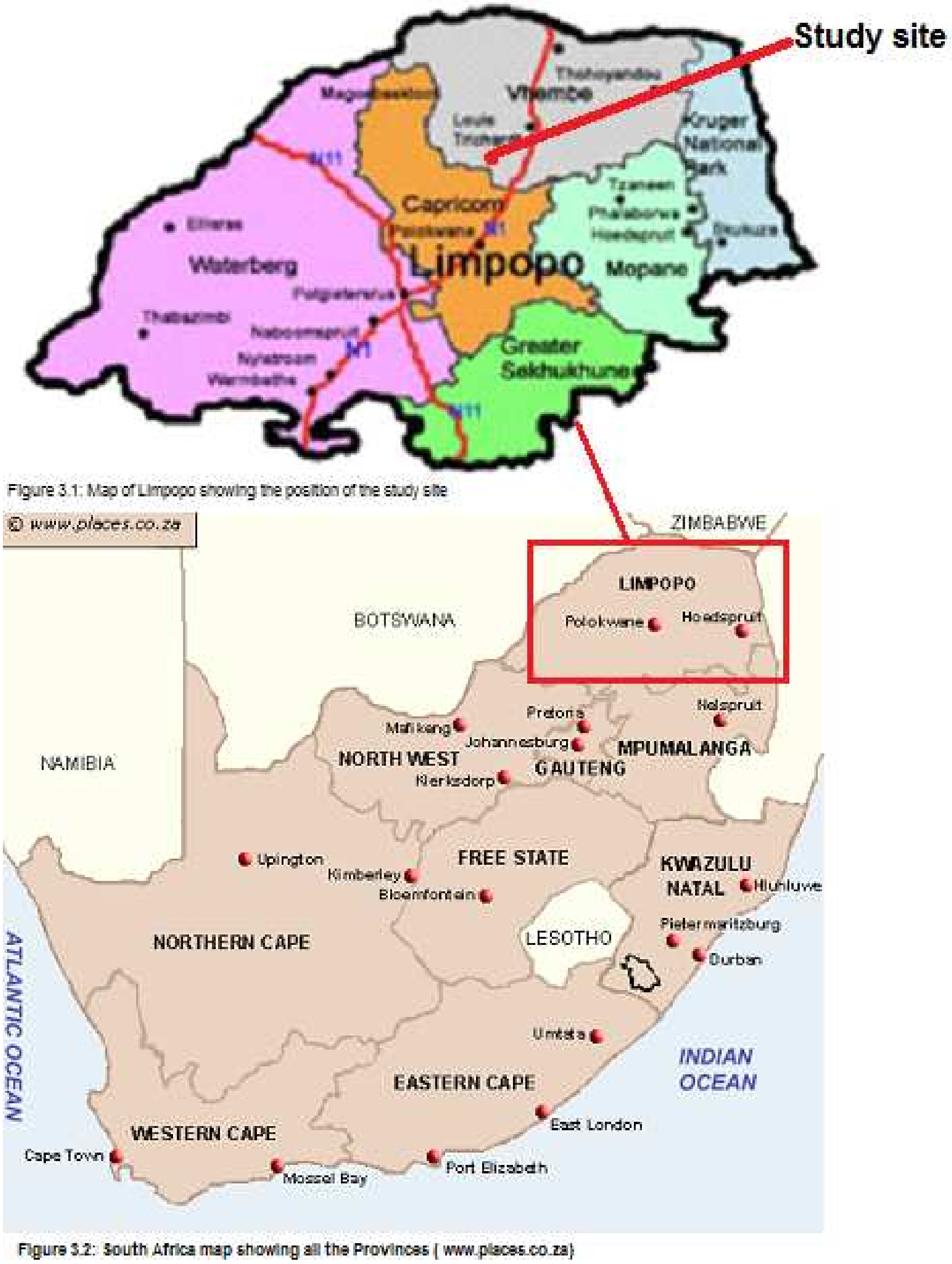

Figure 3.1: Map of Limpopo showing the position of the study site

Figure 3.2: South Africa map showing all the provinces

3.2 COLLECTION OF SOCIO-ECONOMIC DATA

3.2.1 ORIENTATION AND PLANNING

Much of the responsibility for the administration and control of resources rests with the Makhado Local Municipality, although the de facto rules and regulations operating at the village level are centred on the traditional authorities. Accordingly, it was necessary to request the approval of the Chief and Local Headman to conduct the survey. Several meetings were held with the farmers and with their organisation (Kutama Livestock Farmers Association) in order to brief them about the study and its aims so as to be assured of their full support throughout the study.

3.2.2 INFORMATION SOURCES

The information reported in this study was gathered through interactions with residents and farmers through individual household heads. Focus group interviews were conducted during which a detailed, structured questionnaire was administered to fifty small-scale livestock farmers that share a communal grazing area. In addition, the researcher interacted with the ward extension officer and attended the community monthly imbizo (where all development challenges are discussed) which is organised by the Local headman.

3.2.3 THE QUESTIONNAIRE DESIGN

In order to gather the data required to determine the current demography, production systems and socio-economic status of the small-scale livestock producers in the Mudu village area, a structured questionnaire was developed. This questionnaire was adapted from Stroebel (2004) and covered the following:

Household characteristics

Information was collected pertaining to the number of people in the household; the gender and ages of the members of the household, details about the head of the household, the highest level of education of household members, and fluency in English, Venda and Afrikaans.

Knowledge − farming experience

Information was gathered about the length of time the farmer had been farming; whether he/she farmed either full-time or part-time; when he/she had started farming on the present farm; how long ago the current enterprise had been started, details about the farmer’s other work and experience, total household income per month; income from farming activity per month and arithmetic ability of the farmer.

Farm information

This information focused on the following:

Who owns the land, Size of the farm; is the farm fenced; herd structure as regards numbers and ages of animals(cows: number of cows that have calved before. heifers: young females which have not calved before, bulls, steers), breeds of cattle, reason for choosing particular breeds, other species of animal raised, what types of animals, reasons for farming; does the farmer raise crops; what type of crops and the extent in hectares, what happens to the crop residue; how is the residue fed to the stock; any other supplements provided; under what conditions are supplements used, labour employed; permanent or temporary; total number of temporary or permanent labour; how are labourers paid; and total monthly amount paid to labourers.

Production and management information

Biological

This information focuses on records kept for animals; the kind of records kept; identification of animals; age at which heifers first calve; number of females which calved last year, how many had calving difficulties or problems; cause of calving difficulties; intervals at which females calve; are weights of new born calves taken; calves weaned or not (natural weaning); reason why calves are weaned; when is the weaning period; and how many calves were weaned or separated successfully last year. It is important to note that there is no set breeding and calving season in the area

Natural resource and environmental issues

This includes type of veld on which the animals graze; do they graze on planted pasture; size of the grazing veld/planted pasture, present status of the veld compared to when the farmer started farming; when did the farmer start farming; existing knowledge of the carrying capacity; number of hectares required to graze one cow with one calf per year for optimum production; measures taken to ensure adequate feed supply during winter and periods of feed shortage, and whether animals graze on the same veld all year long or are they moved. If moved, on what is the decision based? Are there any signs of erosion? If yes, how severe is the erosion; what caused the erosion and is any attempt being made to prevent/control the erosion.

Production risk reduction

This information pertains to the following. Whether the farmer had any form of insurance against theft, loss of income etc. Whether the farmer implements any external, internal, disease control or vaccination programmes? If so, which remedies are used and how often? Are the animals sheltered at night? If yes, what type of shelter is provided? How often does the farmer see an extension officer; does the farmer travel to see an extension officer or does the extension officer visit the farmer? Are the services of a veterinarian or a surgeon used? Does the farmer travel to the veterinarian officer/veterinarian clinic or does he/she visit the farmer? If veterinary services are not used, reasons. Sources of information which the farmer uses in his/her day to day decision making on the farm; the extent to which the farmer relies on the advice and assistance of his/her neighbours, the extent to which the farmer relies on the advice and assistance of his/her extension officer. The type of bull used for cattle breeding; does the farmer make use of a breeding season or does he/she allow the males to run with the female stock, when is the breeding season. The number of animals which died the previous year and the causes of the deaths.

Marketing management

This information pertains to the following: The markets available which are within an accessible distance from the farm; type of marketing system used when marketing livestock; livestock products offered for sale; for what reason the livestock products are sold; methods used in milking the cows; how many cows were milked last year; when are the cows milked; how often is the milk and meat sold and how often per year the sales are organised. It was established from the study that the community never keeps records. Accordingly, it was extremely difficult to assess this aspect.

Economic viability

This information dealt with the following: Total amount of money spent on the farm last year; total amount of money obtained from livestock and livestock products sale during the previous year; and any other income besides from that derived from farm activities. If yes, name these sources of other income.

Social acceptability

This information pertains to the following: Whether the farmer is happy with his/her family? If not, give reasons. Has the farmer borrowed money to finance the farming activities? If yes, indicate source, amount borrowed; interest rate and monthly payment. Farmer settlement or far from the town and services. Problems the farmer experiences with neighbours/community as a result of his/her farming activities. Establish whether the farmer is happy with the progress he/she has made with his/her livestock business.

3.2.4 STATISTICAL ANALYSIS

The data analysis was performed using the Statistical Package for Social Sciences (SPSS), the Windows version for frequency tables, descriptive statistics (mean, median, standard deviation, etc.) and cross tabulations. Mathematical calculations were performed on certain data in order to obtain summary statistics.

3.3 ESTIMATING BOTANICAL COMPOSITION OF THE VEGETATION

3.3.1 SAMPLING OF VEGETATION

The point-centred method of Heyting (1968) was used in order to sample the vegetation. Accordingly, a quarter quadrate of $1m^2$ was made of thin iron poles (droppers) welded together.

The two grazing areas were visually surveyed to identify possible sites for data collection. The communal veld was characterised by variation as a result of the impact of human activity and this made it impossible to take the plant communities only into consideration in identifying the site location. The aim of the survey was to include most of the major impacts that human activity had had on the site. These include distance of the site from the watering point, fallow land, distance of the site from the kraal, pioneer condition of the veld, removal of firewood and soil gradient. Three sites were identified on both systems. These sites all included as many of the abovementioned variables as possible. Once the areas that include all above-mentioned differences had been identified, the sites were chosen at random.

On the other side of the dividing fence (between Mara ADC and Mudu), the area that had been grazed during the period of sampling was surveyed. It was found that this entire area of veld was characterised by the same plant community. As a result, one camp − No. 135 − was targeted (see Figure 3.3). This camp had been grazed at the time when oesophageal and rumen samples were taken and would, therefore, represent the grazing material available. Three sites were identified at random.

Each of the six sites was marked out using natural marking posts (trees). Each site comprised an area of approximately 2500 m^2. All the sampling took place within these demarcated areas.

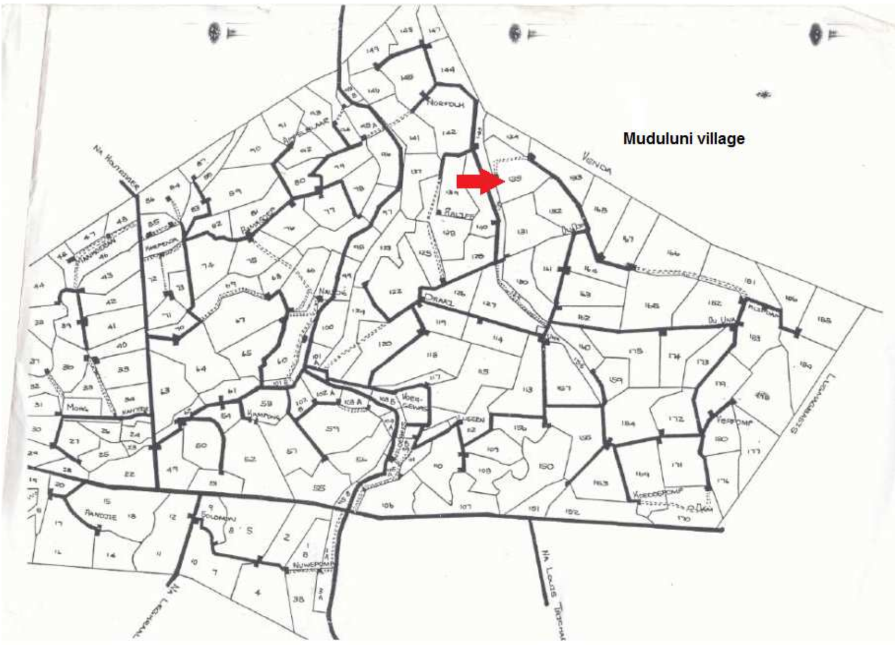

Figure 3.3: A map of Mara ADC with camp no 135 indicated by an arrow on the map. The map also shows the adjacent Muduluni village area that borders Mara ADC

Sampling was initiated at a specific corner of the demarcated site which had been identified. The quarter quadrate was thrown randomly by hand in the direction of the opposite corner of the site (simple random). Sampling took then place at every spot where the quadrate landed. The same procedure was repeated in visually estimated strips over the entire sample site until sampling had been conducted at 100 spots.

Two assistants threw the quadrates simultaneously but one person only identified the species and supervised the data collection process. The same sampling procedure was carried out on all of the six sample sites. At every sampling spot data collection took place as follows:

- The quarter quadrate was placed firmly on the soil surface if a tufted grass or branch had prevented a firm landing on the grass layer (soil surface). In every quarter of the quadrate, the grass species closest to the centre of the quadrate denoted the data collection point. The species was identified and noted.

- The next step involved determining the density of the grass layer. One of the quarters had been marked beforehand as the quadrate which would be used to count the number of grass plants at each sampling site. The grass plants were then counted in the specified quarter (Quadrate size: 8.8625 m^2). The same procedure was repeated until sampling had been conducted on 100 points on each site.

- The grasses were classified as palatable, intermediate and unpalatable, in accordance with Trollope (1990) and Van de Pol (2004). The weighted palatability composition (WPC) was calculated for each study area and this was then used to determine the carrying capacity of the two study areas, as described by De Beer (1990). The weighted palatability composition of the two sites was then tested for differences using the t-test (Mendenhall et al., 2006).

3.3.2 ESTIMATION OF CARRYING CAPACITY

Using the method described by Hardy et al. (1999) and De Beer (1990), the grazing capacity, major plant communities and the weighted palatability composition (WPC) were determined. This method is now briefly described in terms of each system (Mara and Mudu):

- The percentage occurrence of each grass species in the system was determined.

- The grass species identified were classified into three classes, namely, palatable, intermediate and unpalatable, according to Trollope (1990) and Van de Pol (2004).
- The percentage occurrence of each species in each of the three classes was multiplied by 3, 2 and 1, respectively. The total values obtained were multiplied by 0.33 to convert these values to the maximum possible value, namely, 300 (100% palatable grasses x 3 = x value).
- The X-value obtained above should be in the scale of 33.3 to 100. Therefore, WPC = 1.5 (x –33.3).
- The WPC value should be read out from the figure proposed by De Beer (1990) in order to determine relative grazing capacity.
- The base value grazing capacity of the two sites was calculated.
- Grazing capacity = base value grazing capacity of the system − ha/LSU x RGC = ha/LSU.

3.3.3 STATISTICAL ANALYSIS

Descriptive statistics and a frequency analysis were obtained for the botanical composition data and the weighted palatability composition of the two sites was tested for differences using the t-test (Mendenhall et al., 2006). The details of the calculations are shown in Annexure 4.

3.4 DETERMINING THE CHEMICAL COMPOSITION OF THE VEGETATION

Prior to commencing the trial, the Kutama Tribal Authority was contacted and briefed in order to seek its approval and support. In terms of the trial, rumen and esophageal operated animals, which need extra care and supervision, were to be released from Mara to the Authority’s communal area (Mudu) to graze together with the animals already there. This was something new to the community. The community responded well and gave their full support throughout the trial.

3.4.1 CANNULATED ANIMALS

A total of 12 fistulated Bonsmara steers were used for this experiment. The surgical procedures, anaesthesia for the cannulations and the experimental steers were approved by Onderstepoort Veterinary School (University of Pretoria) under the leadership of the late Prof van der Walt, Head of the Animal Section. The steers were all 18 months old at the start of the experiment. Each study area was allocated six steers. Of the six steers per study area, three steers were fitted with rumen cannulae while the remaining three steers were fitted with oesophageal cannulae. Bags were fitted to the oesophageal steers before collection started in order to accustom the animals to the extra burden (Koster et al., 1992).

Fresh, clean water was always available. The steers were dosed for internal parasites and regularly dipped for external parasites.

After surgery, the fistulae were opened and cleaned at least every second day with Acriglvine glycerine and cotton wool so as to facilitate the healing of the wounds. During sampling, the fistulae were opened, fingers were inserted to remove any ingested material which may become stuck, and Supona sprayed on after cleaning.

The fistulated animals were inspected daily to ensure that the rubber plugs enclosing the fistula were still intact and to avoid excessive leakage of fluid, especially under free range.

3.4.2 DATA COLLECTION

Samples from the fistulated steers

Prior to sampling, the three oesophageal fistulated experimental steers and the three rumen fistulated experimental steers for the Muduluni village site were introduced to the grazing two weeks before sampling so as to enable adaptation. This was not done during the drought period − July, August and September − when the period was reduced to three days only before sampling and left until the end of the sampling which lasted for eight days, that is, from Monday to the following Wednesday, a week later. Thereafter, the experimental steers were returned to Mara ADC. Samples were collected seasonally throughout the experimental period between 07h30 and 09h30. Summer consisted of November, December and January, autumn consisted of March and April, winter consisted of May, June and July and spring consisted of August, September and October. The experimental apparatus, namely, collection bags, Dacron bags, etc. were obtained from the University of the Free State.

Oesophageal fistulated steers

The six oesophageal fistulated steers (3 for each area) were used for the collection of herbage samples on a monthly basis (Brand et al., 1991). The steers were fasted overnight prior to sampling so as to minimise the possibility of regurgitation during sampling, all contaminated samples were discarded and fresh samples obtained the following day. Fresh, clean water was always available during the fasting periods. The fistula plugs were removed in the morning and the collection bags were tied in place.

These steers were herded to where the remainder of the group were grazing and they were allowed to graze for 20 to 30 minutes only as a longer grazing period may have resulted in fistula shrinkage.

The experimental steers were herded from the veld to the crush pen and the collection bags were removed. The excess saliva was carefully extruded from the samples through cheesecloth (Beck et al., 2007; Kosteret al., 1992; Meissner et al., 1996). Any samples showing excessive quantities of saliva or contamination with regurgitated material were discarded. Three consecutive days were required to constitute an “experimental day” (Brand et al., 1991; Meissner et al., 1996). The samples were dried in a force draught oven at 50 C (Coblentz et al., 2002) after which the samples were ground in order to obtain a homogeneous sample and to minimise the effect of mastication. The ground samples were placed in an airtight container to fill in the Dacron bags for further chemical analysis (AOAC, 1998) and NDF (Van Soest and Robertson, 1985). Residual N was then determined using the macro-kjedal methods.

Rumen fistulated steers

- *Rumen fluid*

The sampling of rumen fluid took place over the period during which the OF samples were collected. Approximately 200 ml of rumen fluid which had passed through cheese cloth was collected from each of the eight rumen fistulated steers on two consecutive days. This fluid pooled and preserved with 1 ml H_2SO_4 for NH_3

concentration analysis. The samples were kept in sealed plastic bottles and frozen in order to prevent any loss of ammonia.

- *Dacron bag*

On day five of sampling 5g of DM was accurately weighed into each Dacron bag (Van der Merwe et al., 2005, Ogden et al., 2005: Huntington and Givens, 1995). Thereafter, the Dacron bags were placed back in the oven until day six of sampling. On day six of sampling, the Dacron bags were removed from the oven, cooled off in a desiccator and weighted.

Thereafter, four Dacron bags were incubated in the rumen of each steer for a period for 24 hours. The bags were guided by small, metal stainless steel weights attached to a string and fixed to the screw–in plug of the cannula (Trinacty et al., 2003; Ramsay et al., 2001). The same bags were placed in the same rumen steers throughout the trial period (Trinachty et al., 2003).

These bags were removed at the same time so that they would all be washed simultaneously (Taghizadeh et al., 2005). The bags were placed in a bucket filled with cold water to terminate fermentation/ microbial activity (Holtshausen and Cruywagen, 2000; Van der Merwe et al., 2005; Okello et al. 2005), and rinsed under running tap water until the rinsing water squeezed from the samples was colourless and clear (Smith and Vosloo, 1994). The washed Dacron bags were dried to constant weight at 50^0 C for 24 hours (Coblentz et al., 2002). The following morning the Dacron bags were removed from the oven and placed inside a desiccator to cool off. The bags were then recorded and residue weights were taken in order to calculate the dry matter disappearance (Manyuchi et al., 1997; Okello et al., 2005).

3.4.3 STATISTICAL ANALYSIS

Data from the chemical composition of the oesophageal samples, dry matter disappearance from the Dacron bags and rumen ammonia concentration was analysed using the SAS statistical package. In addition, models were used that accounted for variations as a result of site and seasons, and their interaction in the PROC GLM procedure. Where significant effects were observed the means were separated by using the PDIFF facility of SAS. All the data analyses were performed using SAS (2002 to 2003).

CHAPTER 4

RESULTS

4.1 SOCIO-ECONOMIC ASPECT

This chapter describes the general characteristics and profiles of the sampled small-scale farmers' households in Muduluni village in Limpopo province. The primary data were collected using a questionnaire while the secondary data were obtained from the entire Muduluni community, livestock association members, the local community secretary, two women residents of Mudu nominated by the local headman to accompany the field workers, extension officers, enumerators (field workers), local headman, personal observation, focus group meetings and discussions, and key informants input.

The household characteristics, knowledge in terms of farming experience; farm information; production and management information which includes biological, natural resource and environmental issues; production risk reduction; economic viability and social acceptability are presented in this chapter.

However, there was a challenge in that many of the farmers, despite agreeing to complete the questionnaires, were uncomfortable with some of the questions and were, in fact, not prepared to answer them. In addition, the livestock farmers in the area were mainly older men, with little education, with very few women and younger men taking part in livestock farming. Working with the community proved very difficult, despite their having been briefed about the survey and the visiting schedule. In many instances, the enumerators had to wait around for people or even reschedule the visits. There were a few instances where farmers refused to be interviewed; however, after talking to them and proposing to call in the local headman to intervene (because he had granted us permission to conduct this survey) they agreed.

4.1.1 MUDULUNI VILLAGE OVERVIEW

Muduluni village, located 33 kilometres west of Makhado − previously known as Louis Trichardt − falls under the Kutama Local Council. The village is characterised by communal grazing on unimproved pasture, with some of the land under cropping and some comprising village settlements Muduluni village started in 1962 when the Land Tenure system came into effect. Prior to that date, people lived in disorganised settlements with people building homesteads in these settlements where they deemed fit. However, with the introduction of the tenure system, a more linear type of settlement emerged. The village had originally had a small population, comprising a few households, but the past three years have seen the population increasing from 3089 in 2008 to approximately 6500 in 2011. The area is subdivided into six blocks. There are three schools in the village: two primary schools, Mbabada and Muduluni, and one secondary school, Kutama.

Vegetation

Natural veld is the main source of livestock feed. Grazing in the area is communal shared and, as a result of the high stocking rate pressure and the resultant degradation in the area, the climax vegetation has been replaced by unpalatable species which are at lower levels of the succession ladder for example, *Tragus berteronianus*. The tree layer consists of the Acacia species that encroached on the area and which has coppiced vigorously because of the harvesting of fire wood by the community. The grass is palatable and sweet.

The people of Muduluni are the proud custodians of a rare species of tree endemic to the village. The tree is known by its vernacular name, Mudulu. It is evergreen and provides shade for people, livestock and other wildlife throughout the year. The village name was derived from this tree. The tree, however, is under constant threat of being wiped out as a result of the overexploitation for firewood.

Water and soil

There is a shortage of water in the area and the water is brackish. The infrastructure provided by government, for example, drinking troughs and windmills, has either been vandalised or is broken as a result of a lack of proper care and maintenance.

Running water is also an issue, as the community depends on communal taps which they share. One tap is expected to cater for at least four households. It is a common sight to see people doing their washing around these taps, which poses a health hazard to the villagers. The issue of water remains an immense challenge, as most people are forced to buy water from those who own boreholes. Almost two-thirds of the community have boreholes. The domestic use of water includes bathing, cooking and washing. However, it is expensive for families in the village to sustain their way of life. Originally there were boreholes available for public use but these are no longer working. Domestic animals get their water from a single dam − Mbabada dam. The local municipality has built two reservoirs to supplement the water shortage.

Legal or tenure grazing right

There are no legal or tenure grazing rights and, thus, anybody living in the village is allowed open access to the land. At present, there is no system of application for grazing rights in place; nor is there an administrative body overseeing the allocation of grazing rights.

Role of the Local Headman and the council in the management of grazing

The role played by the Local Headman and the council in the management of grazing is minimal. The central role of the Local Headman in the local community involves mainly the following:

- residential matters (allocation of land for housing, schools, businesses etc.)
- overseeing of livestock and crop production although not effective
- other social and physical needs of the community
- resolving households matters and referring some of these matters to the local law enforcement agency.

Farmer cooperative

At present there is no farmer cooperative although it is possible to obtain veterinary equipment and remedies in the nearby town of Makhado.

Role of men in livestock farming

Livestock production activities, including herding, treating diseases and castration, are dominated by males. During the meetings held with the community, men tended to dominate the discussions on all aspects related to livestock, whereas the women tended to focus on small livestock (goats and chickens) issues.

Role of women in livestock farming

Women, however, do play a fairly important management role in the livestock farming of their own and their husbands' animals. However, in many cases, this involvement is not of their own choice but as a result of the deaths of their husbands or other relatives. The handling and sale of animals, thus, place an additional burden on the shoulders of women farmers and, in some instances, social (sexual harassment) and criminal activities (being robbed) pose a definite problem. Many women farmers expressed the need for hands on training as regards animal husbandry.

Youth

At present, the involvement of the youth in livestock farming has been under pressure from their parents while they are still at home only but, once they leave home, this involvement is not maintained and, thus, future farmers are not being trained.

Type of farming

Cattle and crop production are the main farming activities in the area. Accordingly, the area is divided into grazing and crop production fields. However, the majority of the farmers prefer livestock farming to crops.

- *Crop production*

The weather conditions prevailing in the village influence both the type of crops which the people are able to grow and the type of livestock which they rear. The soil type and weather are more suitable for the growing of sorghum. Historically, sorghum has been the staple food of the area but, because its preparation into mealie meal is labour intensive, people have switched to growing maize. However, sorghum had the advantage of being drought resistant which meant that people were always to reap something, irrespective of the amount of rainfall. The problem with maize is that it is not drought resistant. Smallholder farms are located throughout the area, and are characterised by low levels of productivity. Production is primarily for subsistence purposes, with little marketable surplus However, the farmers are in the process of initiating an extensive sorghum project.

However, as a result of both drought and the low rainfall in this area, the sustainability of crop production is decreasing.

Between 1999 and 2002 a group of women mobilised among themselves to form an irrigation community project concentrating on cabbages, spinach and maize. However, this project was short-lived because the group was not able to afford to pay for electricity and water tanks while the motor for the water extraction machine was stolen and the whole irrigation system vandalised.

There used to be an agricultural scheme next to Dropriver. The extension officers used to assist the community with information on farming. However, the project collapsed as a result of the theft of the cable which was used to pump water. During 2007, the chief had identified an individual to run the scheme but the community refused to accept the man on the grounds that there had not been sufficient consultations with the the community. The dam is now used for fishing.

Currently those people who still practise crop production are doing so in their backyards – 50 m x 50 m stands. However, the stands are now being reduced to 30 m x 40 m as a result of a municipality cost saving strategy when connecting water or electricity services, that is, shortening the distance from one household to another. In this way, there is a saving on electrical cables and water pipes. Spinach, tomatoes, sweet potatoes and onions are the most popular crops planted although these crops are produced mainly for home consumption with the surplus being sold to hawkers.

- *Livestock production*

Cattle and goats are major livestock animals in the village. Other domestic livestock in the village include sheep, pigs, chickens and donkeys. The cattle owners are mostly elderly male group. A number of women act as farmers on their husband's behalf when the husband has immigrated to town to seek employment to supplement their living and young professionals who are part-time with interest to become full-time farmers provided they could obtain the extra land needed to farm.

There are several reasons why the number of households that farm with livestock is declining. These reasons include livestock theft. It is not always possible, especially during winter, to keep an eye on the stock since this time of the year they range freely, road accidents and the punitive consequences to the owner of the animal, drought, diseases, lack of support from the government, and so on.

The livestock farmers in the community indicated that they had opted for livestock farming because of either pension money they had received, income from employment, or an inheritance from parents had enabled them to become livestock farmers. Most people keep cattle simply because they were able to afford to buy them. However, there are some people who do not want to farm but keep cattle merely as a backup plan. Most of the professionals and others working in the cities own cattle which they leave back at home in the village.

Livestock farming in the area is practised for the following reasons − financial security, as a symbol of wealth, status or pride, payment of school fees, draught power, transport (donkeys), home consumption (if an animal is slaughtered, it is common practice to share it with neighbours and relatives), for customary events such as traditional rituals and celebrations, lobola, funerals, weddings, dung for floor polish, hides used for decoration, and the covering of the drums used at traditional dances and at churches .The cattle are not used for lobola but the cash proceeds from the cattle are used .

- *Livestock association*

The livestock association is, at present, involved in the management of grazing, but its activities should be extended to include other aspects such as health management, veterinary services, drought feeding, livestock improvement and livestock marketing.

- *Different kinds of livestock*

Goats: Goats are becoming extinct as a result of the Indians who are buying them for slaughtering purposes. Goats are used by the community mainly for ritual purposes, for example, during burial a black goat has to be slaughtered for the deceased person. Goat milk was also used for babies as a result of the belief that goat milk is highly nutritious compared to cow's milk. The goat hides are sold to traditional healers and are also used as house mats.

Pigs: Pig farming not very popular because certain sections of the population such as the Lembas (Venda clan), do not eat pork meat because of their religious beliefs while some Christians also abstain from eating pork. Pig oil is used for medicinal purposes for example, earache and coughing in babies. Pork is the cheapest meat available and is usually sold among the locals.

Sheep: Sheep farming is limited to two households only and is, therefore, very rare.

Donkeys: These animals play an extremely important role in the lives of this community. They are used for the following purposes:

- Water collection
- Collecting wood
- Transporting people, especially during social grant payouts, and to clinics
- Own ploughing as well as contract ploughing.

- *Stock theft*

According to the farmers, stock theft is matter of grave concern with farmers claiming that the stock thieves are people from the community itself or neighbours stealing for the local butcheries. They also maintain that neighbouring white commercial farmers steal their cattle. They claim that these farmers brand these stolen cattle, thus making it impossible for community members to identify their animals because they do not brand their animals. The lack of fencing around the grazing areas and increased levels of poverty because of unemployment also lead to stock theft. Community cattle are not supervised and, thus, they stay in the veld with no fulltime supervision. They are checked only when the owner gives them water, but this does not happen on a regular basis as there are small dams in the veld. Accordingly, the owner may stay away for two to three weeks, not knowing the whereabouts of his/her cattle. Regular checking happens only when there is a drought because it is only then that the livestock farmers realise that their cattle are in need of more water.

- *Livestock mortality*

Livestock mortality is linked mostly to drought, animal diseases, road accidents and the subsequent shortage of grazing material.

- *Grazing management systems*

Continuous grazing is practised because the grazing area is communal. The continuous grazing system entails grazing animals in designated grazing areas throughout the year and kraaling them at night. The schoolchildren of the livestock owners are mostly in charge of herding these animals after school. The herds are allowed to graze freely away from the homesteads. However, this system of management tends to lead to over-grazing and it may also lead to problems as regards the proper management of the resource base (natural pasture). This, in turn, leads to a high stocking rates and, thus, reduced feed availability and subsequent depressed animal performance.

Breeding systems

Generally, there is no specific breeding season in the area with the bulls running with the cows all year round, resulting in improper, unspecified calving periods. Many farmers do not buy their own breeding bulls and depend on bulls from other livestock farmers. This, in turn, results in no specific breed of cattle. The majority of the cattle are mixed breeds. In addition, the selection and culling of any breeding animal is the sole responsibility of an individual owner. However, a number of “genetically superior” bulls were donated to communities throughout Limpopo Province by the South African government, including this area. These bulls were to be owned and used by the respective communities in order to upgrade their breeding herds. It is significant that this introduction of exotic bull breeds into the communal areas were not the decisions of the farmers affected. The communal grazing system results in the unplanned cross breeding of cattle with the farmers having no say in the breeds they would prefer. Accordingly, the farmer does not always handle an ever-changing genotype he/she has planned for, nor that he/she has the financial capacity to manage. The introduction of new strains has eroded the indigenous genotype base – a genotype base which is known to be adaptable to the communal area environment. It is also unfortunate that no studies or evaluations were undertaken to assess the impact of this exercise.

In addition, calving is not predictable. There is no specific mating period, and the cows and heifers run with the bull throughout the year This, in turn, results in uncontrolled calving throughout the year.

Routine management operations

Routine operations such as *castration*, dehorning, branding, dipping, record keeping and inoculation are practised in livestock management systems, but with varying degrees of modification and adaptation. Castration is carried out mainly to ensure docility in oxen and is carried out much later in life. Animals of up to two years and more are castrated. The most commonly used method of castration involves cutting the vas deferens with a burdizzo or using a knife and salt. However, most farmers choose not to castrate their male animals for the following two main reasons. They view castration as cruelty to animals, and are also afraid to reduce the numbers of their cattle. On the other hand, dehorning is also not widely practised. However, in most cases, if carried out it is done at less than six months old. On the whole, livestock owners do not feel it is necessary for them to do branding as they do not participate in the formal market. Dipping used to be compulsory and was carried out at Manavhela village which is adjacent to Muduluni village on Fridays and was sponsored by the government. Nevertheless, there are those who decided to dip their animals on their own after the government cut the subsidy in 1999. However, many of the poorer farmers are unable to do the dipping themselves after the government cut the subsidy. Accordingly, there are now a few farmers only who are able to afford to buy the chemicals to do their own dipping and thus the majority of the cattle in the area are not dipped.

Animal records

In general, the animals in the area are not weighed and no records are kept, except for unreliable records reflecting the number of animals owned by the livestock farmers. These records are compiled with the assistance of local animal health technician and are not updated.

Health management of livestock

As far as health management is concerned the Government Veterinary Services do not offer veterinary services in this area. Accordingly, each livestock farmer buys his/her own medicines with which to treat sick animals and vaccinate, inoculate and dip the animals.

Livestock feeding

From a technical point of view, insufficient feed supply, in terms of both quantity and quality, is the major cause of poor livestock production in this area. Winter or the dry season is the time when the feed is in shortest supply. There is almost no supplementary feeding taking place in the area, with the farmers citing a lack of funds and the relative low importance of commercial production as regards the cattle herd as reasons. After harvesting, the animals are allowed to forage randomly on crop residues in the arable areas. Cattle are usually sold in an unprocessed state, straight from the veld.

Drought management systems

Drought is a natural phenomenon although, unfortunately, farmers have not learnt either to live with or to plan for this phenomenon. Each drought occurrence is viewed as a new occurrence as the farmers panic and seek drought mitigation strategies. The course of action chosen depends on the farmer’s circumstances, that is, resources at his/her disposal, severity of the drought and market availability. However, it would seem that a “do-nothing” approach continues to be the usual strategy adopted by all farmers. This, in turn, often results in the deaths of large numbers of cattle.

The community often experiences difficulty in accessing drought relief because of administrative problems. While some areas receive drought relief in the form of fodder and other inputs, this particular community does not enjoy such privileges. Farmers claim that the subsidised fodder meal is delivered to the veterinary office in the neighbouring village and is supposed to be shared. However the office gives priority to its own farmers.

Veterinary and extension services

The farmers feel overlooked by government. This stems from the fact that they are of the opinion that veterinary services in the area are non-existent and that this, in turn, results in the high cattle mortality rate as they do not possess the knowledge required to manage animal diseases. Government had envisaged at least one extension officer or veterinary officer per village/ward but it would appear that this has, in fact, not happened. The nearest veterinary services are more than 3 km away from the village while the extension officer allocated to the area is non-functional.

Marketing

- *Livestock*

The lack of information and training means that farmers often fail either to market their products properly or to access the formal markets. This may be attributed to the fact that there is no extension services offered to these farmers while this, in turn, has resulted in the farmers trading between themselves. The farmers, thus, practise informal trade and this prevents them from rising above subsistence farming. One of the main reasons why farmers sell their stock is the need to address financial household problems, including funerals, weddings and school fees. Accordingly, the farmers lose interest in pursuing farming because it is not perceived as economically viable. In addition, the farmers in the area are reluctant to brand their animals, thus making it difficult for their animals to be sold through auction. Cattle are, thus, sold to the butcheries or among themselves. In most cases these animals are sold when they are too old and they fetch low prices.

- *Crops*

A few of the families have small backyard gardens in which they produce cash crops such as tomatoes, vegetables, onions, and so on. These crops are mainly for home consumption and, in case of surpluses, are sold to neighbours and hawkers.

Grazing area

There are certain individuals who do still keep livestock although their number is decreasing as a result of unfenced and overgrazed camps .There are two camps only available and the fences are not in a good condition. The fencing is maintained by the community on its own with the community relying on monetary contributions or else approaching the local municipality for assistance. However, the latter is often a lengthy process.

The grazing areas are becoming smaller as a result of the growing demand for residential sites because of the population explosion. It was clear from the discussion with farmers that they are not willing to reduce their stock numbers, even during times of insufficient grazing. In addition, because the grazing area is communal, there is no set grazing pattern. This, in turn, has led to both the poor maintenance of the infrastructure, for example, fences and to poor land management systems. The latter means that rotational grazing in order to avoid overgrazing is not being practised. On the other hand, as a result of the lack of maintenance on fences, cattle roam around on main roads, causing accidents. In addition, the number of livestock is not restricted and farmers have no idea what the village natural pasture carrying capacity is. Accordingly, as a result of all these factors which lead to overgrazing, some of the animals starve to death, thus causing major financial losses for the farmers. Plant invaders are also on increase because of overgrazing.

The fact that cattle numbers are not controlled leads to overgrazing. Nevertheless, the numbers of livestock owners as well as livestock numbers are both decreasing. One of the contributory factors to the fact that livestock numbers are decreasing is that somebody in the community dies every week and a cow has to be slaughtered at the funeral. In addition, farmers are no longer interested in farming because of water shortage, rising stock theft and animal diseases. Communities also do not control their livestock in terms of carrying capacity. Even during droughts, livestock farmers are reluctant to reduce the numbers of their livestock because the community mindset is that the more cattle an individual owns, the richer he/she is and the higher his/her status within the community.

Cattle handling facilities

The handling facilities provided by the government have been vandalised and they had to be refurbished to conduct this trial.

Training

There is no training available to the farmers. However, the farmers indicated that they would like to receive training.

Non-farming activities carried out by local residents in order to supplement their incomes:

- *Social grants*

The majority of the villagers are poor and they rely on the social grants from the government. Accordingly, the majority of the community is surviving on social grants, especially the elderly, orphans; child grant, the physically challenged, those individuals who are ill and, thus, not able to maintain themselves and also foster parents.

- *Farm workers*

Most people from this area seek work opportunities on the neighbouring commercial farms.

- *Town employment*

The nearest town of Makhado offers much work to the community members while others 30% of the Muduluni population have migrated to the big cities in search of employment.

- *Development project*

A local bank provides loans for community members, especially the women who form groups of a maximum of five women each. These loans range from R1 500 to R10 000. With the loans, the women are encouraged to start their own small businesses, for example, selling fruits and vegetables or second-hand clothing, bead making, and so on.

- *Deforestation*

Deforestation is a major problem in the area with trees being continually felled for firewood and traditional herbs. Despite having electricity, most households continue to use firewood in order to cut their electricity costs and also to sell to others. The community members collect wood for selling among themselves for cooking and for major events such as funerals and parties and also to sell to schools as the government nutrition programmes require that the schools cook for their learners.

- *Hunting and poaching*

Wild animals such as impalas, kudu and hares are still to be found in the area. However, in spite of the government regulation that prohibits poaching and the hunting of these wild animals they are still poached and the meat either used for the poachers' own consumption or sold to others.

- *Sand collection*

The area in which the study was conducted is in the vicinity of the Sand River. This river is known for its sand and, hence, its name. The community members collect this sand for building purposes and also sell to others.

- *Herbalists*

Traditional healers cut and collect plants for medicinal purposes.

- *Businesses*

Small businesses, such as car washes, restaurants, crèches and tuckshops proliferate in the area. Car washes are usually operated by those community members who have boreholes in their yards.

- *Mopani worms*

The local community members regard mopani worms as a favourite delicacy. Some members of the community travel to neighbouring areas and countries in search of mopani worms to sell.

- *Taxi industry*

There are several community members who operate taxis for a living.

4.1.2 FARMERS SURVEY RESULTS

Household characteristics

The fifty smallholder livestock farmers households surveyed comprised a total number of 291 people −an average of 5.82 people per household. Department of Land Affairs (2006) report an average of 5.7 people per household in the Limpopo Province. Eighty-five percent of the people were less than 60 years old and most of these were females. A small majority of households were headed by males, possibly because the effect of rural−urban migration, in terms of which males migrate to the urban areas in search of work, is minimal in the area. Forty-six percent (46%)of farmers interviewed were married. The farmers interviewed had no idea of how much communal land available for utilisation by their livestock.

Apart from the fact that education is one of the important variables which enhance the farmers' ability to acquire, process and use agriculturally related information, it is also widely recognised as a vehicle for empowerment, economic growth and general improvements in welfare. Approximately 36% of farmers have no formal education. This finding is supported by Statistics South Africa (2010) which also reported that the provinces of Limpopo, Mpumalanga and the North West continue to have the highest illiteracy rates in the country. However, the scenario is likely to change with the government's policy of compulsory, funded education for all. Sixty-eight percent of the farmers in the study were able to speak, read and write Venda whilst some of the farmers were able to speak, read, and write more than one language. The youth were minimally involved in all livestock production activities.

Knowledege-Farming experience

The majority of the farmers in the sample (72%) are full-time farmers with few animals each to look after and in most cases family labor is used however, few farmers hire labour with the result that average amounts spent on hired labour per household are extremely low.

The total farmer income per month showed that the majority of farmers (36%) earned between R1000 to R1499 from farming.

Table 4.1: Total farming income (R's)/ month

INCOME FROM FARMING	(%)NUMBER OF FARMERS
0–499	6
500–999	12
1000–1499	36
1500–1999	18
2000–2999	12
3000–4999	8
5000	8

The total income from farming activity showed that 42% of farmers earned less than R500 per month (Table 4.2)

Table 4.2: Total off-farm income (R's)/month

INCOME FROM OFF-FARM	(%) NUMBER OF FARMERS
0–499	42
500–999	6
1000–1499	10
1500–1999	4
2000–2999	10
3000–4999	12
5000	14

Farm information

Female animals make up the largest proportion of the herd Table 4.3. This finding is in agreement with the results of other studies conducted in South Africa (Musemwa et al, 2008; Schwalbach et al., 2001). Musemwa, (2008) reported that the fact that female animals are predominant in the herd is because cows are charge-free, inflation-free and also constitute a high interest form of banking for resource poor farmers as they give birth and, thus, contribute to increasing the herd size. In this case the bull-cow ratio = 1,3.8. Schwalbach (2001) reported a bull to cow ratio of 1:3.3 in North-West and Stroebel et al. (2010) reported a bull to cow ratio of 1:3.7 in Limpopo Province. The average herd size in this study is 9.4 per household. This figure is in line with that reported for other areas of South Africa. Musemwa et al. (2008) reported the following average herd sizes in the Eastern Cape Province:

Amatole 9.7 and Alferd Nzo 9.9. Schwalbach et al. (2001) reported that the average herd sizes in Thaba-Nchu and Botshabelo in the Free State province were 10.8 and 7.2 respectively, while Nthakheni, (1996) reported a mean of eight cattle per farmer in Venda in the Limpopo Province. The mean herd size in the Transkei in the Eastern Cape Province is six per herd (Bembridge, 1984). Literature reviewed indicated that more animals and/or larger herd size confirms greater wealth, and hence increased physical capital, as discussed in section 5.1.

Table 4.3: Cattle herd structure of farmer herds

TYPE OF ANIMAL	TOTAL NO. OF ANIMALS PER CATEGORY
Cows	245
Heifers	110
Bulls	94
Steers	20
Total	469

The majority of farmers (48.3%) preferred the Nguni breed (Table 4.4). The farmers' choice of breed is based on the adaptability traits of the animal to the environment. This is in line with the recommendation made by Mapinye et al. (2009) that, in order to increase sustainability and the contribution of cattle to alleviating poverty and also to improve the food security and livelihoods of the resource-poor farmers in Southern Africa, there is a need to make use of locally adopted breeds, for example, Nguni cattle. Nguni cattle are well adapted to the management levels of resource-poor farmers who require disease resistant multipurpose animals with low-maintenance feed requirements and relatively high beef output.

Table 4.4: Preferred breeds of cattle

BREED NAME	RELATIVE BREED PREFERENCE OF FARMERS (%)
Bonsmara	7
Brahman	4
Nguni	28
Afrikaner	7
Any breed	12

Cattle are the dominant livestock species kept by the farmers, followed by goats, chickens and sheep. Qualitative information from the respondents shows that donkeys are regarded as of little importance. Seventy-six percent of the farmer's farm because of the status livestock confers on them, while money to pay school fees and hospital expenses emerged as the least important reason to keep livestock (Table 4.5). Social prestige has been identified as the most important reason contributing towards social capital in the context of the SLF framework, as discussed in section 5.1.

Table 4.5: Reasons for keeping livestock

REASONS FOR FARMING	(%) NUMBER OF FARMERS
Commercial purposes	16
Pay school fees and hospital fees	6
Social prestige	76
None	2

Maize was reported to be the only major field crop grown in the area, with some fruit and vegetables. The maize was grown mainly for home consumption, as were the fruit and vegetables. The community is in the process of starting a sorghum project.

Crop residues were used by the majority of farmers (94%) as animal feed. Most of these farmers (80%) only used the "cut and carry "method to feed the animals.

Production and management information

Information given by farmers regarding first calving and calving interval was very dubious due to lack of proper records. The average age at first calving was 36 months followed by calving interval of 21.5 months .Calves are allowed to run with the cows until natural separation occurs.

The majority of farmers (76%) buy fodder during the period of feed shortage or in winter. A similar major portion (76, 6%) of farmers drove their livestock when the veld is overgrazed (showing signs of no more feed). Farmer's perceptions of the major cause of soil erosion are as follows: 40% blame high animal numbers, 20% blame stormy rains and 10% various other reasons.

Production risk reduction

Fifty-four percent (54%) of the farmers do not control livestock diseases while 40% takes varying measures to control diseases (Table 4.6). However, many of the respondents appear not to know the names of the diseases from which their animals suffer, which make it difficult to treat and control these diseases.

Table 4.6: Control of diseases

CONTROL	(%) NUMBER OF FARMERS
Yes	40
No	54
No response	6

Fifty-six percent (56%) of the farmers do not provide shelter either at night or in winter for their livestock

Sixty-two percent (62%) of farmers never see an extension officer (Table 4.7), while forty-two percent (42%) never see a veterinary officer (Table 4.8) and 86.4% of the farmers who responded indicated that veterinarians are not easily available in the study area.

Table 4.7: How often do you see an extension officer?

NUMBER OF TIMES	(%) NUMBER OF FARMERS
Once per year	14
Twice per year	6
Five times per year	2
Six times per year	4
I never see an extension officer	62
No response	12

Table 4.8: How often do you see a veterinarian?

HOW OFTEN DO U SEE A VET	(%) NUMBER OF FARMERS
Once per year	2
Twice	2
I never see a veterinarian	42
No response	54

Sixty-two percent of the farmers rely on co-farmers/ neighboring and own records as source of information for their daily livestock management decisions.

Six percent (6%) of the farmers kept own bulls and the majority (78%) use communal bulls (Table 4.9). Eighty–six percent of the farmers who responded indicated that they do not have a specific breeding season.

Table 4.9: Type of bull used

TYPE	(%) NUMBER OF FARMERS
Own herd bull	6
Community bull	14
Any bull	78
No response	2

The mortality rate of the livestock is not very high (an average of less than 2 per household per year) with those animals killed by diseases and motor vehicles contributing to the number of dead animals reported by the owners. Road deaths result in a complete loss to the owner because the dead animal is used to pay for any damages to the vehicle.

Marketing management

Eighty-two percent (82%) of farmers who responded prefer private sale marketing channel and simplest form of market outlets (Table 4.10), while 72.1% of farmers sold slaughtered animals (Table 4.11).

Table 4.10: Marketing systems

SYSTEM	(%) NUMBER OF FARMERS
Auction	2
Private sale	82
Middlemen	2
Local livestock	2
No response	12

Table 4.11: Products sold

PRODUCTS SOLD	(%) NUMBER OF FARMERS
Live animals	11.1
Milk	11.1
Meat	72.1
Dung	5.6

However, 42.9 percent (42.9%) only of the farmers sell their cattle in times of adverse agricultural conditions followed by emergencies (e.g. pay school fees, hospital etc.), traditional ceremonies (funerals) and cash benefit .This clearly indicates that the majority of respondents are reluctant to reduce their livestock numbers during adverse agricultural conditions while this, in turn, impacts negatively on grazing (see Table 4.12).

Table 4.12: Reasons for selling

REASON	(%) NUMBER OF FARMERS
Routine cash sale	4.8
Pay school fees, hospital costs	28.6
Funeral expenses	23.3
Adverse agricultural conditions	42.9

Economic viability

The main expenses incurred pertained to the purchase of feed and supplements while more income was earned through the sale of bulls. In addition, the majority of farmers derived income from social grants.

Social acceptability

Eighty percent (80%) of the farmers indicated that were satisfied as regards the existing welfare of their families (Table 4.13) while those who were not satisfied provided more than one reason for this dissatisfaction, amongst others too much debt, constant lack of money, poor housing for the family, lack of money to expand farm ,farm income not enough. In addition 31.3% of the farmers who responded to this question indicated a lack of financial resources with which to expand their farms as a challenge.

Table 4.13: Satisfaction as regards welfare of family

SATISFIED	(%) NUMBER OF FARMERS
Yes	80
No	20

The farmers indicated that they had to travel more than three kilometres to obtain veterinary, extension and cooperative services.

Eighty-two percent (82%) of the farmers who responded to the question regarding problems they might be experiencing with their neighbours indicated that they have no complaints about their neighbours (Table 4.14)

Table 4.14: Problems with neighbours

PROBLEMS	(%) NUMBER OF FARMERS
Destroy other peoples' crops	6
Invade other peoples' farm	4
Expected to move for water	8
No complaints about neighbours	82
No response	2

Ninety-eighty percent (98%) of the farmers who responded to the question of whether they are on track to becoming successful farmers indicated that they feel that they are on track. Some farmers chose more than one response about the reasons why they are happy with livestock business, while 75.4% of the farmers who responded indicated status and a sense of security as the main reasons why they are happy with livestock business and few farmers (24,6%) indicated that they are making money out of livestock business.

Approximately 17.6 % of the farmers require assistance with drought relief subsidy from the government, financial support, veterinary and extension services. Infrastructure, for example, fencing and training appeared to be areas in which the least assistance is required (Table 4.15).

Table 4.15: Assistance required by farmers

TYPE OF HELP	(%) NUMBER OF HOUSE HOLDS
Camps	9.6
Financial support	14.7
Veterinary and extension services	17.6
Subsidy of medicines	12.5
Training	2.9
Dipping and handling facility	11.8
Water	11.0
Fence along the road	2.2
Drought relief programme	17.6

4.2 NATURAL FEED RESOURCE BASE (BIOMASS)

4.2.1 RAINFALL

Figure 4.1 depicts the mean monthly rainfall for four years (2000–2003) and the average rainfall for the last 10 years (1994–2003). On average, the annual rainfall in the area is extremely low (less than 350 mm for the period of study) with the ten year average rainfall being 426 mm. During 2000 the rainfall was relatively high (765.9 mm) and, in fact, there were floods.

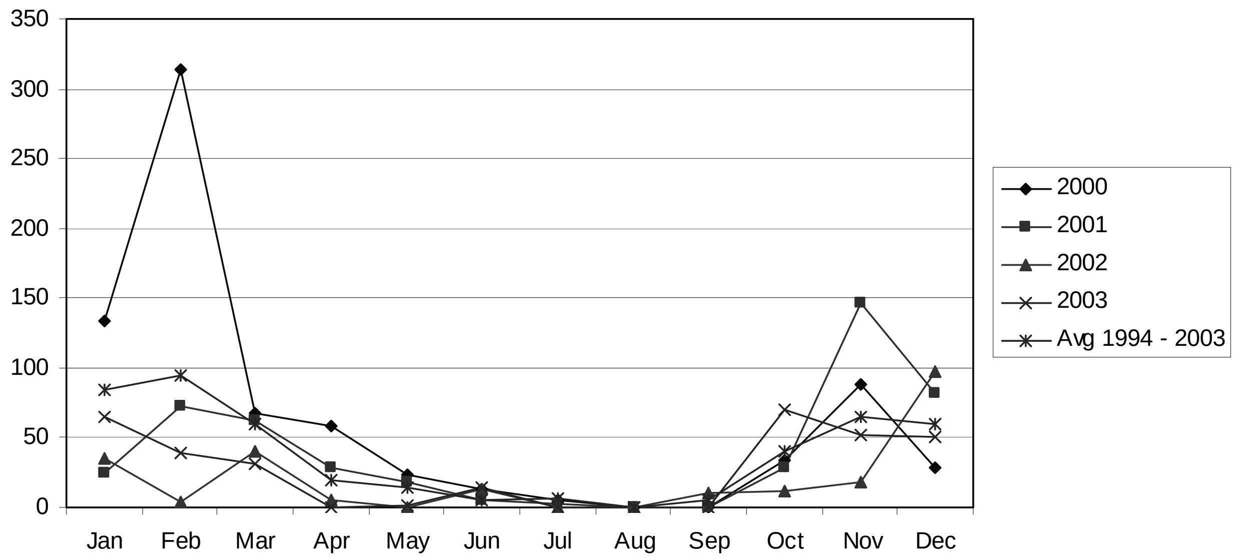

Figure 4.1: Four-year (2000–2003) and ten-year (1994–2003) average rainfall (mm)

4.2.2 BOTANICAL COMPOSITION

Table 4.16 shows that Mudu is dominated by low palatability species (35.3% of grass cover vs. 8.5% in Mara) and this, in turn, contributes to a poorer ($p < 0.05$) weighted palatability composition (45 vs. 82). There was approximately double the amount of land not covered by grass in Mudu as compared to Mara (10 vs. 5%).

Table 4.16: Distribution of grass species and weighted palatability composition (per methods of De Beer, 1990) of Mara and Mudu grazing areas

	MARA				MUDU				TOTAL F
	%	F*	PS**	WEIGHTED PS	%	F*	PS**	WEIGHTED PS	
Aristida congesta	2.83	34	1	2.83	18	216	1	18	250
Brachiaria nigropedata	0.08	1	3	0.24	0.17	2	3	0.51	3
Cynodon dactylon	0	0	3	0	0.25	3	3	0.25	3
Chloris pychotrix	0	0	2	0	0.17	2	2	0.17	2
Digiteria erianth	4.08	49	3	12.24	0.42	5	3	1.26	54
Eragotis lehmaniana	0.25	3	3	0.75	2.58	31	3	12.84	34
Eragrostis barbinodus	0.25	3	2	0.5	6.50	78	2	0.16	81
Eragrostis rigidor	17.25	207	3	51.75	7.92	95	3	15.84	302
Microclora caffra	0.67	8	1	0.67	1.25	15	1	1.25	23
Melinus repens	0.75	9	1	2.25	0.42	5	1	0.84	14
Panicum coloratum	7.17	86	3	21.51	0.5	6	3	1	92
Panicum maximum	13.25	159	3	39.75	0.58	7	3	1.16	166
Schmidtia pappophorides	15.58	187	3	46.74	0.5	6	3	1.5	193
Tragus berteronianus	5.08	61	1	5.08	16.08	193	1	32.16	254
Themeda Triandra	0.17	2	2	0.34	0	0	2	0	2
Urochloa mosambensis	27.67	332	3	83.01	35	420	3	105	752
Uncovered	4.92	59	-		9.67	116	-	29.01	175
Total		1200		267.66		1200		191.94	2400
Weighted palatability composition=				82. 5 [a]				45. 1 [b]	

Key to terms in table above:
*f = frequencies
**PS = palatability score (De Beer, 1990)
1 = unpalatable
2 = intermediate
3 = palatable

Table 4.17 Mara had more than double the dry matter productivity (1686 vs. 733 kg/ha) of Mudu.

Table 4.17: Dry matter (DM) production (kg/ hectare) in Mara and Mudu for 2003-2004

NAME OF ENCLOSURE WITHIN SITE	DM PRODUCTION/HECTARE
4 Mara camp 1	1001
5 Mara camp 2	2166
6 Mara camp 3	1891
Average (Mara)	1686[b]
1 (next to Muduluni)	432
2 − Muduluni village centre	494
3 − Muduluni village (alongside Mara fence)	1272
Average (Mudu)	733[a]

4.2.3 DRY MATTER DISAPPEARANCE

The loss of dry matter after 24 hour incubation in the rumen of steers was affected by both the site and the season with the most significant lowest dry matter loss occurring during winter on both sites (Table 4.18).

Table 4.18: The 24-hour dry matter disappearance (%) using the Dacron bags inserted in the rumen of the experimental steers on the Mara and Mudu sites

DRY MATTER DISAPPEARANCE (%)				
SEASONS	**Mara**	**SEM**	**Mudu**	**SEM**
Summer	39.54[a]	.1667	43.89[a]	.1667
Autumn	52.67[b]	.2887	50.65[b]	.2887
Winter	31.65[c]	.2887	27.73[c]	.2887
Spring	44.59[d]	.2041	42.07[d]	.2041

a, b, c and d refers to the same column but with different superscripts

4.2.4 CHEMICAL COMPOSITION OF FORAGES IN MARA AND MUDU

Table 4.19 showed low values of organic matter content of herbage in summer − 83.70% at Mara and 75.93% at Mudu. In addition, the crude protein declined by approximately 64 % from summer to spring in Mara and by 61% in Mudu whereas the NDF increased by about 17% between the two seasons in Mara and by 24% in Mudu

Table 4.19: Organic matter, crude protein, neutral detergent fibre and acid detergent fibre (%) in the oesophageal samples collected from the experimental steers grazing at Mara and Mudu

CHEMICAL COMPOSITION									
Site	Season	Organic matter	SE	Crude Protein	SE	NDF	SE	ADF	SE
Mara	Summer	83.70 [a]	.23570	21.03 [c]	1.031	60.31 [b]	1.779	29.54 [b]	1.260
	Autumn	88.60 [a]	.28868	12.75 [a]	1.263	72.00 [a]	2.179	38.42 [a]	1.542
	Winter	92.47 [b]	.40825	9.93 [ab]	1.787	76.91 [a]	3.082	43.32 [a]	2.182
	Spring	89.50 [c]	.28868	7.60 [b]	1.263	70.41 [a]	2.179	43.36 [b]	1.542
Mudu	Summer	75.93 [a]	.23570	17.10 [a]	1.031	57.45 [b]	1.77b	35.04 [a]	1.260
	Autumn	86.17 [b]	.28868	14.08 [a]	1.263	67.17 [a]	2.179	36.07 [a]	1.543
	Winter	91.70 [c]	.40825	6.89 [b]	1.787	76.14 [a]	3.082	42.52 [a]	2.182
	Spring	90.77 [c]	.28868	6.71 [b]	1.263	74.03 [a]	2.179	45.48 [b]	1.543

a, b, c refers to the same column within sites but with different superscripts.

The ammonia concentration (%) in the rumen of steers was not affected by site ($p > 0.05$) (see Table 4.20).

Table 4.20: The ammonia concentration (% NH_3) collected from the rumen fistulated experimental steers grazing at Mara and Mudu

AMMONIA CONCENTRATION (%)				
SEASON	MARA	SE	MUDU	SE
Summer	5.13 [a]	0.3333	6.5 [a]	0.3333
Autumn	6.68 [b]	0.4083	5.02 [b]	0.4083
Winter	6.26 [c]	0.5773	4.51 [c]	0.5773
Spring	2.52 [d]	0.4083	3.35 [d]	0.4083

a, b c and d refers to the same column but with different superscripts.

CHAPTER 5

DISCUSSION

In order to set the scene for this discussion, a comparison needs to be made between the two systems (Mudu and Mara) in terms of the main components that define their functioning.

In terms of the socio-economic components, Mudu would appear to be largely socially driven. Accordingly, Mudu's input markets are informal and erratic, for example the purchase of feed and medicines and so forth appears to be ad hoc. The same applies to the output market, for example the sale of animals which mostly takes place privately and which is determined by social need. Moreover, the value of the animals is determined mainly by their status and banking value. Furthermore, the support systems in the area are predominantly informal structures and occur among the local populace. Lastly, Mudu has no risk evasion measures apart from the support offered by fellow farmers and local community members.

By contrast to Mudu, the Mara system experiences a minimal mortality rate and maximum animal performance. The inputs made into this system are highly organised, for example they are established businesses. The same applies to the output, for example the holding of auction sales. Moreover, the value of the animals is determined by their performance. In contrast to Mudu's socially oriented support systems, Mara is supported by formal structures. Finally, within the Mara system low to medium risk is accepted backed by insurance against higher risk situations.

In terms of biophysical components the following is of interest: In Mudu the pattern of land use by communal farmers is driven mainly by social factors (organisation of farming and lifestyle). Furthermore, this system takes very few land use management decisions individually, with such decisions being taken collectively or by government. The knowledge base in this area is for the large part indigenous. In contrast, Mara land use patterns are economically directed and high levels of decision making based on scientific knowledge take place.

5.1 SOCIO-ECONOMIC ASPECTS

The poor continue to be a source of huge concern in the rural and agricultural sectors with most of them being dependant on agricultural activities for their livelihoods. Livelihoods refer to the ways in which people make a living, including how they distribute their productive resources and the type of activities in which they are engaged. The decisions which people make about organising their livelihoods may incorporate a whole new range of goals and values, for example an individual's preference for livestock as opposed to cultivated pastures. Some of these goals and values are influenced by cultural norms. Accordingly, it is relevant to consider the cultural context within which people structure their society. This chapter discusses the results in the context of the SLF framework.

Context in which rural people live

External trends

- *Economic*

The economic landscape of the areas surrounding Mudu, which include the business centre − Makhado town − differs in various ways from the local Mudu community business set-up. In short, it may be said that the local economy is not complex and that changes to the economy occur at a slower pace. As a result of their isolation from the economic heartbeat of the business centres, rural communities are, in essence, recipients of the changes that occur under both macroeconomic and microeconomic conditions. This situation, together with the low buying power of rural communities, explains why it is only businesses dealing with basic products and services that are operating in the rural communities. The absence of modern agricultural services, for example livestock marketing agents, veterinarian services, agricultural services, makes it difficult, if not impossible, to alter the existing mindset of the community. The result is a stable, but poor, economy, which is, to a large degree, supported by government social spending (pension funds).

- *Technological*

As regards the economic landscape explained above, technological advances in rural communities are also slow. Islands of high technology which exist in small business centres and other services do exist in rural communities but this high technology is either diffused slowly, or not at all, through the community. The aging profile of rural communities contributes to this phenomenon as the younger generation of families living in these communities have joined the migration to the big centres. This explains why external efforts on the part of organisations, for example donor funding projects, government initiatives and local organisations, aimed at changing the livelihoods to rural communities are either slow and/or non-existent.

- *Population growth*

It is a common fact that the majority of poor people in South Africa still reside in the rural sector. In the Mudu rural community this is resulting on the gradual expansion of the residential area with this expansion occurring at the expense of agricultural land. More and more residential sites are being erected in previously grazing or cash crop production areas. As the population and residential area expands so does the pressure on natural resources for agricultural production activities increase. This, in turn, results in a negative spiral in terms of non-sustainable production and the degradation of natural resources. The population also becomes more dependent on government social spending for their livelihoods.

- *Seasonality*

The effect of seasons on the livelihoods of rural communities, such as Muduluni, is, perhaps, greater than in the outside world. Livestock production constitutes the major agricultural activity that contributes to household income. However, it is a common feature of rural communities that the communal grazing land is in a degraded state. The reasons for this situation include the pressure arising from the growth in human population, which then results in the invasion of residential sites onto grazing land. This pressure on grazing land can accelerate the damage caused by droughts, as well as the premature advent of the annual winter (dormant) season. Farmers are then forced either to sell their livestock in order to reduce the pressure to buy feed from outside or else to buy in feed from outside. However, both of these options − the forced selling of livestock in poor conditions or the excessive purchase of feed − have a negative impact on the financial resources of farmers and on the community as a whole. Clearly, the impact of seasons on the livelihood of rural communities is significant.

Access to assets and the ability to put these assets to productive use

- *Natural capital*

Animals are often referred to as walking crops, providing manure to increase soil fertility, and traction power (Stroebel et al., 2008). According to Campbell et al. (2002), incomes in rural Africa are closely tied to natural resources, land for crop and livestock production, woodland for a wide variety of goods and services, and water for household consumption and small-scale irrigation. In addition, human activity may either reduce or increase the quantity and quality of a resource. Traditional authorities allocate land to people either for cropping or grazing or for residential sites within the village. Generally, the largest portion of this allocated land is used for livestock, followed by fruit production, with the smallest portion being used to grow vegetables. Grazing and cropping lands are usually allocated at some distance from the residential areas. Land is part of the natural stock of capital that may be used in conjunction with other inputs to support livelihoods. In this study the households had been allocated land for crop production. These lands comprise a field close to the household and another field which is usually further away from the household. The former is intensively managed and, over time, the latter is continually subdivided into smaller units as the owners pass on land to their adult sons. This situation, in turn, has led to the area available for dry land crop production per household declining over time. In addition, drought has meant that there are few lands which are being used for dry land maize production and the farmers are not faring well. However, the community is in the process of starting a big project on sorghum which is drought resistant. Fruit and vegetables are also considered as the main crops in the area and are cultivated in the backyard gardens for the purposes of home consumption. Livestock production depends entirely on the natural grazing resource base and comprises an important source of wealth for households. However, the sustainability of this livestock production warrants more attention from researchers.

- *Human capital*

Livestock provide an invaluable source of food (Meat, milk, eggs) from animal origin to improve the nutritional status of people. Livestock products account for 30% of protein-intake by humans (Ndlovu, 2010). Human capital includes health, education, knowledge and skills, capacity to work and capacity to adapt, with labour often being regarded as the chief resource available to households (Campbell et al., 2002). In this study a household comprises an average of 5.82 people per household. A large household may mean that the required labour for cattle production and marketing is readily available. In addition, a large household may mean more labour hours are available per household. The majority of farmers (72%) in the study are farming on a full-time basis. This confirms the qualitative information obtained in the study that few households hire labour with the result that average amounts spent on hired labour per household are extremely low.

The majority of households (54%) in the study are male headed. This, in turn, indicates that few adult males are migrating to the urban areas in search of opportunities. Adult males played a dominant role in all cattle production activities. Education represents one of the variable which may enhance the farmer's ability to acquire, process and use agriculturally related information (Kachoro, 2007). Approximately 36.1% of the farmers in this study have no formal education, although this trend is likely to change in the future with the government legislation which supports compulsory education. A larger enrolment (22.2%) for Grade 1 to Grade 2 is predicted and this, in turn, is a positive indication of the community's future investment in education. The level of education and training has a bearing on the ability of farmers both to manage their resources and to accept extension services. The focus group discussions revealed that livestock farmers require training on livestock management and that they depend on their own labour.

The number of family members with post-secondary school education is extremely low. The majority of farmers in the area are able to speak, read and write the Tshivenda language, thus making it easier for them to benefit from publications or newsletters written in Tshivenda. In addition, disease control is vitally important for any successful livestock farmer. However, it would appear that farmers in this area do not control diseases while the qualitative information revealed that the farmers are also not aware of the diseases in their area. In most instances, when interviewed, they had to describe the diseases to the enumerators and were not able to name the diseases. This situation is exacerbated by the absence of veterinarians and extension services within reach. It is interesting to note that a lack of money and transport are not the problem as regards the farmers not accessing the veterinary services but that these services are virtually unavailable. However, the absence of these services may lead to fatal animal diseases not being identified timeously. In addition, certain of these diseases, for example, zoonotic diseases, may prove fatal to human lives. However, most of the farmers receive management and production training advice from their fellow farmers.

- *Financial*

As regards the smallholder systems, financial capital in the form of cash is severely constrained with any money received being soon allocated and spent (Campbell et al., 2002). Livestock is an important component of financial capital and acts both as a store of wealth and as a buffer against bad times. However, farmers often have multiple income sources. Income levels are key determinants of livelihood security, determining not only the amount of food a household is able to purchase but whether the household is able to afford essential non-food goods and services, for example, agricultural inputs, livestock medicines, education, and healthcare. A distinctive characteristic of the households in the area is the fact that these households attempt to finance their livelihoods from a mixture of activities that include crop production and the sale of live animals, dung and meat.

From the literature is clear that herd mortality and offtake is low, confirmed by the results of this study. Herd mortality in this study is high, which obviously represents a considerable loss to farmers, with an offtake percentage of 9%. However, in most cases, part of or the entire carcass of dead animals is consumed by the household. This high mortality rate could have been aggravated by the severe drought experienced during the year of the study in this area. Due to the fact that very few farmers keep production records of their herds, mortality rates of the different herd classes could not be calculated. However, it is well documented that mortality rates of lactating cows and calves increase significantly during multi-year drought periods (Stroebel 2004; Nthakheni 2006). In extended dry periods and droughts, the probability of lactating cows dying is higher than for non-lactating cows. Cows which calve regularly remain in relatively poor condition and rarely have the opportunity to gain weight. During severe droughts, therefore, highly fertile cows are at high risk. Non-lactating cows are 'insurance' and enhance economic survival (Stroebel 2004). The offtake of the present study is low at 9%, which is comparable with other values reported for southern Africa (Musemwa et al., 2010). Many respondents did not want to sell cattle as they believed in maximising the number of cattle owned. Others felt that owning many cattle safeguards against losses during drought. This will not cause a total loss as they will use the meat for consumption purposes. It is clear that there is a need to encourage the communal farmer to increase offtake from their herd and to establish an appreciation of improved productivity and quality, instead of maximising animal numbers only (Stroebel et al., 2008).

Farmers earn between R1000 and R1500 per month from off-farm activities. It emerged from the qualitative data information that this figure includes pension grants with the farmers generating an average of R500 per month from their farming activities. However, both the monthly income from external sources and the income from farming activity do not reflect the true situation, since most of the farmers interviewed try to evade this question by giving random responses. Besides non-farming activities the farmers also engage in crop production with dry land maize production being the main crop, followed by fruit and vegetables in their backyards, in an attempt to sustain their households. During winter the farmers experience feed shortages for their livestock and, thus, in order to supplement this shortage, they use cut and carry techniques to feed their animals. The qualitative information indicates that, if farmers wish to sell their animals through auction, their cattle should be branded. However, the farmers do not want to brand their animals, which mean they are left with their preferred option of selling their animals through private sales. Unfortunately, this usually happens in adverse agricultural years. The main income generators sold include meat, live animals and dung, with meat as the most important product. However, farmers realise more money from the sale of bulls. The farmers spent significant amounts of money in buying feed and supplements for their animals which, in turn, indicates that they are interested in keeping their livestock. Social grants, wages, development projects, deforestation, hunting and poaching, sand collection, businesses (restaurants, transport, tuck shops etc.) all comprise ways of generating income besides farming.

- *Physical capital*

The physical assets of a household include the composition of the livestock. Cattle comprise the most important livestock species kept, followed by goats, chickens, sheep and donkeys. The focus group indicated that donkeys were of little importance despite being used for transport. The average size herd in the study is 9.4 cattle, which is almost within the range of 9.7 reported by Musemwa (2008). A large herd size means more wealth and this has a direct impact on the natural feed resource base. Female animals comprise the largest component of the herd (75.7%) with bulls making up the smallest proportion of the herd in the sample area. The reason for breeding females constituting the largest proportion of the herd may be attributed to the fact that females are charge-free, inflation-free and a high interest form of banking for resource-poor farmers as they give birth and, thus, increase the size of the herd (Musemwa, 2008).

The farmers tend to farm with the Nguni breed (48,3%) as a result of the breed's ability to adapt to harsh environments .The survey revealed a bull–cow ratio of 1:3.8. Cattle, goats and chickens are the chief forms of livestock kept and they are usually kept for home use rather than for commercial slaughter. Heifer first-calving and weaning rates are very high, although the latter may be as a result of of weaning being left to take its natural separation. The animals are often stolen and, in addition, they often destroy the neighbours' crops because shelter is not provided at night or during winter when feed is in short supply. Breeding management includes one practice only in terms of which livestock keepers decide which animals are allowed to reproduce and which are not (De Haan, 1999). As a result of the fact the all the animals run together in the communal setup farmers do not have the option of choosing which bulls to use and there is also no specific breeding season. The farmers in the study also indicated that they had to travel more than three kilometres for veterinary, extension and cooperative services.

- *Social capital*

Social activities have been cited as the most important reason for keeping cattle, and confirm the social-economic status related to the ownership of cattle. This is commonly referred to as the “cattle complex”, where cattle are kept for prestige and status and not for production (Mtetwa, 1978). Nengovhela (2010) refer to this as the “cattle owning cultures” of Africa. The fact that cattle farmers had high socio-economic status in their communities emphasizes the relationship between rural livestock production and social development (Kitalyi et al., 2005). This analogy is logical because the production and consumption of animal products are not necessary for survival but add to quality of life. Improvements in animal production have often been represented as one of the best avenues for raising the smallholder producer from the level of subsistence to that of a small commercial entrepreneur. “Production” is relative, especially when comparing two systems which from the outset have different objectives, as is obviously the case between smallholder communal (open system) and conventional commercial systems.

There are various executive projects committees within the area, including the livestock committee. These committees comprise a chairperson, vice chairperson, secretary, vice secretary, treasurer and six additional members. The chief and the headman are ex-officio members. These committees hold meetings on a quarterly basis to decide on the developmental issues of the community. These quarterly meetings are usually followed by a mass meeting of the whole community. Should a a member miss three consecutive meeting, his/her membership is cancelled. However, many of the developmental projects are no longer viable as a result of infighting, mismanagement of funds and insufficient beneficiary training.

The majority of farmers are farming on a full-time basis, they enjoy good relationships with their neighbours, they are on track to becoming successful farmers and they are satisfied with the existing welfare of their families. As regards the few who expressed dissatisfaction this was largely as a result of a lack of money with which to expand their farms. Social status and a new sense of security were cited as the main reasons why farmers were happy with livestock farming. However, this area is prone to drought and it is essential that the farmers receive assistance from the government during drought periods to enable them to acquire fodder. The qualitative information revealed that the farmers had to travel to nearby villages to obtain fodder and as outsiders they are given second choice.

Various strategies the tribal authority adopt in pursuit of their goals

The tribal authorities formally regulate the livelihood of rural communities. This includes regulating various important aspects pertaining to the communities within their area of jurisdiction – see above. These duties ascribe definite importance to the protection of natural resources as well as to the orderly allocation of residential and business sites. In addition, each of these duties listed indicates those elements that are of strategic importance to the community as a whole.

The informal strategies adopted by the individual households are equally as important as the abovementioned formal plans with the sinking of private boreholes, opening of residential tuck shops and the extensive purchasing of animal feed being amongst the strategies adopted by individuals.

All these strategies, whether formal or informal, are aimed at satisfying the basic need for survival. However, there is no strategic impetus attached to either the progressive economic and/or social needs of the community, for example, initiatives to attract franchise businesses and the livestock marketing of labour within a collective package to outside businesses or else a collective call on government to provide the much needed services.

5.2 NATURAL FEED RESOURCE BASE

The motivation for this study was grounded in the lack of basic information available on the nutritive value of the natural feed resource base as grazed by the livestock in communal areas.

The South African veld types are known to be extremely diverse in terms of their botanical composition and, dry matter production potential and, thus, their nutritive value − ability to sustain animal production (De Waal, 1990.)

The research results of numerous of the writers cited in the preceding literature study add significant value to a better understanding of the specific topics relevant to both natural pasture management in respect of animal performance and the dynamic interaction between the veld, environment, animals and livestock owners as the managers of the system.

De Waal et al. (1998) report that knowledge of both the edible dry matter yield, energy and protein status of a pasture and seasonal changes is of paramount importance as regards good pasture management. In addition, such knowledge also plays a significant role in the determination of (i) the carrying capacity of the pasture, (ii) the expected animal production, (iii) the periods of the year when nutritional deficiencies occur, (iv) the type and amount of fodder or concentrates required to correct these deficiencies and (v) the best way to match the animal's needs to the pasture's ability to provide nutrition throughout the year.

The purpose of this section is to introduce and discuss the biological findings from this study, but focusing only on those scientific facts that will eliminate misconceptions and identify the actual reasons for the findings of this study.

The vegetation measurements between the two faming systems were all significantly different. This, in turn points to the fact that the grazing capacity between the two farming systems is vastly different. In addition, the literature review revealed that botanical composition and veld management are both factors affecting grazing capacity (Van der Westhuizen et al., 2001) and, as such, they will contribute to the first part of this discussion.

Grazing capacity is the norm used to express the value of the natural pasture for animal performance in the broad sense. There is extensive information in the literature is which provides possible reasons for any differences found in grazing capacity.

The next part of the discussion will address the quality aspects of the forage ingested. The results revealed that the nutrient content of selected forages did not differ between the sites. Nutrient content affects the quality of the natural pasture. The results pertaining to chemical composition, dry matter disappearance and ammonia concentration will be discussed in detail in this section.

Grazing capacity

The main factors affecting grazing capacity include rainfall, available soil moisture which is dependent soil type, soil depth and evapo-transpiration, veld condition, topography, stock type and climatic and management factors (Van der Westhuizen et al., 2001). However, these factors all differ in different ecological areas. Neither the environmental factors nor the climatic factors will be discussed in this section as the two sites compared are located within the same identifiable area. Accordingly, Mudu and Mara showed different grazing capacity values emanating from the differences observed in both the botanical composition and the veld management practices on both sites. These two factors will be dealt with in greater detail later in this discussion Carrying capacity is another term which is commonly used for sustainable grazing. Smet and Ward (2005), Erskine (1993), Dijkman (undated), Behnke and Scoones (1993) and Kumpula (undated) collectively agree that there are several types of carrying capacities which exist. Of these, the ecological and the economical types are the most important. Their definitions of these terms are almost similar and may be summarised as follows. Economic carrying capacity refers to the long term stocking rate that will support sustainable high production per animal while sustaining the veld condition in a succession phase that progresses towards the climax successive phase. In comparison, ecological carrying capacity refers to the long term stocking rate that will sustain the veld condition at, or near, the ecological equilibrium. Ecological equilibrium refers to a veld condition state that represents the point just before ecological collapse. Ecological collapse may occur as a result of environmental pressure (drought) or management pressure (excessive overstocking) or a combination of both.

In order to determine grazing capacity, the botanical composition of the veld should be studied to enable descriptions of the major plant communities, palatability, weighted palatability composition and dry matter produced. According to De Beer

(1990) and Van der Westhuizen et al. (2001) grazing capacity must be estimated by relating the weighted palatability composition to the relative grazing capacity

Walker (1970) reported that there have been various methods devised for estimating botanical composition, including the line intercept, the wheel-point, the variable plot, quadrant counting, the point-centred–quarter, (Heyting, 1968), the angle order, species frequency by quadrant, the dry-weight rank and the disc-pasture meter methods (Dekker et al., 2001). Walker (1970) then evaluated these methods based on precision, information content, operator variability and efficiency (information gained for time spent). The results indicated that there is no valid recommendation as regards which method to use and that each method is entirely dependent on the integrity and attitude of the operator. In fact, human stress has often been cited as a factor invalidating the results obtained. However, despite the fact that these methods were developed five decades ago, they are still used, despite the fact that there some controversy surrounding them. It was decided to use the point-centred-quarter method in this study in order to include measurements of grass density in the method (Heyting, 1968).

Botanical composition

Compared to Mudu, the botanical composition at the Mara site shows a strong bias toward the perennial species (58.1%). However, the opposite is true for Mudu with the majority species belonging to the annual group (71%).

The species diversity also varies at both sites with Mara having four species, namely, *Eragrostis rigidor, Panicum maximum, Schmiditia pappophorides* and *Urochloa mosambencis,* − present in quantities of more than 8% − compared to the two species of *Aristida congesta* and *Tragus berteroniaanus* at Mudu. Three of the four species at Mara are perennial species compared to zero of the two species at Mudu. This situation suggests a more resilient species composition at the Mara site, as compared to the Mudu site. However, a lack of resilience against extreme environmental situations may cause a breakdown of the ecological system which may occur when the ecological equilibrium is surpassed. The latter, in turn, may be caused by either drought or the termite outbreaks that are typical of the prevailing veld type. The poor diversity of species at Mudu suggests that the ecological status of the veld on that site is substantially closer to ecological equilibrium compared to the more diverse and more perennial Mara site. It is important to note that the relative frequency of counted grass tufts corresponds closely to the percentage frequency of the species because the percentage frequency is derived from the other grass counts.

Palatability

The classification of species into palatability classes was carried out on the basis of the experience gained on the veld. However, despite the fact that the classification classes of Trollope (1990) were used as starting point, the palatability of species does differ between diverse types (Trollope, 1990; Van de Pol, 2004).

It emerged from adding the percentage of all the palatable species for the respective sites that Mara has 85.33% palatable species compared to 47.9% for Mudu. In view of the fact that palatability is an important determinant of voluntary intake through species selection, this result indicates that there is more edible grass available for grazing at the Mara site. The *Urochloa mosambisences* species merits a special mention. There were high percentages of this species at both sites with 27.7% at Mara and 35% at Mudu. This species serves as bulk feed during the growing season. However, during the dormant season, the leaves and stems erode completely and disappear from the sward, thus leaving less palatable feed available for the animals. The *Urochloa mosambencis* is known to be dominant in the arid Bushveld and serves as ground cover. The fact that it occurred in high percentages at both sites underscores its ecological resilience as regards the prevailing veld type.

Weighted palatability composition

The grazing capacity is directly related to its weighted palatability composition (De Beer, 1990).

The following weighted palatability compositions were obtained from this study, namely, 45.1% at Mudu versus 82.5% at Mara. The weighted palatability compositions confirmed the results of the study which had indicated low estimated grazing capacity for Mudu and high estimated grazing capacity for Mara.

Dry matter production yield

Both rainfall, as well as its distribution during the growing season, was cited as the cause of the large variations in both dry matter yield and quality. These variations may occur at any specific site between years and are invariably reflected in animal performance (De Waal et al., 1998; De Waal, 1990). Changes in temperature have also been cited as a causative factor as regards dry matter yield (Okello et al., 2005).

The dry matter production results indicated 130% higher dry matter production on the Mara site compared to the Mudu site. This significant difference between Mara and Mudu was also discernible visually. The protected site at Mudu was, however, surprisingly well covered by the grass layer compared to the denuded veld that surrounded it. The findings of the large dry matter production difference between the two sites may be as a result of the continuous overstocking and overgrazing which were observed at Mudu (De Waal, 1990).

A subjective appraisal of the grass species on both sites indicate that the majority of the grass species were annuals *(Aristida congesta, Urochloa mosambicensis,* and *Chloris pychotrix*) with a minor occurrence of perennial grasses (*Schmiditia. pappophorides, Cynodon dactylon and Digiteria eriantha*). Despite the fact that the grass species were visually appraised only, these findings suggest that a notable seed bank was still present in this veld and that veld recovery may be surprisingly faster if allowed to rest.

The dry matter production on the Mara site was relatively high, but not constant. This variation corresponds to the visual variation observed. It also corresponds with the general observation that the semi-arid Bushveld is known for its significant variation, even at micro level (Van de Pol, 2004).

Veld management

The main objectives of veld management have been extensively reviewed by various researchers, including Tainton et al. (1993). They summarised these objectives as follows: ensure continued vigour among the main forage-producing plants, ensure that as much as possible of the available forage is consumed by the animals and ensure that the basic resources of soil and water are conserved.

Although Mara is well managed (fenced and rotational grazing practised), Mudu is not (vandalised fences and continuous grazing practised). The management input for Mudu simply comprises the daily grazing of the cattle in the area, with no specific rotation. In view of the fact that there are no proper fences separating any part of the veld, it may be concluded that continuous grazing, without seasonal rest, is practised. The stocking rate is not controlled and the number of animals varies, depending on the total number of animals in the communal herd.

In the main, commercial farmers recommend rotational grazing. Farm planning and fenced camps comprise tacit knowledge and are essential if rotational grazing is to implemented. The literature does not reveal any conclusive findings which indicate that rotational grazing is superior to continuous grazing as a long term management input (Morris, 2002; O'Reagan and Turner, 1992; O'Reagan 1994b). However, continuous grazing is responsible for widespread range deterioration while rotational grazing is reported as the only system capable of maintaining long-term range and animal production (O'Reagan and Turner, 1992). There is a general belief that rotational grazing of the veld, and, more especially, multi-paddock, rotational grazing, is invariably advantageous as compared with continuous grazing (Barnes, 1992).

Both animal performance and veld condition under continuous grazing reveal the same or even superior results, when compared to rotational grazing. However, it would appear that stocking rate is the important management issue balancing the impact of either rotational grazing or continuous grazing. Kreuter et al. (1984) reviewed rotational, continuous and multi-camp grazing systems and indicated that it may be expected that each grazing systems would have its own optimum stocking rate. Results indicate that either a moderate stocking rate or a stocking rate that is derived from the grazing capacity of the rangeland produce optimal animal performance.

The above discussion may provide the basis for explaining one of the fundamental differences between the commercial and the communal approach to natural pasture management. However, the application of stocking rate (LSU/ha) as a conscious management input, corresponding to the grazing capacity of the natural veld, may explain the superior grazing capacity of the commercial site in the trial.

The higher grazing capacity of the veld on the Mara side is supported by the superior botanical composition, dry matter production and palatability index of the site. This, in turn, supports the conclusive result of a significantly higher grazing capacity figure obtained for the Mara site. However, as regards the Mara site; this site may not be the ideal comparative site as a result of the absence of any economic incentive to produce at optimal/maximal which prevails on a government funded research station. This argument is supported by the numerous research results of Duvel (1995), Van der Westhuizen et al., (2006) and O'Connor (1995) which indicate the overall poor condition of the veld in South Africa. The reason for this state of affairs is always quoted as both a high stocking rate and also the absence or poor application of a scientific veld management system. Against this backdrop, it may be concluded that the Mara site is leniently stocked and better managed. Nevertheless, the site provided a sound comparison for the purposes of this study.

The significant differences in the botanical composition and dry matter production parameters measured both strongly support and reveal the difference between the effects of diverse stocking rates on veld condition. Despite the fact that it was not possible to obtain conclusive evidence from the research results, it would appear that the Mara site is aiming at attaining the economic carrying capacity which is synonymous with the goal of commercial livestock farming, for example, obtaining gains in a sustainable manner.

Nutrient content

According to Cheeke (2005), nutrient content is a dietary essential for one or more species of animals. However, not all animals require the same nutrients with ruminants manifesting fairly simple nutrient requirements compared to non-ruminants. The known nutrients are grouped in one of the following categories: protein, carbohydrates, lipids, minerals, vitamins, and water. The following discussion will revolve around the first two nutrients, namely, protein and carbohydrates.

The specific site is known to affect indirectly the chemical content of grasses and grass parts through soil and plant development, water runoff, intensity of shade, as well as other environmental factors (Cook, undated). However, it was not possible to observe these site effects in this study as a result of the fact that both the sites are located within the same identifiable area. The findings of this study indicated no significant different in the nutrient content of the ingested feed between the two sites, despite the fact that the grazing capacity between the two sites differs significantly.

This finding clearly indicates that the animals on both sites were able to select the nutritious material, irrespective of the site of grazing with the immense difference observed in the botanical composition not appearing to affect the influence of the selection of the nutritious grazing material by the animal. This observation clearly indicates that economic carrying capacity is superior in terms of dry matter production, but not in terms of the nutrient content of ingested material.

Cheeke (2005) reported that the digestibility of forages is an important factor in determining herbage nutritive values for two reasons, namely, the higher the digestibility, the more nutrients are released for use by the animal, and, as digestibility increases, feed intake may increase because the turnover rate in the rumen increases.

De Waal (1990) reported that the amount of herbage ingested by grazing ruminants depends on the availability of acceptable herbage, the physical and chemical composition of the pasture and the nutrient requirements of the animals as well as the capacity of the animals to ingest herbage**.** There is considerable information available on the chemical composition of veld herbage, whereas little is known about the digestibility and intake of ruminants. The latter is affected by factors relating to the concentration and composition of the fibre fraction (digestibility) as well as by factors relating to the nutrients that are essential for the micro-organisms in the rumen, and for the host animal. It should be noted that that pasture intake may be biased by non-feeding factors, such as the availability and distribution of the pasture and by the animal type and its physiological state (Cilliers and Van der Merwe, 1993).

The use of oesophageal fistulated animals to obtain representative samples to be analysed for organic matter, crude protein and crude fibre (NDF and ADF) and rumen fistulated animals to study the rate and extent of degradation and the digestion of feed in the rumen are two of the methods used to measure the digestibility of the herbage eaten by grazing animals. These methods were extensively reviewed by various writers, including De Waal (1990), Huntington and Givens (1995) and Okello et al. (2005). Rumen liquor was extracted from rumen fistulated animals in order to determine the ammonia concentration.

Chemical composition

The literature review had revealed that natural pasture veld is a cheap source of ruminant feed. On the other hand, Tainton (1999) reported that the South African veld types are extremely diverse in terms of nutritive value. Nutritive value depends on the chemical composition of natural pasture, the digestibility of the ingested nutrients and the voluntary intake/unit of time by the animal. Blaxter (1964) and Mannetje't (1984) described the nutritive value of pasture as its ability to provide animals with energy and nutrients for the maintenance of bodily functions and the production of offspring, meat, milk, fibre and draught power (Cook, undated). The nutritive value of a forage species refers to the ability of the usable forage to meet the nutritional requirements for the physiological functions performed by the grazing animal during the various seasons of the year as individual grass species vary in nutrient content during their annual life cycle. During spring and summer (active growing season) grazing animals receive adequate nutrients but, during autumn and winter, when the plants are dry and mature, the diets of grazing animals are deficient in certain nutrients.

Nutritive value is governed by complex relationships between the pasture and the animal, and is influenced by climate, soil, pasture composition, the type of animal and the management of both land and animal. The climate (temperature and rainfall) and soil fertility, in addition to the characteristics of the plant species present, are factors that influence both the carrying capacity and the feeding value of a pasture.

Accurate information on the nutritive value of feed is important to animal production. Licitra et al. (1997) reported that the combination of several species in pastures is important because each species has its own vegetative cycle and, therefore, at any time of the forage season, the species present will be in different stages of growth. This, in turn, results in a balancing the nutritional composition of the pasture, in contrast with cultivated forages where fewer species are usually represented.

Chemical composition varies with season, mainly as a result of both a change in the stem-to-leaf ratio and the normal maturing process that causes a translocation of nutrients within the plant parts (Cook, undated).

- Organic matter and crude protein

The organic matter revealed low summer values on both sites, namely, 83.70% and 75.93% for Mara and Mudu, respectively. These low values may be as a result of the animals ingesting herbage contaminated with soil during the wet season, thus increasing the ash values. This finding is in accordance with the findings of Brand et al. (1991).

Mannetje't (1984) reported that ruminants have primary requirements as regards dietary energy and a minimum crude protein level. When dietary crude protein is below the estimated level of 6 to 8.5%, intake will be reduced.

Licitra et al. (1997) reported that the crude protein contents of pasture are low during spring. They recommended 6 to 8% crude protein to satisfy both rumen and animal maintenance requirements. The crude protein on both sites in this study showed seasonal trends of declining from summer to spring. A similar typical seasonal trend as regards crude protein trend was reported by Okello et al. (2005) – 100 g kg/dm in wet season to 49 gkg/ dm in dry season – when working with cattle while De Waal (1990), working with sheep, reported a decline of crude protein from 14.5% during the wet season to 8% during the winter season. Fourie et al. (1986), also working with cattle, reported that the crude protein content varied from an average of 13.6% during the wet season to 5.3% during the dry season. Okello et al. (2005) reported that the peak level during the wet season may be as a result of both the climax of herbage growth, which falls in the late wet season, and increased dietary selectivity with advancing herbage availability.

Faure et al. (1983) reported a crude protein content of between 5 and 20% for sheep grazing on natural pasture but observed no clear trend over the seasons as regards the crude protein content.

Grazing animals have a primary requirement for a dietary energy and minimum crude nutrient levels in order to support the animal production level. The nutrients levels obtained in this study were confirmed to be within the estimated levels of good pasture capable of satisfying the minimum level of animal production

- *Crude fibre (Neutral detergent fibre (NDF) and acid detergent fibre (ADF)*

Okello et al. (2005) reported that 34 to 38% of NDF is optimal for both dietary degradation and feed intake. However, the levels of NDF found in this study were much higher than the optimal level recommended by Okello et al. (2005) but in agreement with Okello et al. (2005), who also reported higher NDF values.

Both the ADF and NDF (cellulose, hemicellulose and lignin) in this study showed a seasonal trend of increasing from summer to spring. This is in accordance with the results reported by Okello et al. (2005) who, when working with cattle, reported that crude fibre reached its highest level immediately prior to the rains returning. Both ADF and NDF are known to be resistant to microbial breakdown, thus leading to longer retention time within the reticulo-rumen.

Dry matter disappearance and rumen ammonia concentration

- *Dry matter disappearance*

The rumen solubility potential degradability of the insoluble material and rate of degradation of the latter are feed characteristics which are important to degradation and which are likely to change with the seasons, according to the cycles of herbage growth and maturity (Okello et al., 2005). The chemical composition of the cell wall and its degree of lignification affect both the potential degradability of the insoluble material as well as the rate of degradation of the insoluble cell wall. The dry matter disappearance in this study showed seasonal variations between silts and low values during the winter season of 31% and 27% for Mara and Mudu, respectively. In addition, the values were significantly lower in winter than in summer on both sites. Similar observations were reported by De Waal (1990) who attributed this finding to the relative resistance to microbial breakdown resulting from senescent herbage during winter. Okello et al. (2005) reported that crude fibre reached its highest level immediately prior to the rains returning (winter season) and known to be resistant to microbial breakdown, thus leading to longer retention time within the reticulo-rumen.

- *Rumen ammonia concentration*

Cheeke (2005) estimated 20 mg/100 ml of rumen fluid as the minimum ammonia concentration necessary for microbial growth while McDonald et al. (1988) and Hacker and Ternouth (1987) estimated the optimum concentration of rumen liquor to vary from 85 to 300 mg/l and 70 to 80 mg/l. The latter also reported that there is still much debate concerning the optimum concentration of rumen ammonia for microbial activity. However, the levels reported in this study are within the permissible range and there were no signs of toxicity (muscular twitching, ataxia, excessive salivation, tetany, bloat and respiration defects) in the animals throughout the duration of this study.

CHAPTER 6

CONCLUSIONS

This study exposed certain concerns about the interaction between people and their environment. In this case, the commercial farmers and their large areas of grazing and the small-scale farmer with communal grazing further complicated the interaction between the people and the environment

The significant difference in the grazing land productivity between commercial and communal farming gave the impression that the former is both superior and sustainable in all aspects of animal productivity and the concomitant financial benefits. This argument is supported by the assumption that the commercial carrying capacity is the requisite yardstick with which to measure pasture management and the marketing of animals in optimal condition for successful animal production. There has little attention given in the past to the fact that a different set of values should be applied to the scoreboard of communal farmers and their farming practices. In the case of communal farmers the evaluation of their animal performance is measured in terms of progeny weaned and animal survival under adverse conditions.

The high stocking rate increases the risks inherent in the communal grazing land, while the denuded condition of the veld led to the conclusion that the carrying capacity was approaching the ecological equilibrium for the specific veld type. Of significant importance also is the resilience of the grazing pasture, which is reflected in the quick recovery of the protected sites in terms of the perennial grass sward. After one season only of rest, the perennial grass composition of the protected site did not differ significantly from that of the Mudu grazing camp. However, this finding is in contrast with the general assumption that several years of rest is required before denuded/overgrazed veld will recover to a stable perennial sward.

The simultaneous grazing of Mara ADC and Mudu by the oesophageal fistulated steers indicated that the nutritive value of the selected material as ingested by the animals was the same for both sites. Any differences in performance between the two sites is not the result of poor quality grazing in the case of communal land, but rather the result of insufficient dry matter intake. This is in contrast with the belief that grazing on overgrazed land is poor as a result of the lower quality of the dry matter intake.

The data of the socio-economic study indicated that there is a complex interaction between primary needs (food and money) and social status (cattle). The data also indicated that communal farmers are both dedicated and committed to their farming practices. However, the overgrazed condition of the grazing land is not of major concern to the livestock owners. This is, in fact, the case in all countries in which communal farming is practised in spite of attempts by local government to enforce stricter natural pasture management. Nevertheless, this is a cause for grave concern as it would appear from household income sources that the rural community is largely dependent on government social funding in order to satisfy its primary financial need.

Accordingly, this situation calls for urgent attention on the part of government to review their involvement strategy with rural communities. Short term relief programmes for poor communities should be abandoned and replaced by long term strategic planning with an inter-governmental liaison committee that involves the tribal authority formulating long-term strategic plans for the region.

The significantly higher dry material production per hectare and the relative palatability at the Mara site compared to the Mudu site highlighted the substantial difference in the quantity, although not so much in the quality, of the plant material. These two factors constitute the grazing capacity of the natural pasture. Calculations of the grazing capacity underline the considerable difference found in terms of the quantity of the natural pasture produced at the Mara site in comparison to the Mudu site. However, in spite of the general expectation that the quality of overgrazed pasture at the Mudu site should be lower than that at the Mara site, no significant difference in quality was recorded.

The demand for cattle far exceeds the local supply as a result of both the high mortality rate of the local people and traditional functions and there is, therefore no need for the organised auctioning of animals. In any case, most of the animals are unbranded and it is, therefore, not possible to sell them on auction.

Livestock is not the main source of income for most of the farmers and many of them hold full-time jobs, for example, teachers, nurses, and business owners, with cattle farming as either a hobby or an additional source of income. This low dependence on income from livestock is probably a natural outcome to lower the risk of farming in communal areas, as income from outside sources serves to lower the risk of farming. However, it is impossible to compare a commercially driven enterprise with the socially driven enterprise. The Mudu farmers are not commercially driven but are more socially driven, using animals for customary purpose and status.

Under the present management conditions it was impossible to compile a complete picture of the value chain with input and output market due to the informal nature of purchases and sales. It is also difficult to plan the marketing of animals under the present management conditions because of the informal nature of the sale and purchase of animals. In addition, it is also difficult to conduct formal research under informal management conditions that will impact directly on the results of the research.

In terms of risk management the natural pasture is totally dependent on favourable environmental conditions. The farmers require the support by local government during adverse conditions, such as high temperatures and low rainfall (drought). The loss of livestock impacts negatively on the income of farmers and may lead to drastic decline in their animal herds. The risk presented by animal diseases warrants the intervention of veterinary services to ensure that losses are kept to a minimum.

In terms of vulnerability, the farmers are usually without any access to funding for improvements, water reticulation, handling facilities, purchase of breeding animals, animal medicines and transport of their animals to market as often, as there is no cooperative in the nearest town. The government should establish special units that attend to the needs of rural farming communities in terms of demonstrations, lectures, visits to successful farming communities, and subsidies during adverse conditions and outbreaks of animal diseases in the area.

The challenges for livestock production in the face of current realities are overwhelming and need urgent resolution. These include frontal attention to the following, inter alia:

- increasing animal protein supplies to match human needs;
- increasing efficiency in natural resource management;
- increasing food and nutritional security;
- mitigating or adapting production systems to deal with climate change threats;
- identifying ways to eliminate the poverty dilemma;
- establishing more concerted poverty alleviation and pro-poor development
- projects;
- improving livelihoods of smallholder farming communities;
- improving self-reliance of smallholder farmers; and
- investing in agricultural growth.

The resolution of these issues hangs in the balance in the developing world. Revitalising pathways to increase productivity and the multifunctional contribution from livestock for developing communities in the future is, therefore, compelling and challenging. Addressing the many interrelated issues is a collective task, emphasising:

- the enduring evolutionary links between humans and livestock,
- the continuing multifunctional contribution of animals, and
- the demonstrable capacity of animal production as one of the important sustaining industries for human welfare in the future.

CHAPTER 7

WAY FORWARD

It is evident from the data collected from the Kutama farming community residents as well as the field data obtained from natural pasture that local actions as well as external inputs may improve the livelihoods of the rural community. The role of African traditional leadership in natural resource management is often underscored in the decision taking and planning of local development with this role varying according to local traditions. There are chiefs who take the role of social authority only while others have jurisdiction over the land. Some of the chiefs are the guardians of the traditions while others are the guardian of social relations (Van Schoubroeck, 2011).

The tribal authority at Tshikwarani has the executive power to enforce development strategies that may progressively improve the livelihood of the residents. This underscores the importance of the tribal authority and confirms the fact that all outside initiatives should respect and take this authority into account if they are to have any chance of success. However, it would appear that external initiatives on the part of the government and private organisations are the prime drivers of change aimed at improving the livelihoods of rural communities. Holistic approaches by inter-governmental initiatives, combined with outside donor funding and the support and cooperation of tribal authorities, should form the backbone of any inputs into these poor rural communities. In addition, short-term relief, for example, mobile clinics, seasonal drought relief programmes and increases in social spending, should gradually be replaced by more ongoing, locally initiated strategies that will not only solve problems but also produce permanent solutions which make use of both local expertise and the local stalwarts' knowledge of development – in other words, the well-known approach of going to the people and learning from the people and then going back to the people and teaching them what you have learned. Inter-governmental committees and external donor funding may then be productively applied to working towards fundamental improvements in the living conditions of the rural poor.

It is evident from the results of this study that livestock farming on its own is unable to provide sufficient financial means for the survival of rural households. Accordingly, households are compelled to become involved in off-farm activities in order to generate enough income to sustain their livelihoods. Against this backdrop, there is a clear need for policy makers to come up with the most suitable ways to ensure that agriculture is less risky, and more profitable and more sustainable.

In order to combat the current veld degradation at the Mudu site, there is a need for natural pasture management practices to change from continuous grazing to rotational grazing in order to ensure both long-term sustainability and pasture improvement .This will require the replanning of the grazing camps, improving water reticulation and erecting additional fencing.

To combat the current veld degradation in the Mudu site, there is a need of changing the farmers' socio-economic practices and mindset inherited from the past where vast land was available, to the current trend characterized by the increasing demand of the land for housing /cash crop and grazing resulting in the available grazing getting smaller leading to veld degradation so significant at Mudu.

The creation of a new intervention plan, which takes into consideration all the above-mentioned problems, regarding over-utilisation and the prevailing lack of support for livestock farmers, may result in long-term solutions to the existing problems at Mudu. In addition, a definite plan aimed at involving the local youth in livestock handling and management may contribute to a better understanding of the value of livestock production and the possibility of animal by-products being used in the creation of artefacts for sale to tourists.

In order to address the multiple problems experienced by the local farming community, local government intervention is needed as regards the following:

- The general health of livestock is of primary importance to the local farmers. At present, vaccines and training on the administration of vaccines is non-existent.

- The availability of fodder during droughts also features high on the farmers' priority list and, thus, assistance in the procurement of fodder during droughts should receive urgent attention.
- The involvement of extension officers and visits to Mara should be arranged for the local farmers. In addition, sponsorships for farmers should be obtained from local companies involved in the sale of feed, and livestock remedies, and so on. It is also important to include the youth in order to cultivate their interest in farming.
- It emerged from the survey conducted that water reticulation is high on the priority list. This problem may be addressed by sinking more boreholes.
- From discussions with the local community it became clear that there is a lack of exposure to any new animal production systems. There would definitely be long term rewards if the local farming community were to be exposed to new ideas and practices.
- In view of the fact that the day to day survival of large numbers of the farmers is made possible by social grants, the local community should be assisted in preparing applications for government grants for local infrastructure development such as handling facilities, water distribution, fencing and fodder subsidies.

In addition, an environmental management plan should be developed in these communal areas in order to prevent the total destruction of the environment as a result of over-utilisation.

Getting it right in communal cattle farming has always been difficult, as many of the people refuse to work together. However, the Vuvha community has made a breakthrough in overcoming this challenge and it has been proved that managing all the community cattle as one herd and sharing resources has worked perfectly for this poverty stricken community in Venda. Nevertheless, this project was not drawn from any formal study nor was it researched. In an attempt to solve the problems that come with communal cattle farming, for example, cattle roaming in the streets and sometimes causing accidents, damaging neighbours' fences, and so on, the village chief, and his friend, came up with this project (Mashala, 2010). Accordingly, there should be a concerted effort made to persuade the local cattle owners at Mudu to investigate the possibility of adopting a similar approach to the handling and management of their animals as this would ensure the proper feeding and health care of the entire cattle herd at Mudu. This project would then be an excellent example to follow as it is also in the same area and with similar customary traditions and culture.

The two systems at present represented by the Mara and the Mudu sites present excellent opportunities for further applied research on animal production that may, in turn, contribute further to our understanding of the complex nature of commercial and subsistence agriculture. The complexities of communal agriculture justify both the research into the problems at Mudu and the comparison drawn between Mudu and other communal farming areas in order to create an awareness of these problems, both nationally and internationally.

In looking toward enhancing the contribution of livestock, a synthesis of the available information identifies several important issues that need to be addressed urgently. These issues, presented below, constitute the challenges and pathways for future direction:

- The multifunctional role and contributions of livestock are varied and numerous, but are currently inadequate to meet projected needs. Vigorous development strategies are needed to enhance nutritional and food security, and to improve livelihoods of developing communities.
- Prevailing livestock production systems are unlikely to change in the foreseeable future, although specialisation and intensification are inevitable. These systems have been severely hampered recently, especially in small farm systems, due to rising costs of production inputs, unpredictable markets and other externalities.
- Development policy and livestock production objectives need clearer definition, as well as institutional commitment for poverty alleviation projects.
- Predictable improvements and sustainable development that have a poverty alleviation focus will require initial assessments and response to important prerequisites in the R&D agenda such as understanding the biophysical environment, aspirations of farming communities, constraints and real needs,

gender equality and empowerment, risks and vulnerability, value chains and innovation and partnerships.

- Given the range and complexity of the issues involved, interdisciplinary R&D using systems perspectives and community-based participation are essential. These efforts need to focus directly on small farm systems, which in Asia and Africa alone account for 95 percent of the 470 million small farms worldwide that have less than 2 ha of land.
- Livestock provide an important entry point for the development of rainfed environments.
- Value chains should be seen in the broader context of the production-postproduction-consumption systems theme.
- More aggressive and innovative efforts are necessary to improve on past efforts in projects designed to address poverty alleviation, which have now been exacerbated.
- Pro-poor poverty initiatives are threatened by climate change, which has to be incorporated into the R&D agenda.
- Creation of appropriate networks will enhance R&D capacity.
- Increased investments in livestock R&D are urgently required.
- Promotion and development of community-based self-help groups and farmer associations and cooperatives, as well as of technology transfer can be enhanced through training and empowerment.
- With specific reference to the developing world, much more needs to be done to accelerate information exchange through innovative and enlightened networking, tapping into the knowledge capital of the developed world, and strengthening South-South linkages, meetings, exchanges and visits.

These future diections have been confirmed by Devendra et al. (2010).

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ANNEXURE 1:

ABSTRACT

UITREKSEL

Abstract

Small-scale livestock production systems are an inherent part of communal livestock farming in the Southern African region and require certain interventions and well-developed management systems to ensure long-term sustainability. To this end a better understanding of the biophysical and socio-economic features of communal farming communities can contribute to the planning and implementation of better focused agricultural development programmes in these areas.

The present study presented a unique opportunity to study and compare two adjacent areas where mainly livestock farming has been practised for generations by, on the one hand, communal farmers who apply limited pasture management, and on the other, the Mara, which uses proven pasture management and rotational grazing, practices. This research presented an opportunity not only to compare livestock production systems but also to determine the impact of communal farming on plant composition and edible plant material production.

The study elicited excitement and enthusiasm among local animal and pasture scientists, as well as social scientists, as the outcome of this study could impact directly on future small-scale livestock farming development.

The objective of this study was twofold. The first objective was to evaluate the socio-economic complexities of small-scale ruminant livestock production under communal farming conditions. To this end, fifty farmer households that share a communal grazing area were surveyed. Data analysis was performed using Statistical Package for Social Sciences (SPSS). Most pertinent results of this study are the following: female animals make up the largest proportion of a herd; the majority of farmers sustain their livelihood from off-farm activity and farm for status not for profit; and farmers farm mainly with the Nguni breed owing to its adaptability to the environment.

Given the socio-economic scenario, the second objective was to investigate the way socio-economic conditions impact on the natural feed resource base. Twelve fistulated Bonsmara steers were used. Rumen fistulated steers were used to

determine the dry matter disappearance and ammonia concentration using nylon bag technique and the Oesophageal fistulated steers were used to determine the chemical composition. Data were analysed with the SAS Statistical package (2002-2003) and the results indicated that there was no significant difference measured between the two sites in terms of ingested dry matter (DM) disappearance from the rumen and chemical composition of ingested material and ammonia production in the rumen and vegetational measurements were all significantly different between the two sites.

The study concludes that differences in the grazing material available in terms of the two systems are a result of the quantity of the dry material available and not the quality. Moreover, livestock farming on its own is declining and is unable to provide sufficient financial returns for the survival of households. Households are consequently compelled to become involved in off-farm activities in order to generate enough income to sustain their livelihoods.

Uittreksel

Kleinskaalse diereproduksie is ‘n inherente deel van kommunale veeboerdery in die Suider Afrikaanse streek en vereis sekere intervensies soos ‘n goed ontwikkelde beplanning en bestuurstelsels ten einde langtermyn-volhoubaarheid te verseker. Ten einde hierdie doelwit te bereik is ‘n beter begrip van die biofisiese en sosio-ekonomiese kenmerke van kommunale boerdery gemeenskappe wat kan bydra tot die beplanning en implimentering van gefokusde landbou-ontwikkelingsprogramme in hierdie gebiede nodig.

Die huidige studie het ten doel gehad om die genoemde twee belangrike aspekte wetenskaplik te ondersoek. Dit het ‘n unieke geleentheid daargestel om twee aangrensende natuurlike weidingsgebiede, waar hoofsaaklik veeboerdery vir geslagte beoefen word, met mekaar te vergelyk. Die twee gebiede is die kommunale boere wat beperkte weidingsbestuur toepas aan die een kant en die Mara Landbou-ontwikklingsinstituut aan die ander kant waar daar wisselweiding toegepas word.

Hierdie navorsingsprojek het die unieke geleentheid geskep om nie net veeproduksie stelsels te vergelyk nie, maar ook die impak van kommunale boerdery op dié van plantspesiesamestelling en benutbare plantmateriaal te bepaal. Die studie het groot opwinding en entoesiasme onder vee- en weidingskundiges sowel as sosiale wetenskaplikes ontlok, aangesien die uitkomste van hierdie studie direkte invloed op die toekomstige strategiese beplannings van kleinskaalse kommunale veeboerdery sal inhou.

Die doel van hierdie studie was tweeledig naamlik om eerstens die sosio-ekonomiese kompleksiteite van kleiskaalse diereproduksie van herkouers (beeste) onder kommunale boerdery toestande te ondersoek en te evalueer.Vir hierdie doel is vyftig plaaslike huishoudings wat kommunale/gemeenskaplike boerdery be-oefen ondervra. Data-analise is uitgevoer op die inligting wat deur die kommunale boere verskaf is deur gebruik te maak van die Statistiese Paket vir Sosiale Wetenskappe (SPSS). Die belangrikste bevindings van hierdie studie was die volgende: Die oorwegende geslag van die beestroppe is vroulik, die meeste boere verdien die

meeste van hul finasiële inkomste deur van die plaas af aktiwiteite te beoefen en boer nie soseer vir inkomste nie, maar eerder vir status en aansien. Die Nguni beesras is veral gewild as gevolg van sy aanpasbaarheid by plaaslike omstandighede.

Die tweede belangrike aspek was om die impak van die twee weidings-bestuurstelsels op die kommunale weiding en Mara Landbou-ontwikkelingsinstituut te bepaal. Daar is van gefistuleerde osse gebruik gemaak om slukdermmonsters en rumenmonsters te kollekteer waarop die samestelling van geselekteerde plantmateriaal (slukderm fistula) en verteerbaarheid en verdwyning uit die grootpens/rumen bepaal is. Die plantopnames was die enigste waarnemings wat betekenisvol verskil het.

Die studie het geen duidelike verskille in terme van kwaliteit (verteerbaarheid) gehad nie, en slegs die kwantiteit (hoeveelheid plant mareriaal) het betekenisvol verskil. Die sosio-ekonomiese ondersoek toon duidelik dat veeboerdery onder huidige kommunale omstandighede nie aan die ekonomiese behoeftes voldoen nie en daar is addisionele inkomste vanuit ander bronne noodsaaklik vir oorlewing.

ANNEXURE 2:
QUESTIONNAIRE

QUESTIONNAIRE

AN EVALUATION OF SOCIO-ECONOMIC, NATURAL RESOURCE AND ENVIRONMENTAL ISSUES COMPLEXITIES OF SMALL-SCALE COMMUNAL LIVESTOCK AND CROP PRODUCTION SYSTEMS BASED ON A CASE STUDY FROM LIMPOPO PROVINCE: MUDULUNI VILLAGE

Name of farmer:…………………………………………………………………………...

Name of the village:……………………………………………………………………….

Telephone number:………………………………………………………………………..

Enumerator ……………………………
TELEPHONE NUMBER……………………..

SECTION A

1. Farmer Household Characteristics

1.1 Number of people in household ☐

1.2 Gender of people in the household. No. of males No. of females ☐ ☐

1.3 Age of people in the farmer's household

Male

Age	1	2	3	4	5	6	7	8	9	10	11
>10											
11-18											
19-30											
31-40											
41-50											
51-60											
60+											

Female

Age	1	2	3	4	5	6	7	8	9	10	11
>10											
11-18											
19-30											
31-40											
41-50											
51-60											
60+											

1.4 The household is headed by:

Father ☐ Mother ☐ Other ☐

If other, specify the relation:

1.5 Marital status of head of the household

Single ☐ Married ☐ Divorced ☐ Widow ☐ Widower ☐

1.6 What is the level of highest education of household members?

	CHILDREN					FARMER	SPOUSE
None							
Grd1-Std 2							
Std 3-Std 6							
Std 6-Std 9							
Std 10							
Tertiary							

1.7 The farmer can speak, read and write the following languages?

	SPEAK	READ	WRITE
English			
Sotho			
Afrikaans			
Others(specify)			

2 Knowledge –Farming Experience

How long have you been farming? [Year]

2.1 Are you a fulltime (FT) or part time (PT) farmer? [FT | PT]

2.2 How long have you been farming on your current farm? [Year]

2.3 How long have you been farming with the current enterprises? [Year]

2.4 What other type of work do you and/ or other members of your household do?

	Self employed	Farm worker	Industry worker	Office worker	Service worker	Professional	Farming only
Farmer							
Spouse							
Child 1							
Child 2							
Child 3							
Child 4							
Child 5							
Child 6							
Other (specify)							

2.5 What is your total household income (R's) per month?

0-499	500-9999	1000-19999	1500-19999	2000-2999	3000-49999	5000+

2.6 What is your income from your farming activity per month?

0-499	500-9999	1000-19999	1500-19999	2000-2999	3000-49999	5000+

2.7 As a farmer, indicate your arithmetic ability?

	None	Little	average	Good
Adding				
Subtracting				
multiplying				
dividing				

SECTION B

3 Farm information

3.1 Who owns the land?

a) Own ☐

b) Lease ☐

c) Tribal ☐

d) Communal ☐

3.2 What is the size of your farm (ha)?

a) Less than 5ha ☐

b) 5-10ha ☐

c) 10-15ha ☐

d) 15-20ha ☐

e) over 20ha ☐

3.3 Is the farm fenced?

Yes ☐

No ☐

3.4 What herd structure do you operate with?

Cows (any female that has calved before)

Age (years)	**Number**
2-3	
3-4	
4-6	
7-9	
More than 9 years	

Heifers (young females which have not calved before)

Age(years)	**Number**
0-1	
1-2	
2-3	

Bulls

Age (years)	**Number**
0-1	
1-3	
3-5	
5-7	
Above 7 years	

Steers

Age (years)	Number	
0-1		
1-3		
3-5		
5-7		
Above 7 years		

3.5 What cattle breed(s) do you use and why? (tick breed and reason applicable)

Crossbreed (give name)	
Bonsmara	
Hereford	
Brahman	
Nguni	
Afrikaner	
Any breed	
Other (specify)	

3.6 Reason for choosing this breed

It was recommended to me	
Because of its size or colour	
Because most other farmers have this breed in the area	
Because it is adapted to my area	
Because it was the cheapest I could get	
I don’t know why I am using this breed	
Other (state)	

3.7 Do you raise other species of animals? If yes, what type of animal(s)

Animal type	**Number of males**	**Number of Females**
Sheep		
Goats		
Chicken		
Other(specify)		

3.7.1 Reasons for keeping livestock

Commercial purposes for money	
For lobola(bride prize)	
Bank on hoofs (Savings)	
Pay school and hospital fees	
For social prestige	
Others (specify)	

3.8 Do you raise crops?

Yes ☐

No ☐

3.9 If yes to (3.8) above, what types of crops do you grow and to what extent (size)?

Type of crop	**Size in hectares**
Maize	
Sorghum	
Millet	
Vegetables	
Fruit	
Other (specify)	

3.10 What do you do with your crop residue?

a) Feed to animals ☐

b) Leave on field ☐

c) burn the residue ☐

d) Sell to other farmers ☐

e) Other (specify) ☐

3.11 If you feed the residue to your stock, do you:

a) Cut and carry to animals ☐
b) Send animals to graze on field ☐
c) Or do you plant the whole crop for the animals ☐

3.12 What other supplements do you provide?

a) Salt licks ☐
b) Mineral licks ☐
c) Mealie concentrates ☐
d) Mixture of above ☐
e) No supplements provide ☐

3.13 Under what conditions do you supplement?

a) Winter ☐
b) Summer ☐
c) Year round ☐
d) During pregnancy ☐
e) only in bad year ☐

3.14 Do you employ any labour? Yes (state number) ☐ No ☐

3.15 If yes, is employment temporary (T) ☐ or permanent (P) ☐

3.16 How many of: Permanent labour ☐ Temporary labour ☐

3.17 How do you pay your workers? I pay with:

Money (R/month)	
Milk(liters /day)	
Grain (kg/month)	
Combination of all or some of above (specify)	
Other (specify)	

3.18 If you pay with money, how much do you pay in total per month to:

Permanent workers	R
Temporary workers	R
Casual workers, if any	R

SECTION C

4 Production and management information

Biological

4.1 Do you keep records on your animals?

Yes ☐

No ☐

4.2 What kind of records do you keep?

Production records i.e births, weight of calf etc.	
Financial records i.e input purchases, income from sales	
Health records i.e diseases	
Sales records	
Others(specify)	

4.3 How do you identify your animals?

a) ear tags ☐

b) fire brand with numbers ☐

c) fire brand tattoos ☐

d) other (specify) ☐

4.4 At what age (months) do your heifers first calve?

a) 24 months ☐

b) 30 months ☐

c) 36 months ☐

d) 42 months ☐

e) 48 months ☐

f) more than 48 months ☐

4.5 How many females calved last year________ and how many had calving difficulties or problems? ____________

4.5.1 What was /were the cause (s) of the difficult births?

a) Large calf ☐

b) Leg out first ☐

☐

c) Wrong presentation (breech)

d) Sick dams ☐

e) Other specify ☐

4.6 At what interval do your females calve:

a) Every year ☐

b) Every 18 months ☐

c) Every 24 months ☐

d) Every 30 monthS ☐

e) 36 months or more ☐

4.7 Do you take the weight of the new born calf? Yes ☐ No ☐

4.8 Do you wean or is separation natural

a) I wean ☐

b) Separation is natural ☐

4.9 If you wean, for what reason do you wean?

a) Time to wean ☐

b) Time to breed ☐

c) Need milk for sale ☐

d) Other ☐

4.10 When do you wean?

a) soon after birth ☐

b) 2-3 months old ☐

c) 4-5 months ☐

d) 6-8 months ☐

e) other specify ☐

4.11 How many calves did you wean or separate successfully last year?

Natural Resource and Environmental issues

4.12 What type of veld do your animals graze from?

a) Communal
b) Trust land
c) Private owner
d) Renting

4.13 Do your animals also graze planted pasture?

a) Only on veld
b) Also on pasture

4.14 What is the size of the grazing veld?............ha, and planted pasture, if any …….ha

4.15 In your view, what is the present state of the veld as compared to when you started grazing your animals?

a) Better
b) same
c) Poorer

4.15.1 When did you start grazing your animals?

4.16 Do you know the carrying capacity of your veld? Yes No

4.17 On how many hectares do you need to graze one cow with a calf per year for optimum production?

a) less than 2ha
b) 2-4 ha

4.18 What measures do you take to ensure adequate feed supply during winter and periods of feed shortage?

a) Store fodder
b) Buy fodder
c) Borrow from neighbor
d) Sell some animals
e) I do nothing

4.19 Do your animals graze on the same veld all year long or you move them?

a) Graze same veld ☐

b) Move once ☐

c) Twice ☐

d) More than twice ☐

4.20 Based on what do you move them?

a) veld status ☐

b) Time to move ☐

c) Season ☐

d) No more feed ☐

4.21 Are there any signs of erosion? a) Yes ☐ b) No ☐

4.22 If yes, how severe is the erosion?

a) Very bad ☐ b) Bad ☐

4.23 What do you think is (are) the cause(s)?

a) Too many animals ☐

b) Stormy rains ☐

c) Wind ☐

d) Fire ☐

e) Bad cropping practices ☐

4.24 Have you made any attempt to prevent /control the erosion?

a)Yes ☐

b) No ☐

If yes, what do you do?

a) I don’t know what to do ☐

b) I am planting trees ☐

c) I am moving my animals ☐

d) Erecting contour ☐

e) Other ☐

Production Risk Reduction

4.25 Do you have any form of insurance against theft, loss of income etc?

a)Yes ☐

b)No ☐

4.26 Do you undertake any external, internal, disease control or vaccination programme?

a) Yes ☐

b) No ☐

If yes, indicate type of remedy and number of times / year

External parasites e.g. Ticks

Conventional Remedy Type	Traditional Remedy Type	No. of Times per year

Internal parasites e.g. Worms

Conventional Remedy Type	Traditional / Herbal	No. of Times per year

Vaccinations

DISEASES VACCINATED AGAINST	**NAME OF VACCINE USED**	NO. OF TIMES VACCINATED
1. Black quarter/ anthrax	1.Blanthrax	
2 .Heartwater	2.Terramycin	
3.Ticks	3.Deadline-pour on dip	
4.Mastitis	4. Terramycin-blue	

General medication e.g. Wounds

Name of common diseases	**Name of drug / antibiotic**	No. of times /yr
1.Wounds	Supona aerosol or Terramycin wound powder	
2.Eyes problem	Terramycin eye-powder	

4.27 Are your animals sheltered at night and in winter?

a) Yes

b) No

4.28 If yes, what type of shelter do you provide?

a) Roofless kraal

b) Roofed kraal

c) Open yard with trees

d) On the veld

4.29 How often do you see an extension officer?

How often do you see a vet	
Once/year	
Twice	
I don't see a vet	

4.30 Do you go (travel) to the extension officer or he /she comes to visit you at the farm?

a) I go (travel) to him / her

b) He / she comes to me

4.31 Are veterinary services or surgeon used? Yes ☐ No ☐

If yes indicate how many times?

Once per year	
Twice per year	
Three times per year	
Four times per year	
Five times per year	
I don't see a Vet .officer at all	

4.32 Do you go (travel) to the vet officer/ vet clinic or he/she comes to visit you at your farm?

a) I go(travel) to him /her

b) He / she comes to me

4.33 If veterinary services are not used please indicate as many reasons as possible.

Veterinary services are too expensive	
Have no money to afford Vet. Services	
Veterinary services are not easily available	
Have no transport to get sick animals to Veterinary surgeon	
Veterinary services are not necessary	
Other	

4.34 What source(s) of information do you make of in your day to day decisions on the farm?

	Management and production decisions i.e. time to breed, supplement, etc	Financial decisions i.e buying inputs	Marketing decisions i.e time to sell and where, what price, etc	When you need training or advice
Extension officers				
Co-farmers (neighbors)				
Radio and / or television				
Co-operative manager				
Extension publications (newsletters, periodicals etc				
Own records				
Other				

4.34.1 To what extent to you rely on advice and assistance from your neighbours?

4.34.2 To what extent to you rely on advice and assistance from the extension officer?

4.35 What type of bull do you use for cattle breeding?

Registered bred bull	
Own bred bull	
Communally owned bull	
Borrow from neighbours	
Any bull available	
Artificial insemination	
Other (specify)	

4.36 Do you make use of breeding season or do your male (s) run with the female stock?

a) Use breeding season

b) Male(s) run with female all year

4.37 If you use breeding season when do you breed?

a) Winter

b) SummeR

c) Spring

d) Autumn

4.38 How many of the following animals died last year, and for what reason?

Animal group	Number of deaths	Reason for death (Choose answer from reasons given below)
Cows		
Bulls		
Heifers		
Young bulls		
Oxen		
Steers		

Reasons for death

Sickness
Hunger or starvation,
Killed by cars (accident) etc
Attacked by predators
Stolen
Other (specify)

Marketing Management

4.39 Are there output markets available within an accessible distance from your farm?

Yes ☐ No ☐

4.40 Through which marketing system(s) do you market your livestock ?

	Cattle	Other livestock
Auction or public sale		
Private sale		
Middlemen		
Cooperative		
Butchery		
Open market in town		
Local livestock traders		
Other (specify)		

4.41 Indicate the products that you usually offer for sale.

a) Live animals ☐

b) Milk ☐

c) Meat ☐

d) Dung ☐

e) other (specify) ☐

4.42 For what reasons do you sell the product(s) indicated above?

a) Routine sale for cash ☐

b) To pay school /hospital fees ☐

c) For funeral expenses ☐

d) In bad agricultural years (i.e drought) ☐

e) Other (specify) ☐

4.43 If you milk your animals

a) Do you leave calves with dams all day ☐
b) Separate calves from dam during the day ☐
c) Separate calves at night ☐
d) Separate calves soon after birth and bucket feed ☐

4.44 How many cows did you milk last year? State number.

4.45 Did you milk your cows

a) all year ☐
b) only in summer ☐
c) in winter ☐

4.46 If you sell milk or meat, how often do you sell?

a) Daily ☐
b) Weekly ☐
c) Monthly ☐
d) Occasionally ☐

4.47 How many times per year do you organize your sales?

a) All year round
b) Two times a year
c) Three times a year
d) When needed

Economic Viability

4.48 How much did you spend on your farm for the last year?

Item	**Amount (R)**
Purchase of animals	
Feed and supplements	
Veterinary services and drugs	
Labour (permanent and temporary)	
Machinery and equipment	
Transport and marketing	

Extension services	
Training	
Levies i.e on communal grazing land etc	
Loan repayments	
Other (specify)	
Other (specify)	

4.49 How much did you get from the sale of the following last year?

Item	**Amount (R)**
Weaners	
Cows	
Bulls	
Oxen	
Steers	
Milk	
Meat	
Dung	
Other animals except cattle i.e sheep, goats, chicken	
Crops	
Others (specify)	

4.50 Do you have any other income besides income from the farm activity?

Yes ☐ No ☐

4.51 If yes, from what sources?

State sources of extra income	**Amount (R) per year**
Pension fund	
Tuck shop	
Transport business	
Subsidies i.e from Govt, NGO's, Coop, etc	
From other family members	
Other (specify)	

Social Acceptability

4.52 Are you satisfied with the welfare of your family? Yes ☐ No ☐

4.53 If no, give reason (s) why you not satisfied.

Too much debt	
Constant lack of money to maintain family	
Poor housing for my family	
Lack of money to expand farm	
Farm income not enough	
Other (specify)	

4.54 Do you borrow money for your farming activities?

Yes ☐ No ☐

4.55 If 'yes' indicate source, amount borrowed, interest rate and monthly payment.

	Amount borrowed	**Monthly repayment**	**Interest rate**
Cooperative			
Commercial banks (name)			
Credit unions			
Family and friends			
Land bank			
Agric. Credit board			
Suppliers credit			
Other (specify)			

4.56 How far is your farm or settlement from town and the following services?

	Less than 1km	**Between 1 and 2km**	**Between 2 and 3km**	**More 3km**
Facility				
Telephones				
Schools				
Health facilities				
Recreational facilities				
Post offices				
Main Roads				
Veterinary services				
Extension services				
Co-operatives				
Others (indicate)				

4.57 What problems do you have with your neighbours / community because of your cattle farming activities?

a) They destroy other people's crops ☐
b) Destroy the water source ☐
c) Invade and graze other farmers land ☐
d) Bring diseases and flies ☐
e) Expected to pay more for water used by my animals ☐
f) No complains and getting on well with my neighbours ☐

4.58 Are you personally happy with the progress being made on your livestock business

Yes No ☐ ☐

If 'yes' give reason (s)

I am making enough money out of it	
It has enhance my status in the community	
I have a new sense of security for my family	
Other (specify)	

If ‘no’ give reason(s)

I am not making enough money	
It has put me in debt	
I don’t get any support from any source	
Have problems with neighbours as a result of my animals	
Other reasons (specify)	

4.59 Do you think you need technical help or any other assistance to do better than you are currently doing or you are convinced that you are on track to becoming a successful livestock farmer?

Yes, I need help ☐ No, I don’t need help ☐

Type of help	Reason why you need this help
Type of help	
Camps	
Financial support	
Veterinary and ext services	
Subsidy of medicines	
Training	
Dipping and handling facility	
Water	
Fence along the road	
Drought relief	

4.60 Give any comment or information that you think is necessary to know about your farm.

ANNEXURE 4

VELD SURVEY AND DATA COLLECTED AT MARA AND MUDU

Veld survey and data collection on Mara and adjacent communal area						
Stand no	Sample no	Sub 1	Sub 2	Sub 3	Sub 4	Density
Stand 1	1	S. pappo	E. rigid	A. cong	U. mos	13
Madodonga	2	S. pappo	D. eri	P. col	P. col	2
Camp	3	U. mos	U. mos	A. cong	U. mos	8
next to	4	U. mos	T. berte	T. berte	T. bert	22
village	5	U. mos	T. berte	U. mos	T. bert	2
	6	T.berte	A. cong	U. mos	A. cong	16
	7	A. cong	U. mos	U. mos	U. mos	17
	8	U. mos	U. mos	U. mos	T. bert	31
	9	none	none	none	T. bert	3
	10	A. cong	M. caf	T. berte	M. caf	13
	11	T.berte	U. mos	A. cong	A. cong	13
	12	E. rigid	T. berte	E. bar	E. rigid	6
	13	M. rep	P. max	P. max	E. rigid	3
	14	E. bar	S. pappo	S. pappo	E. bar	3
	15	E. lem	T. berte	A. cong	T. bert	19
	16	T.berte	T. berte	U. mos	U. mos	32
	17	T.berte	A. cong	T. berte	C. pyc	24
	18	T.berte	T. berte	T. berte	U. mos	20
	19	A. cong	T. berte	A. cong	A. cong	13
	20	E. bar	U. mos	E. bar	M. caf	10
	21	T.berte	T. berte	T. berte	M. rep	23
	22	U. mos	E. rigid	T. berte	E. bar	21
	23	U. mos	U. mos	U. mos	U. mos	12
	24	T.berte	E. bar	U. mos	T. bert	13
	25	E. rigid	U. mos	T. berte	T. bert	18
	26	U. mos	T. berte	T. berte	T. bert	12
	27	T.berte	T. berte	A. cong	T. bert	16
	28	T.berte	T. berte	U. mos	T. bert	14
	29	U. mos	T. berte	U. mos	T. bert	11
	30	U. mos	U. mos	none	U. mos	1
	31	T.berte	P. col	U. mos	T. bert	16
	32	A. cong	T. berte	A. cong	U. mos	5
	33	none	T. berte	E. lem	E.lem	2
	34	U. mos	U. mos	U. mos	T. bert	10
	35	E. bar	U. mos	E. bar	E. bar	13
	36	A. cong	U. mos	U. mos	none	7
	37	E. lem	A. cong	none	E. lem	14
	38	U. mos	T. berte	T. berte	T. bert	10
	39	U. mos	T. berte	T. berte	T. bert	31
	40	U. mos	T. berte	U. mos	U. mos	9

	41	A. cong	U. mos	U. mos	U. mos	11
	42	U. mos	E. lem	T. berte	U. mos	22
	43	none	U. mos	T. berte	T. bert	6
	44	A. cong	A. cong	E. lem	U. mos	8
	45	T.berte	U. mos	E. bar	T. bert	22
	46	A. cong	T. berte	U. mos	U. mos	8
	47	T.berte	T. berte	T. berte	T. bert	16
	48	U. mos	E. bar	U. mos	U. mos	7
	49	E. bar	D. eri	E. bar	D. eri	13
	50	E. bar	M. caf	T. berte	E. bar	11
	51	A. cong	T. berte	U. mos	A. cong	14
	52	D. eri	U. mos	T. berte	U. mos	7
	53	E. bar	A. cong	A. cong	A. cong	1
	54	E. bar	none	none	E. bar	0
	55	M. caf	D. eri	M. caf	M. caf	13
	56	A. cong	U. mos	U. mos	E. rigid	10
	57	S. pappo	U. mos	E. bar	T. bert	7
	58	P. max	U. mos	T. berte	P. max	10
	59	P. max	T. berte	E. bar	A. cong	9
	60	E. bar	U. mos	U. mos	E. bar	7
	61	U. mos	U. mos	E. bar	T. bert	32
	62	U. mos	T. berte	U. mos	A. cong	8
	63	T.berte	U. mos	U. mos	U. mos	6
	64	U. mos	T. berte	U. mos	T. bert	11
	65	U. mos	P. col	U. mos	P. col	17
	66	U. mos	U. mos	U. mos	U. mos	9
	67	E. bar	U. mos	T. berte	A. cong	16
	68	A. cong	U. mos	U. mos	A. cong	17
	69	none	none	none	none	0
	70	E. lem	U. mos	U. mos	U. mos	1
	71	U. mos	C. pyc	U. mos	T. bert	14
	72	T.berte	T. berte	T. berte	T. bert	10
	73	T.berte	T. berte	T. berte	T. bert	14
	74	E. lem	U. mos	U. mos	U. mos	12
	75	U. mos	U. mos	T. berte	U. mos	3
	76	T.berte	U. mos	A. cong	A. cong	25
	77	U. mos	U. mos	U. mos	U. mos	6
	78	T.berte	U. mos	U. mos	T. bert	4
	79	T.berte	T. berte	T. berte	A. cong	17
	80	T.berte	T. berte	U. mos	none	0
	81	T.berte	U. mos	T. berte	T. bert	15
	82	T.berte	T. berte	U. mos	A. cong	23
	83	T.berte	M. caf	T. berte	M. caf	9
	84	A. cong	T. berte	T. berte	T. bert	1
	85	T.berte	A. cong	T. berte	T. bert	11

	86	A. cong	T. berte	T. berte	U. mos	14
	87	A. cong	A. cong	T. berte	T. bert	21
	88	T.berte	E. bar	T. berte	A. cong	13
	89	T.berte	M. caf	E. bar	E. bar	5
	90	U. mos	T. berte	M. caf	T. bert	12
	91	M. caf	M. caf	M. caf	T. bert	11
	92	A. cong	T. berte	T. berte	E. bar	12
	93	E. bar	T. berte	U. mos	E. bar	23
	94	T.berte	E. bar	E. bar	T. bert	8
	95	T.berte	T. berte	T. berte	T. bert	4
	96	P. col	T. berte	T. berte	E. rigid	12
	97	E. bar	U. mos	T. berte	T. bert	9
	98	T.berte	T. berte	U. mos	U. mos	11
	99	U. mos	T. berte	E. bar	U. mos	2
	100	U. mos	T. berte	E. bar	T. bert	6

Veld survey and data collection on Mara and adjacent communal area						
Stand no	Sample no	Sub 1	Sub 2	Sub 3	Sub 4	Density
Stand 2	1	T.berte	E. bar	E. bar	E. bar	1
Muduluni	2	T.berte	A. cong	A. cong	A. cong	9
camp	3	A. cong	none	none	T. bert	1
middle of	4	none	none	U. mos	U. mos	0
camp	5	U. mos	A. cong	U. mos	none	2
	6	A. cong	none	none	none	1
	7	A. cong	A. cong	M. caf	T. bert	20
	8	T.berte	A. cong	A. cong	A. cong	2
	9	A. cong	A. cong	A. cong	E. bar	11
	10	U. mos	U. mos	T. berte	A. cong	13
	11	T.berte	A. cong	A. cong	A. cong	20
	12	none	none	none	none	0
	13	U. mos	T. berte	U. mos	U. mos	2
	14	A. cong	U. mos	U. mos	U. mos	5
	15	A. cong	A. cong	none	U. mos	1
	16	A. cong	A. cong	E. bar	A. cong	23
	17	U. mos	T. berte	T. berte	U. mos	10
	18	U. mos	U. mos	U. mos	U. mos	2
	19	none	U. mos	none	U. mos	6
	20	U. mos	U. mos	U. mos	E. bar	1
	21	U. mos	none	E. bar	none	2
	22	A. cong	E. bar	U. mos	E. bar	15
	23	none	none	none	none	0
	24	U. mos	U. mos	E. bar	U. mos	34
	25	none	U. mos	none	E. bar	2
	26	U. mos	U. mos	U. mos	U. mos	7
	27	none	U. mos	U. mos	U. mos	8
	28	U. mos	U. mos	U. mos	T. bert	8
	29	U. mos	A. cong	none	U. mos	5
	30	U. mos	A. cong	U. mos	U. mos	13
	31	A. cong	T. berte	T. berte	U. mos	4
	32	U. mos	U. mos	U. mos	U. mos	26
	33	A. cong	U. mos	A. cong	U. mos	5
	34	U. mos	U. mos	U. mos	U. mos	21
	35	A. cong	A. cong	A. cong	U. mos	12
	36	U. mos	U. mos	U. mos	A. cong	32
	37	U. mos	U. mos	U. mos	U. mos	4
	38	U. mos	U. mos	U. mos	U. mos	24
	39	U. mos	E. bar	E. bar	E.bar	3
	40	U. mos	U. mos	none	A. cong	2

	41	E. bar	E. bar	E. bar	E. bar	9
	42	U. mos	U. mos	U. mos	E. bar	10
	43	none	none	A. cong	A. cong	1
	44	none	none	E. bar	E. bar	3
	45	U. mos	E. bar	E. bar	E. bar	2
	46	U. mos	U. mos	T. berte	T. bert	27
	47	none	U. mos	T. berte	none	0
	48	A. cong	A. cong	T. berte	A. cong	16
	49	none	none	U. mos	U. mos	1
	50	U. mos	A. cong	U. mos	U. mos	6
	51	none	none	none	none	0
	52	T.berte	A. cong	U. mos	U. mos	4
	53	U. mos	U. mos	U. mos	T. bert	11
	54	E. bar	U. mos	none	none	4
	55	T.berte	U. mos	U. mos	T. bert	12
	56	none	none	none	none	0
	57	none	none	none	T. bert	0
	58	U. mos	E. bar	none	E. bar	3
	59	none	U. mos	U. mos	U. mos	6
	60	U. mos	E. bar	A. cong	U. mos	8
	61	U. mos	U. mos	U. mos	U. mos	11
	62	U. mos	T. berte	U. mos	U. mos	3
	63	U. mos	U. mos	U. mos	U. mos	8
	64	T.berte	U. mos	U. mos	geen	5
	65	none	U. mos	none	none	1
	66	U. mos	E. bar	U. mos	S. pappo	2
	67	A. cong	T. berte	T. berte	A. cong	5
	68	T.berte	A. cong	A. cong	A. cong	3
	69	none	none	A. cong	U. mos	0
	70	U. mos	A. cong	U. mos	U. mos	22
	71	U. mos	U. mos	U. mos	U. mos	11
	72	U. mos	A. cong	U. mos	none	0
	73	U. mos	U. mos	U. mos	U. mos	6
	74	none	none	none	none	0
	75	none	none	none	none	0
	76	U. mos	U. mos	U. mos	U. mos	17
	77	none	none	A. cong	A. cong	0
	78	E. bar	A. cong	E. bar	T. bert	8
	79	E. bar	U. mos	A. cong	A. cong	11
	80	A. cong	A. cong	A. cong	T. bert	27
	81	T.berte	A. cong	A. cong	A. cong	16
	82	U. mos	T. berte	A. cong	U. mos	27
	83	U. mos	E. bar	U. mos	U. mos	5
	84	U. mos	U. mos	U. mos	A. cong	14

	85	U. mos	A. cong	A. cong	A. cong	29
	86	none	U. mos	T. berte	U. mos	15
	87	U. mos	U. mos	E. bar	U. mos	3
	88	U. mos	U. mos	U. mos	U. mos	3
	89	A. cong	A. cong	none	A. cong	14
	90	U. mos	none	T. berte	U. mos	1
	91	T.berte	E. bar	E. bar	none	6
	92	U. mos	U. mos	U. mos	U. mos	17
	93	none	none	none		1
	94	U. mos	U. mos	U. mos	U. mos	16
	95	none	none	none	none	0
	96	none	none	U. mos	U. mos	2
	97	A. cong	A. cong	U. mos	A. cong	2
	98	none	A. cong	A. cong	A. cong	2
	99	A. cong	A. cong	A. cong	E. bar	2
	100	E. bar	E. bar	E. bar	E. bar	8

Veld survey and data collection on Mara and adjacent communal area						
Site no	Sample no	Sub 1	Sub 2	Sub 3	Sub 4	Density
Site 3	1	E. rigid	E. rigid	E. rigid	E. rigid	29
Manavhela	2	E. rigid	E. rigid	E. rigid	M. rep	16
camp	3	E. rigid	A. cong	E. rigid	E. rigid	13
next to	4	E. rigid	E. rigid	E. rigid	U. mos	15
Mara	5	A. cong	E. rigid	U. mos	none	3
	6	E. rigid	A. cong	A. cong	E. rigid	16
	7	U. mos	U. mos	U. mos	E. rigid	2
	8	U. mos	U. mos	E. lem	U. mos	1
	9	U. mos	U. mos	E. lem	E. rigid	5
	10	E. rigid	E. rigid	E. rigid	E. rigid	25
	11	A. cong	T. berte	P. max	A. cong	30
	12	T.berte	E. rigid	T. berte	A. cong	26
	13	A. cong	E. lem	A. cong	A. cong	7
	14	A. cong	A. cong	U. mos	U. mos	20
	15	A. cong	none	E. rigid	E. rigid	0
	16	E. rigid	U. mos	E. rigid	A. cong	22
	17	none	E. lem	E. lem	U. mos	6
	18	E. rigid	A. cong	E. rigid	E. rigid	32
	19	A. cong	A. cong	U. mos	A. cong	20
	20	E. rigid	U. mos	E. rigid	U. mos	34
	21	U. mos	U. mos	A. cong	A. cong	2
	22	U. mos	U. mos	T. berte	A. cong	43
	23	U. mos	P. max	A. cong	U. mos	20
	24	U. mos	T. berte	U. mos	T. bert	1
	25	E. rigid	E. rigid	U. mos	E. rigid	8
	26	E. lem	E. lem	E. lem	E. rigid	32
	27	A. cong	U. mos	U. mos	A. cong	22
	28	A. cong	A. cong	U. mos	E. rigid	21
	29	U. mos	U. mos	U. mos	A. cong	10
	30	U. mos	A. cong	A. cong	U. mos	45
	31	U. mos	U. mos	A. cong	A. cong	14
	32	A. cong	E. rigid	A. cong	U. mos	39
	33	A. cong	U. mos	A. cong	U. mos	14
	34	U. mos	U. mos	U. mos	U. mos	19
	35	U. mos	A. cong	A. cong	E. rigid	12
	36	T.berte	U. mos	U. mos	U. mos	10
	37	U. mos	U. mos	U. mos	U. mos	5
	38	U. mos	A. cong	U. mos	U. mos	15
	39	U. mos	U. mos	U. mos	A. cong	14
	40	A. cong	U. mos	U. mos	A. cong	29
	41	U. mos	U. mos	U. mos	U. mos	11

	42	A. cong	A. cong	A. cong	E. rigid	58
	43	A. cong	U. mos	A. cong	E. rigid	19
	44	A. cong	E. rigid	A. cong	A. cong	54
	45	A. cong	A. cong	A. cong	A. cong	14
	46	A. cong	U. mos	A. cong	A. cong	31
	47	U. mos	U. mos	U. mos	U. mos	15
	48	A. cong	E. lem	U. mos	U. mos	41
	49	U. mos	U. mos	E. rigid	U. mos	14
	50	A. cong	E. rigid	E. rigid	U. mos	24
	51	T.berte	none	E. lem	U. mos	3
	52	U. mos	T. berte	U. mos	T. bert	14
	53	E. rigid	E. lem	U. mos	A. cong	2
	54	E. lem	E. rigid	U. mos	U. mos	10
	55	T.berte	T. berte	A. cong	U. mos	26
	56	A. cong	U. mos	E. rigid	U. mos	12
	57	A. cong	A. cong	A. cong	U. mos	20
	58	E. lem	E. lem	E. rigid	E. rigid	5
	59	E. rigid	U. mos	U. mos	U. mos	3
	60	B. nig	B. nig	U. mos	U. mos	19
	61	T.berte	U. mos	A. cong	E. rigid	7
	62	U. mos	U. mos	U. mos	A. cong	16
	63	E. rigid	E. rigid	T. berte	A. cong	22
	64	E. rigid	E. rigid	E. rigid	none	5
	65	U. mos	E. rigid	U. mos	E. rigid	11
	66	none	none	E. rigid	E. rigid	0
	67	E. rigid	A. cong	A. cong	U. mos	44
	68	T.berte	none	U. mos	E. rigid	0
	69	A. cong	A. cong	E. rigid	A. cong	31
	70	A. cong	A. cong	U. mos	E. rigid	28
	71	E. lem	E. rigid	E. rigid	U. mos	22
	72	U. mos	E. rigid	E. rigid	E. rigid	5
	73	U. mos	U. mos	U. mos	U. mos	8
	74	U. mos	U. mos	U. mos	U. mos	2
	75	U. mos	U. mos	U. mos	U. mos	5
	76	U. mos	U. mos	none	T. bert	3
	77	U. mos	M. rep	U. mos	U. mos	18
	78	U. mos	U. mos	U. mos	A. cong	8
	79	A. cong	A. cong	A. cong	A. cong	31
	80	E. rigid	E. rigid	E. rigid	E. rigid	7
	81	A. cong	U. mos	U. mos	U. mos	12
	82	E. rigid	A. cong	A. cong	E. rigid	28
	83	U. mos	U. mos	U. mos	E. rigid	20
	84	U. mos	A. cong	E. rigid	none	0
	85	U. mos	none	none	none	0

	86	U. mos	none	none	none	0
	87	T.berte	T. berte	T. berte	none	0
	88	E. rigid	U. mos	E. rigid	U. mos	7
	89	E. lem	E. lem	U. mos	E. lem	5
	90	T.berte	T. berte	U. mos	U. mos	5
	91	T.berte	T. berte	T. berte	T. bert	7
	92	E. rigid	E. rigid	E. rigid	A. cong	10
	93	A. cong	A. cong	A. cong	U. mos	6
	94	T.berte	A. cong	A. cong	U. mos	12
	95	M. rep	A. cong	A. cong	E. rigid	20
	96	U. mos	U. mos	none	none	2
	97	E. lem	E. lem	E. lem	E. lem	4
	98	A. cong	A. cong	U. mos	U. mos	26
	99	C. dac	E. rigid	C. dac	C. dac	8
	100	none	none	E. rigid	E. rigid	0

Veld survey and data collection on Mara and adjacent communal area						
Site no	Sample no	Sub 1	Sub 2	Sub 3	Sub 4	Density
Site 4	1	P. max	P. max	P. max	none	3
Mara	2	U. mos	U. mos	U. mos	U. mos	4
Camp:135	3	D. eri	S. pappo	S. pappo	S. pappo	3
back of	4	none	none	P. max	P. max	2
camp	5	T.berte	D. eri	S. pappo	B. nig	3
	6	S. pappo	S. pappo	U. mos	E. rigid	3
	7	E. rigid	U. mos	S. pappo	U. mos	6
	8	E. rigid	T. berte	A. cong	T. bert	5
	9	E. rigid	T. berte	U. mos	U. mos	3
	10	U. mos	U. mos	T. berte	none	3
	11	S. pappo	T. berte	S. pappo	P. col	11
	12	P. col	none	P. col	none	0
	13	S. pappo	S. pappo	U. mos	S. pappo	6
	14	U. mos	P. col	U. mos	S. pappo	4
	15	P. max	P. max	E. rigid	E. rigid	1
	16	E. rigid	S. pappo	E. rigid	S. pappo	3
	17	U. mos	U. mos	E. rigid	S. pappo	3
	18	S. pappo	S. pappo	E. rigid	E. rigid	3
	19	P. max	D. eri	P. max	P. max	1
	20	none	E. rigid	S. pappo	E. rigid	5
	21	S. pappo	P. max	S. pappo	S. pappo	3
	22	U. mos	U. mos	T. berte	T. bert	3
	23	S. pappo	E. rigid	P. max	U. mos	3
	24	E. rigid	U. mos	U. mos	U. mos	7
	25	U. mos	U. mos	S. pappo	U. mos	5
	26	M. caf	M. caf	P. col	none	0
	27	S. pappo	S. pappo	S. pappo	S. pappo	5
	28	S. pappo	A. cong	D. eri	S. pappo	7
	29	P. max	P. max	E. bar	U. mos	3
	30	E. rigid	U. mos	U. mos	none	1
	31	D. eri	E. rigid	S. pappo	E. rigid	6
	32	S. pappo	S. pappo	E. rigid	E. rigid	5
	33	E. rigid	S. pappo	E. rigid	D. eri	5
	34	S. pappo	S. pappo	D. eri	T. bert	4
	35	P. max	P. max	S. pappo	S. pappo	3
	36	A. cong	S. pappo	D. eri	E. rigid	3
	37	E. rigid	P. max	U. mos	D. eri	2
	38	S. pappo	P. col	E. rigid	U. mos	2
	39	P. max	U. mos	D. eri	E. rigid	4
	40	D. eri	D. eri	D. eri	D. eri	5

	41	P. col	P. col	U. mos	P. col	7
	42	D. eri	S. pappo	U. mos	U. mos	4
	43	U. mos	T. berte	U. mos	D. eri	4
	44	E. rigid	E. rigid	E. rigid	D. eri	5
	45	U. mos	E. rigid	P. max	P. max	7
	46	E. rigid	E. rigid	S. pappo	S. pappo	2
	47	U. mos	D. eri	U. mos	U. mos	9
	48	E. rigid	none	E. rigid	D. eri	4
	49	P. max	P. max	P. max	none	2
	50	P. col	E. rigid	T. berte	U. mos	4
	51	S. pappo	D. eri	U. mos	U. mos	8
	52	E. rigid	E. rigid	none	S. pappo	5
	53	E. rigid	E. rigid	U. mos	S. pappo	2
	54	S. pappo	S. pappo	S. pappo	U. mos	4
	55	P. max	E. rigid	S. pappo	S. pappo	3
	56	P. max	D. eri	P. col	T. bert	3
	57	E. rigid	E. rigid	E. rigid	E. rigid	6
	58	E. rigid	U. mos	none	E. rigid	3
	59	U. mos	P. col	P. col	U. mos	4
	60	E. rigid	U. mos	P. col	U. mos	5
	61	E. rigid	none	S. pappo	S. pappo	0
	62	U. mos	U. mos	U. mos	U. mos	2
	63	E. rigid	E. rigid	S. pappo	E. rigid	1
	64	P. max	P. max	none	P. max	2
	65	P. max	P. max	P. max	A. cong	2
	66	P. max	P. max	S. pappo	P. max	2
	67	E. rigid	U. mos	U. mos	T. bert	8
	68	U. mos	P. max	U. mos	E. bar	3
	69	S. pappo	A. cong	S. pappo	T. bert	4
	70	U. mos	U. mos	U. mos	U. mos	7
	71	U. mos	U. mos	T. berte	E. rigid	5
	72	U. mos	P. max	U. mos	P. max	2
	73	U. mos	A. cong	U. mos	U. mos	3
	74	S. pappo	U. mos	E. rigid	U. mos	7
	75	P. max	none	E. rigid	P. max	4
	76	E. rigid	S. pappo	none	E. rigid	5
	77	E. rigid	none	E. rigid	E. rigid	2
	78	E. rigid	E. rigid	E. rigid	E. rigid	3
	79	P. max	S. pappo	P. col	P. max	
	80	S. pappo	S. pappo	U. mos	P. max	5
	81	U. mos	E. rigid	none	none	2
	82	P. max	P. max	P. max	P. max	9
	83	P. max	P. max	P. max	U. mos	2
	84	P. max	P. max	P. max	none	1

	85	E. rigid	E. rigid	E. rigid	none	4
	86	E. rigid	P. col	P. col	P. col	4
	87	S. pappo	S. pappo	E. rigid	E. rigid	8
	88	U. mos	P. col	P. col	P. col	4
	89	S. pappo	U. mos	U. mos	U. mos	6
	90	P. col	P. col	P. col	P. col	6
	91	E. rigid	P. col	P. col	E. rigid	8
	92	U. mos	U. mos	E. rigid	P. col	4
	93	P. max	P. max	P. max	none	2
	94	P. max	P. max	P. max	P. max	2
	95	P. col	S. pappo	P. col	U. mos	4
	96	P. max	P. max	P. max	P. col	4
	97	P. max	none	none	U. mos	0
	98	none	U. mos	P. max	P. max	0
	99	U. mos	E. rigid	none	T. bert	2
	100	P. col	S. pappo	T. berte	P. max	3

Veld survey and data collection on Mara and adjacent communal area						
Site no	Sample no	Sub 1	Sub 2	Sub 3	Sub 4	Density
Site 5	1	E. rigid	E. rigid	T. berte	T. bert	5
Mara	2	E. rigid	S. pappo	S. pappo	E. rigid	4
Camp: 135	3	U. mos	S. pappo	S. pappo	E. rigid	4
front of	4	M. caf	M. caf	M. caf	M. caf	15
camp	5	none	U. mos	U. mos	U. mos	0
	6	U. mos	S. pappo	none	M. rep	6
	7	M. rep	T. berte	S. pappo	M. caf	2
	8	U. mos	E. rigid	U. mos	U. mos	9
	9	E. rigid	E. rigid	E. rigid	none	2
	10	E. rigid	S. pappo	U. mos	M. caf	7
	11	U. mos	U. mos	U. mos	S. pappo	4
	12	M. rep	E. rigid	none	A. cong	4
	13	E. rigid	D. eri	E. rigid	none	6
	14	T.berte	T. berte	U. mos	U. mos	6
	15	U. mos	U. mos	U. mos	none	7
	16	T.berte	U. mos	U. mos	U. mos	7
	17	T.berte	U. mos	T. berte	A. cong	6
	18	U. mos	U. mos	T. berte	U. mos	14
	19	E. lem	U. mos	E. rigid	A. cong	2
	20	U. mos	U. mos	U. mos	U. mos	8
	21	E. rigid	T. berte	U. mos	U. mos	4
	22	P. max	none	P. max	P. max	2
	23	U. mos	U. mos	U. mos	U. mos	4
	24	U. mos	U. mos	U. mos	U. mos	13
	25	S. pappo	S. pappo	P. max	P. max	2
	26	P. max	P. max	P. max	P. max	3
	27	P. max	U. mos	U. mos	S. pappo	7
	28	T.berte	T. berte	U. mos	U. mos	3
	29	U. mos	U. mos	U. mos	U. mos	8
	30	M. rep	T. berte	S. pappo	E. rigid	6
	31	E. rigid	U. mos	U. mos	T. bert	3
	32	U. mos	U. mos	U. mos	U. mos	7
	33	P. col	E. rigid	U. mos	E. rigid	4
	34	U. mos	T. berte	U. mos	none	5
	35	A. cong	M. rep	U. mos	U. mos	17
	36	U. mos	P. col	P. max	none	0
	37	E. rigid	E. rigid	U. mos	U. mos	7
	38	U. mos	U. mos	U. mos	U. mos	2
	39	U. mos	U. mos	U. mos	U. mos	8
	40	M. rep	U. mos	U. mos	U. mos	5
	41	P. max	P. max	none	P. col	6

	42	M. rep	U. mos	U. mos	U. mos	3
	43	S. pappo	S. pappo	S. pappo	U. mos	1
	44	U. mos	U. mos	U. mos	P. col	3
	45	E. rigid	U. mos	U. mos	E. rigid	3
	46	E. rigid	S. pappo	S. pappo	U. mos	4
	47	U. mos	U. mos	A. cong	T. bert	14
	48	U. mos	U. mos	U. mos	P. col	2
	49	M. rep	S. pappo	T. berte	S. pappo	6
	50	U. mos	S. pappo	U. mos	E. rigid	12
	51	P. max	P. max	T. berte	T. bert	6
	52	E. rigid	S. pappo	E. rigid	E. rigid	3
	53	S. pappo	S. pappo	S. pappo	E. rigid	5
	54	S. pappo	S. pappo	S. pappo	S. pappo	6
	55	E. rigid	D. eri	U. mos	E. rigid	6
	56	U. mos	P. max	T. berte	U. mos	9
	57	U. mos	S. pappo	S. pappo	A. cong	1
	58	U. mos	U. mos	E. rigid	U. mos	7
	59	U. mos	U. mos	E. rigid	E. rigid	5
	60	U. mos	U. mos	A. cong	U. mos	3
	61	P. max	U. mos	E. rigid	U. mos	2
	62	P. col	S. pappo	S. pappo	U. mos	7
	63	T.berte	U. mos	U. mos	none	4
	64	S. pappo	U. mos	E. rigid	U. mos	4
	65	S. pappo	S. pappo	S. pappo	P. max	1
	66	A. cong	A. cong	A. cong	A. cong	4
	67	T. trian	P. col	T. trian	A. cong	5
	68	P. col	none	A. cong	P. max	2
	69	S. pappo	none	S. pappo	U. mos	5
	70	S. pappo	A. cong	E. rigid	A. cong	7
	71	U. mos	U. mos	U. mos	P. col	3
	72	U. mos	U. mos	U. mos	P. col	2
	73	none	P. max	P. max	P. max	1
	74	P. max	U. mos	P. max	U. mos	2
	75	U. mos	U. mos	U. mos	U. mos	8
	76	U. mos	T. berte	none	none	7
	77	P. max	E. rigid	E. rigid	E. rigid	1
	78	E. rigid	T. berte	T. berte	U. mos	3
	79	U. mos	U. mos	P. max	U. mos	3
	80	P. max	P. max	U. mos	P. max	4
	81	T. berte	T. berte	P. max	U. mos	10
	82	T. berte	U. mos	U. mos	U. mos	2
	83	E. rigid	E. rigid	T. berte	E. rigid	8
	84	U. mos	U. mos	U. mos	P. max	4
	85	E. rigid	U. mos	P. max	E. rigid	8

	86	none	E. lem	U. mos	U. mos	4
	87	U. mos	U. mos	P. max	E. rigid	3
	88	U. mos	P. max	E. rigid	E. rigid	3
	89	U. mos	E. rigid	P. max	E. rigid	8
	90	U. mos	P. col	P. col	P. max	3
	91	P. max	P. max	P. max	P. max	1
	92	S. pappo	E. rigid	E. rigid	S. pappo	2
	93	E. rigid	E. rigid	U. mos	U. mos	3
	94	U. mos	U. mos	U. mos	U. mos	2
	95	P. max	P. max	P. max	P. col	1
	96	U. mos	S. pappo	A. cong	U. mos	5
	97	T. berte	U. mos	S. pappo	U. mos	4
	98	U. mos	U. mos	U. mos	S. pappo	17
	99	U. mos	U. mos	U. mos	U. mos	7
	100	U. mos	E. rigid	P. col	E. rigid	8

Veld survey and data collection on Mara and adjacent communal area						
Site no	Sample no	Sub 1	Sub 2	Sub 3	Sub 4	Density
Site 5	1	E. rigid	E. rigid	T. berte	T. bert	5
Mara	2	E. rigid	S. pappo	S. pappo	E. rigid	4
Camp: 135	3	U. mos	S. pappo	S. pappo	E. rigid	4
front of	4	M. caf	M. caf	M. caf	M. caf	15
camp	5	none	U. mos	U. mos	U. mos	0
	6	U. mos	S. pappo	none	M. rep	6
	7	M. rep	T. berte	S. pappo	M. caf	2
	8	U. mos	E. rigid	U. mos	U. mos	9
	9	E. rigid	E. rigid	E. rigid	none	2
	10	E. rigid	S. pappo	U. mos	M. caf	7
	11	U. mos	U. mos	U. mos	S. pappo	4
	12	M. rep	E. rigid	none	A. cong	4
	13	E. rigid	D. eri	E. rigid	none	6
	14	T.berte	T. berte	U. mos	U. mos	6
	15	U. mos	U. mos	U. mos	none	7
	16	T.berte	U. mos	U. mos	U. mos	7
	17	T.berte	U. mos	T. berte	A. cong	6
	18	U. mos	U. mos	T. berte	U. mos	14
	19	E. lem	U. mos	E. rigid	A. cong	2
	20	U. mos	U. mos	U. mos	U. mos	8
	21	E. rigid	T. berte	U. mos	U. mos	4
	22	P. max	none	P. max	P. max	2
	23	U. mos	U. mos	U. mos	U. mos	4
	24	U. mos	U. mos	U. mos	U. mos	13
	25	S. pappo	S. pappo	P. max	P. max	2
	26	P. max	P. max	P. max	P. max	3
	27	P. max	U. mos	U. mos	S. pappo	7
	28	T.berte	T. berte	U. mos	U. mos	3
	29	U. mos	U. mos	U. mos	U. mos	8
	30	M. rep	T. berte	S. pappo	E. rigid	6
	31	E. rigid	U. mos	U. mos	T. bert	3
	32	U. mos	U. mos	U. mos	U. mos	7
	33	P. col	E. rigid	U. mos	E. rigid	4
	34	U. mos	T. berte	U. mos	none	5
	35	A. cong	M. rep	U. mos	U. mos	17
	36	U. mos	P. col	P. max	none	0
	37	E. rigid	E. rigid	U. mos	U. mos	7
	38	U. mos	U. mos	U. mos	U. mos	2
	39	U. mos	U. mos	U. mos	U. mos	8
	40	M. rep	U. mos	U. mos	U. mos	5
	41	P. max	P. max	none	P. col	6

	42	M. rep	U. mos	U. mos	U. mos	3
	43	S. pappo	S. pappo	S. pappo	U. mos	1
	44	U. mos	U. mos	U. mos	P. col	3
	45	E. rigid	U. mos	U. mos	E. rigid	3
	46	E. rigid	S. pappo	S. pappo	U. mos	4
	47	U. mos	U. mos	A. cong	T. bert	14
	48	U. mos	U. mos	U. mos	P. col	2
	49	M. rep	S. pappo	T. berte	S. pappo	6
	50	U. mos	S. pappo	U. mos	E. rigid	12
	51	P. max	P. max	T. berte	T. bert	6
	52	E. rigid	S. pappo	E. rigid	E. rigid	3
	53	S. pappo	S. pappo	S. pappo	E. rigid	5
	54	S. pappo	S. pappo	S. pappo	S. pappo	6
	55	E. rigid	D. eri	U. mos	E. rigid	6
	56	U. mos	P. max	T. berte	U. mos	9
	57	U. mos	S. pappo	S. pappo	A. cong	1
	58	U. mos	U. mos	E. rigid	U. mos	7
	59	U. mos	U. mos	E. rigid	E. rigid	5
	60	U. mos	U. mos	A. cong	U. mos	3
	61	P. max	U. mos	E. rigid	U. mos	2
	62	P. col	S. pappo	S. pappo	U. mos	7
	63	T.berte	U. mos	U. mos	none	4
	64	S. pappo	U. mos	E. rigid	U. mos	4
	65	S. pappo	S. pappo	S. pappo	P. max	1
	66	A. cong	A. cong	A. cong	A. cong	4
	67	T. trian	P. col	T. trian	A. cong	5
	68	P. col	none	A. cong	P. max	2
	69	S. pappo	none	S. pappo	U. mos	5
	70	S. pappo	A. cong	E. rigid	A. cong	7
	71	U. mos	U. mos	U. mos	P. col	3
	72	U. mos	U. mos	U. mos	P. col	2
	73	none	P. max	P. max	P. max	1
	74	P. max	U. mos	P. max	U. mos	2
	75	U. mos	U. mos	U. mos	U. mos	8
	76	U. mos	T. berte	none	none	7
	77	P. max	E. rigid	E. rigid	E. rigid	1
	78	E. rigid	T. berte	T. berte	U. mos	3
	79	U. mos	U. mos	P. max	U. mos	3
	80	P. max	P. max	U. mos	P. max	4
	81	T. berte	T. berte	P. max	U. mos	10
	82	T. berte	U. mos	U. mos	U. mos	2
	83	E. rigid	E. rigid	T. berte	E. rigid	8
	84	U. mos	U. mos	U. mos	P. max	4
	85	E. rigid	U. mos	P. max	E. rigid	8

	86	none	E. lem	U. mos	U. mos	4
	87	U. mos	U. mos	P. max	E. rigid	3
	88	U. mos	P. max	E. rigid	E. rigid	3
	89	U. mos	E. rigid	P. max	E. rigid	8
	90	U. mos	P. col	P. col	P. max	3
	91	P. max	P. max	P. max	P. max	1
	92	S. pappo	E. rigid	E. rigid	S. pappo	2
	93	E. rigid	E. rigid	U. mos	U. mos	3
	94	U. mos	U. mos	U. mos	U. mos	2
	95	P. max	P. max	P. max	P. col	1
	96	U. mos	S. pappo	A. cong	U. mos	5
	97	T. berte	U. mos	S. pappo	U. mos	4
	98	U. mos	U. mos	U. mos	S. pappo	17
	99	U. mos	U. mos	U. mos	U. mos	7
	100	U. mos	E. rigid	P. col	E. rigid	8

Veld survey and data collection on Mara and adjacent communal area						
Site no	Sample no	Sub 1	Sub 2	Sub 3	Sub 4	Density
Site 6	1	T. berte	U. mos	U. mos	none	3
Mara	2	E. rigid	P. col	E. rigid	E. rigid	3
Camp:135	3	P. max	S. pappo	P. max	P. max	5
middle of	4	S. pappo	P. col	D. eri	E. rigid	5
camp	5	P. max	U. mos	P. col	none	2
	6	U. mos	none	P. max	P. max	1
	7	P. max	P. max	P. max	P. max	5
	8	E. rigid	P. max	P. max	P. max	1
	9	E. rigid	U. mos	U. mos	U. mos	9
	10	D. eri	U. mos	U. mos	P. col	3
	11	P. max	P. max	P. max	P. max	7
	12	E. rigid	P. max	E. rigid	E. rigid	4
	13	E. rigid	T. berte	E. rigid	U. mos	7
	14	none	P. max	U. mos	S. pappo	3
	15	E. rigid	M. rep	U. mos	D. eri	6
	16	P. col	S. pappo	T. berte	U. mos	2
	17	P. col	P. col	S. pappo	P. col	2
	18	P. col	P. col	U. mos	P. col	2
	19	S. pappo	P. max	U. mos	T.berte	3
	20	E. rigid	E. rigid	T. berte	U. mos	1
	21	U. mos	E. rigid	P. col	E. rigid	6
	22	U. mos	U. mos	P. max	geen	1
	23	U. mos	T. berte	S. pappo	U. mos	3
	24	S. pappo	P. col	P. col	T.berte	2
	25	E. rigid	E. rigid	E. rigid	S. pappo	4
	26	E. rigid	none	P. col	E. rigid	0
	27	none	none	E. rigid	E. rigid	1
	28	P. max	P. max	P. max	P. max	3
	29	P. max	P. max	U. mos	P. max	9
	30	E. rigid	P. max	P. max	P. max	2
	31	E. rigid	E. rigid	E. rigid	U. mos	10
	32	S. pappo	S. pappo	S. pappo	S. pappo	3
	33	S. pappo	S. pappo	P. col	S. pappo	10
	34	E. rigid	A. cong	S. pappo	A. cong	3
	35	T. berte	S. pappo	S. pappo	S. pappo	2
	36	E. rigid	U. mos	S. pappo	S. pappo	4
	37	E. rigid	S. pappo	E. rigid	E. rigid	4
	38	E. rigid	E. lem	U. mos	U. mos	1
	39	S. pappo	E. rigid	E. rigid	S. pappo	6
	40	S. pappo	P. max	S. pappo	S. pappo	4

	41	S. pappo	D. eri	S. pappo	D. eri	6
	42	none	D. eri	E. rigid	T.berte	1
	43	P. col	U. mos	P. col	U. mos	7
	44	P. max	T. berte	U. mos	U. mos	4
	45	E. rigid	U. mos	U. mos	U. mos	11
	46	D. eri	D. eri	U. mos	P. max	3
	47	E. rigid	S. pappo	E. rigid	E. rigid	4
	48	none	none	A. cong	U. mos	1
	49	P. col	P. col	P. col	S. pappo	8
	50	D. eri	U. mos	P. col	S. pappo	10
	51	P. max	U. mos	P. max	P. max	3
	52	T. berte	U. mos	P. col	P. max	2
	53	U. mos	U. mos	U. mos	D. eri	5
	54	P. col	D. eri	E. rigid	E. bar	8
	55	D. eri	S. pappo	D. eri	D. eri	6
	56	P. col	P. col	P. col	P. col	4
	57	S. pappo	E. rigid	U. mos	none	5
	58	E. rigid	none	E. rigid	E. rigid	2
	59	D. eri	P. col	P. col	D. eri	2
	60	U. mos	P. max	P. max	E. rigid	4
	61	E. rigid	E. rigid	D. eri	geen	3
	62	E. rigid	U. mos	S. pappo	S. pappo	4
	63	P. max	U. mos	P. max	P. max	4
	64	S. pappo	E. rigid	E. rigid	U. mos	7
	65	S. pappo	P. col	P. col	D. eri	7
	66	D. eri	D. eri	T. berte	E. rigid	4
	67	S. pappo	U. mos	S. pappo	S. pappo	5
	68	E. rigid	E. rigid	S. pappo	E. rigid	5
	69	D. eri	P. col	P. max	P. col	1
	70	U. mos	U. mos	U. mos	D. eri	6
	71	P. max	P. col	P. col	P. col	3
	72	S. pappo	S. pappo	U. mos	U. mos	11
	73	U. mos	U. mos	U. mos	S. pappo	7
	74	P. max	U. mos	U. mos	U. mos	4
	75	P. max	U. mos	T. berte	S. pappo	6
	76	U. mos	D. eri	P. max	U. mos	8
	77	A. cong	A. cong	U. mos	U. mos	4
	78	S. pappo	E. rigid	U. mos	S. pappo	7
	79	A. cong	S. pappo	S. pappo	A. cong	5
	80	S. pappo	U. mos	U. mos	S. pappo	5
	81	S. pappo	S. pappo	S. pappo	U. mos	5
	82	S. pappo	U. mos	S. pappo	E. rigid	5
	83	S. pappo	A. cong	S. pappo	U. mos	6
	84	P. col	S. pappo	U. mos	U. mos	8

	85	E. rigid	S. pappo	S. pappo	U. mos	6
	86	P. max	S. pappo	S. pappo	S. pappo	8
	87	P. col	S. pappo	E. rigid	S. pappo	2
	88	U. mos	S. pappo	P. col	E. rigid	9
	89	S. pappo	A. cong	S. pappo	E. rigid	8
	90	U. mos	U. mos	U. mos	U. mos	10
	91	S. pappo	U. mos	T. berte	U. mos	8
	92	U. mos	U. mos	D. eri	U. mos	7
	93	U. mos	E. rigid	D. eri	U. mos	6
	94	E. rigid	E. rigid	E. rigid	E. rigid	4
	95	P. max	A. cong	A. cong	U. mos	4
	96	E. rigid	D. eri	T. berte	E. rigid	3
	97	S. pappo	U. mos	U. mos	S. pappo	5
	98	E. rigid	E. rigid	E. rigid	E. rigid	9
	99	E. rigid	S. pappo	S. pappo	A. cong	5
	100	E. rigid	none	E. rigid	U. mos	4

Mudulun camp:
Veld condition are very poor, mostly denuded or covered by pioneergrass species.
Productivity of the grass layer is low and soil erosion is visible
The tree layer consists of Acasias that encroashed the area and copiced vigerouisly dueto harvesting of fire wood by the community to harvesting of fire wood by the community.

Mara camp:
Veld conditions are moderate to good with a moderate grass cover of Increaser grass species
Productivity of the grass layers is relatively high with little signs of soil erosion.
The tree layer consists of a mixture of Acacia species and broad leave species that are dense but not encroached.

ANNEXURE 3:

NATURAL RESOURCE FEED BASE

Rainfall

TABLE A1

Rainfall figures (mm) for 2000–2003

MONTH	2000	2001	2002	2003	AVERAGE 1994 – 2003
January	133.9	24.8	35.2	65.2	84.34
February	314.1	72.5	4.1	39.1	95.09
March	67.0	61.9	39.7	31.0	59.94
April	58.9	28.5	4.7	0.0	20.03
May	23.0	17.6	0.0	1.6	14.88
June	13.0	5.1	13.3	14.1	4.75
July	4.9	2.8	0.0	0.0	6.88
August	0.0	0.0	0.0	0.0	0.33
September	0.2	0.0	9.8	0.0	4.78
October	34.2	28.9	11.2	69.9	40.45
November	87.8	146.6	18.5	52.2	64.39
December	28.9	81.3	97.1	50.4	59.61

Chemical composition of natural veld at Mara and Mudu

Site: Mara

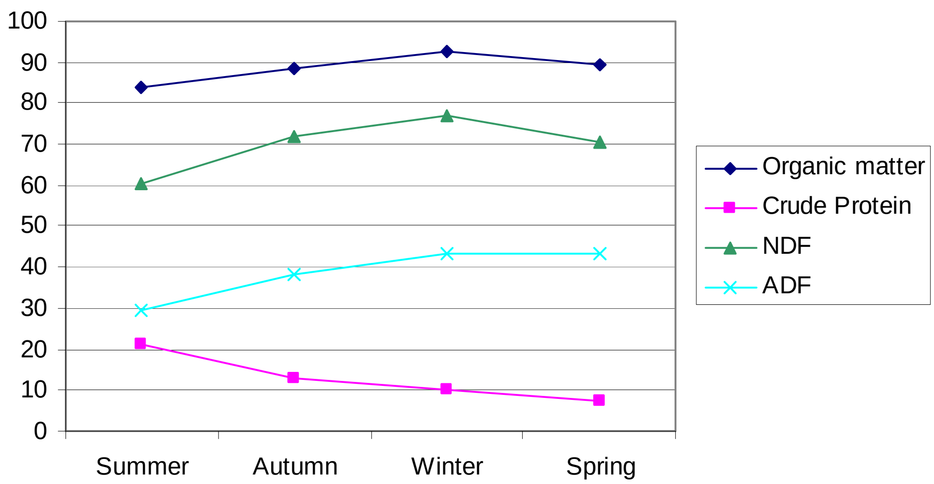

Figure A1. The content of organic matter, crude protein, neutral detergent fibre and acid detergent fibre (%) in the oesophageal samples collected from the experimental steers grazing at Mara

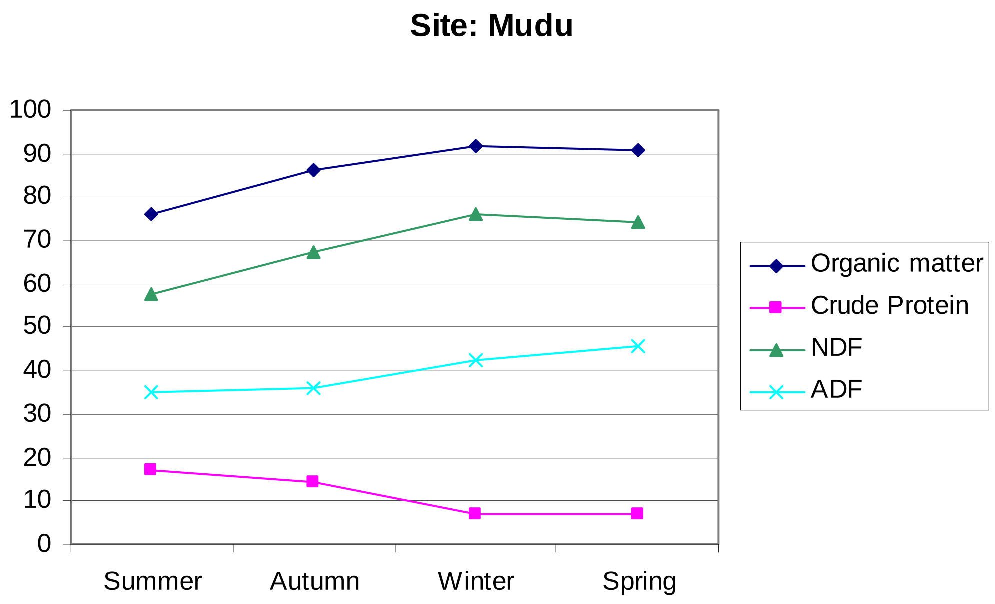

Figure A2. The content of organic matter, crude protein, neutral detergent fibre and acid detergent fibre (%) in the oesophageal samples collected from the experimental steers grazing at Mudu

Dry matter production

The t-test for the averages is presented in the table below. The t = –2.15 falls in the critical region of {t < –2.132}. This means that the hypothesis of equal means is rejected and confirms the derived conclusion that the average production of DM per season is higher at the Mara site compared to the communal site.

t-Test: Two samples assuming unequal variances

	MUDU	MARA
Mean	732.6667	1686
Variance	219121.3	370825.0
Observations	3	3
Hypothesised mean difference	0	
Df	4	
t Stat	-2.14981	
P(T<=t) one-tail	0.049001	

t Critical one-tail	2.131846
P(T<=t) two-tail	0.098003
t Critical two-tail	2.776451

Palatability scores

Test of hypotheses

$H_0 : \overline{WPC}_1 = \overline{WPC}_2$

vs.

$H_a : \overline{WPC}_1 \neq \overline{WPC}_2$

According to Mendenhall, Beaver and Beaver (2006: 409), the test of hypotheses should be conducted as follows:

$$t_{cal} = \frac{\overline{WPC}_1 - \overline{WPC}_2 - (\mu_{WPC1} - \mu_{WPC2})}{\sqrt{S^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

TABLE A2

t-Test: Paired Two Sample for Means

	MARA	**MUDU**
	WEIGHTED PS	**WEIGHTED PS**
Variance	633.907	700.3537
Observations	16	16
Pearson correlation	0.670854	
Hypothesized mean difference	0	
Df	15	
P(T<=t) one-tail	0.190613	
t Critical one-tail	1.753051	
P(T<=t) two-tail	0.381226	
t Critical two-tail	2.131451	

$$S^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2} = \frac{15(633.91 + 700.35)}{30} = 667.13$$

$$\sqrt{S^2\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}=\sqrt{667.13\left(\frac{1}{16}+\frac{1}{16}\right)}=9.13$$

$$t_{cal}=\frac{\overline{WPC}_1-\overline{WPC}_2-(\mu_{WPC1}-\mu_{WPC2})}{\sqrt{S^2\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}}$$

$$=\frac{82.54-45.06-0}{9.13}$$

$$=4.11$$

This tcal = 4.11 falls in the critical region of {t < -2.13, t > 2.13}.There is, thus, statistical evidence to reject the hypothesis of equal WPCs.

The tcal = 0.9022 falls outside the critical values (t < -2.13, t > 2.13).Hence, there is no statistical evidence to reject the hypothesis of equal WPC means. Thus, there is no reason to believe that the two WPCs are different.

Ammonia Concentration (%)

TABLE A3: The ammonia concentration (%) in the rumen collected from the experimental steers grazing at Mara and Mudu

AMMONIA CONCENTRATION (%)				
SEASON	**MARA**	**ST**	**MUDU**	**ST**
Summer	5.13 [a]	0.3333	6.5 [a]	0.3333
Autumn	6.68 [b]	0.4083	5.02 [b]	0.4083
Winter	6.26 [c]	0.5773	4.51 [c]	0.5773
Spring	2.52 [d]	0.4083	3.35 [d]	0.4083

TABLE A4

t-Test: Paired Two Sample for Means

	MARA	**MUDU**
Mean	896.25	857.25
Variance	426.9167	5676.917
Observations	4	4
Pearson correlation	0.999658	
Hypothesised mean difference	0	
Df	3	
t Stat	1.42614	
P(T<=t) one-tail	0.12454	
t Critical one-tail	2.353363	
P(T<=t) two-tail	0.24908	
t Critical two-tail	3.182449	

TABLE A5

t-Test: Paired Two Sample for Means

	MARA	**MUDU**
Mean	916.75	874
Variance	1582.25	9367.33
Observations	4	4
Pearson correlation	0.960899	
Hypothesised mean difference	0	
Df	3	
t Stat	1.434815	
P(T<=t) one-tail	0.123413	
t Critical one-tail	2.353363	
P(T<=t) two-tail	0.246827	
t Critical two-tail	3.182449	

TABLE A6

t-Test: Paired Two Sample for Means

	MARA	**MUDU**
Mean	117	105.5
Variance	4850	2953.667
Observations	4	4
Pearson correlation	0.8578	
Hypothesised mean difference	0	
Df	3	
t Stat	0.635385	
P(T<=t) one-tail	0.285164	
t Critical one-tail	2.353363	
P(T<=t) two-tail	0.570329	
t Critical two-tail	3.182449	

TABLE A7

t-Test: Paired Two Sample for Means

	MARA	**MUDU**
Mean	117	105.5
Variance	4850	2953.667
Observations	4	4
Pearson correlation	0.8578	
Hypothesised mean difference	0	
Df	3	
t Stat	0.635385	
P(T<=t) one-tail	0.285164	
t Critical one-tail	2.353363	
P(T<=t) two-tail	0.570329	
t Critical two-tail	3.182449	

TABLE A8

t-Test: Paired Two Sample for Means

	MARA	**MUDU**
Mean	724	687.75
Variance	5030.667	10048.92
Observations	4	4
Pearson correlation	0.963285	
Hypothesised mean difference	0	
Df	3	
t Stat	1.950516	
P(T<=t) one-tail	0.0731	
t Critical one-tail	2.353363	
P(T<=t) two-tail	0.1462	
t Critical two-tail	3.182449	

Weighted Capability Capacity (WPC)

The critical region for test of equality of the WPCs at the 5% significance level is given by $\{t < -2.13; \;\; t > 2.13\}$.The calculated value is higher than the critical value (in Appendix, tcr = 4.11), which leads to the rejection of the null hypothesis at the 5% level of significance. This means that there is enough statistical evidence that the weighted palatability capacities (WPCs) of the two sites are not identical (Table 55).