EVALUATION OF THE NGUNI CATTLE REPRODUCTIVE PERFORMANCE IN THE COMMUNAL PROPERTY ASSOCIATION AND PRIVATELY OWNED ENTERPRISES ACROSS THE DIFFERENT ECOLOGICAL ZONES OF MPUMALANGA PROVINCE

By

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A FULL-DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE MASTERS DEGREE IN AGRICULTURAL MANAGEMENT (ANIMAL PRODUCTION), DEPARTMENT OF AGRICULTURAL ECONOMICS AND ANIMAL PRODUCTION, SCHOOL OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES, FACULTY OF SCIENCE AND AGRICULTURE, UNIVERSITY OF LIMPOPO, SOUTH AFRICA

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DECLARATION

I declare that the dissertation hereby submitted to the University of Limpopo, for the degree of Master of Agricultural Management (Animal Production) has not previously been submitted by me for a degree at this or any other university; that it is my work in design and in execution, and that all material contained herein has been duly acknowledged.

_____ _____

Sambo J.M. (Mr) **Date**

DEDICATION

To my late father (Ndleleni Alson Sambo), my mother (Rose Pinky Sambo) and most of all: my wife Monica Zoliswa Sambo and daughters (Thulisa, Iviwe, Sethu and Olwethu)

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ABSTRACT

The Nguni is indigenous multi-purpose cattle breed that plays an important role in both commercial and communal farming systems in South Africa (SA). Unfortunately, the breed is currently under threat of diminishing due to farmers' preference for exotic breeds and cross breeding. In recognition of the above, the Industrial Development Corporation, the Mpumalanga Department of Agriculture, Rural Development, Land and Environmental Affairs and the University of Limpopo established the Nguni cattle breed preservation project. In this project, a herd of 30 Nguni heifers and 1 bull were allocated to 34 Communal Property Associations (CPA) and 40 private farming enterprises each. With its three distinct ecological zones (High, Mid and Low-veld), the Mpumalanga province poses a challenge to the Nguni preservation project since cattle have to adapt to different ecological zones in order to grow and reproduce efficiently. Knowledge of cattle herd productivity improves the understanding of the functional attributes and is useful in determining the constraints and the potential of communal beef cattle production systems. Significant differences between ecological zones were observed for age at first calving, weaning rate, calves' birth weight and calves' weaning weight ($p < 0.05$). Calving of heifers in the Mid-veld zone occurred earlier (24 months) on both ownership types compared to Highveld (28.09 months for private and 26.00 for CPA) and the Lowveld (28.35 months for both ownerships). Nguni cattle on the Highveld performed better in terms of weaning rate under both private and CPA ownerships, where the weaning rate were 93% and 80%, respectively. Calves birth weight was lower in both ownership types in the Midveld zone (22.17 kg), whereas in the CPA, the Lowveld zone had higher calves birth weights (26.80 kg). In the private ownership, the highest calves' birth weight (25.35 kg) was on the Highveld. The calves weaning weight were significantly higher ($p < 0.05$) on Highveld in private ownership (190.16 kg) and lowest (160.39 kg) in the Midveld zone. For the CPA, the highest calves weaning weight was also on the Highveld (187.55) and lowest on Midveld (167.50 kg). A full range of backup services that are offered to the communities by stakeholders in the form of a beef package that includes veld and pasture management, nutrition management, beef performance, animal recording keeping, genetic evaluation and animal health management program needs thorough attention.

Keywords: Communal Property Association (CPA), Privately owned enterprises, ecological zones, age at first calving of heifers, conception rate, calving rate, weaning rate, calves birth weight and calves weaning weight

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LIST OF ACRONYMS

ANOVA	Analysis of Variance
DARDLEA	Department of Agriculture, Rural Development, Land and Environmental Affairs
GLM	General Linear Model
IDC	Industrial Development Corporation
H0	Null hypotheses
Ha	Alternative hypotheses
MDB	Municipal Demarcation Board
MP	Mpumalanga province
NAMC	National Agricultural Marketing Council
NERPO	National Emergent Red Meat Producer's Organisation
NRMDP	National Red Meat Development Programme
NDA	National Department of Agriculture
SA	South Africa
UL	University of Limpopo
XLSTAT	Statistical Software for Microsoft Excel

CLARIFICATION OF CONCEPTS

Age at first calving of heifers

Number of months of a heifer born and raised from birth to calving.

Analysis of variance

Is a collection of statistical models and their associated estimation procedures used to analyse the differences among groups of means in a sample.

Calve birth weight

A weight of a calf at birth.

Calve weaning weight

A weight of a calf at weaning age.

Calving rate

Is the pregnancy percentage minus any embryonic or fatal death loss.

Conception rate

A measure of a cow's fertility at service.

Ecological zone

Is a land resource mapping unit, defined in terms of climate, land reform and soils and/or land cover and having specific range of potentials and constrains of land use.

Highveld Zone

The Highveld region is mainly comprised of the grassland veld types with azonal vegetation in patches.

Lowveld Zone

Lowveld is comprised of the savanna veld types and forest biomes.

Mean of squares

Are estimates of variance across groups.

Midveld Zone

The Midveld zone falls in the transitional zone between the savannah and grassland biomes**.**

Nguni cattle

The Nguni cattle is an indigenous multi-purpose breed.

Ownership type

The state or fact of exclusive rights and control over property, which may be an object, land/real estate or intellectual property.

P Value

The p-value is a number between o and 1 and is interpreted in the following way: a small p value (typically<0.05) indicates strong evidence against the null hypotheses, so you reject the null hypotheses.

Sum of squares

Sum of squares measures how far individual measurements are from the mean.

Weaning rate

The number of calves weaned divided by the number of females mated.

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Animal production contributes significantly to the livelihoods and food security of many people around the world through the supply of meat, protein and other animal products (Shackleton *et al*., 2005). In South Africa (SA), there are approximately 14.1 million cattle, and the majority of which are found in communal areas (National Department of Agriculture [NDA], 2008). The Mpumalanga province commands the greater share of beef cattle production in SA, accounting for 22% of the beef produced in 2008 (NDA. 2008). Mpumalanga province has played an important role in the export of beef since 1999 with increased export values recorded from 2000 to 2004 but declined to low levels in 2005 before increasing again in 2008 (NDA, 2008). Most cattle in rural areas are non-descript crossbreeds with small populations of local breeds such as Afrikaner, Bonsmara and Drakensberger (Palmer & Ainslie, 2006). The introduction of exotic breeds for crossbreeding programmes, the lack of records and use of uncontrolled mating system in communal areas have led to non-descript genotypes of unknown genetic characterization being predominant at the expense of indigenous breed such as the Nguni cattle (Bayer *et al*., 2004; Scholtz *et al*., 2008). These practices threaten the existence of the indigenous Nguni breed (Ramsay *et al*., 2000).

The Nguni cattle is one of SA most popular indigenous cattle breeds (Nguni Cattle Breed Society, 2008). It is a multi-purpose breed that plays an important role in both commercial and communal farming systems (Ramsay *et al*., 2000). Previously, Nguni cattle were perceived as inferior by the SA industrial beef sector due to low production outputs (Bester *et al*., 2003). It is postulated that colonialism and lack of performance recording schemes for indigenous cattle breeds played a big role in the aforementioned perception. To date, the Nguni cattle is recognized as a universally important animal genetic resource possessing valuable adaptive traits resulting in a breed that can survive and reproduce efficiently in marginal productive areas (Mapiye *et al*., 2007; Matjuda, 2012; Matjuda *et al*., 2014). This is further demonstrated by large number of Nguni stud herds in the ownership of research institutions where some populations are kept and by farmers in the Mpumalanga

province. Nguni cattle are not only able to tolerate harsh environmental conditions but also have natural immunity to tick-borne diseases and parasites that limit livestock production (Marufu *et al*., 2011; 2014). The Nguni cattle are a sub-type of Sanga cattle (*Bos taurus africanus*), which originated from the imported Arabian Peninsula bulls (Hanotte *et al*., 1998; 2000). The mitochondrial based analysis evidently pointed out that Nguni breed is an admixture of humped *Bos indicus* and humpless *Bos taurus* cattle (Parfitt & Huisman, 1998).

In an attempt to preserve the Nguni cattle breed, the Mpumalanga Department of Agriculture, Rural Development, Land and Environmental Affairs (DARDLEA) in partnership with the University of Limpopo (UL) and Industrial Development Cooperation (IDC) introduced a conservation programme for the Nguni cattle in Mpumalanga province. This programme, which was initiated and funded by the IDC is implemented in all nine provinces of SA. The aim was to re-introduce the breed in many parts of the country in order to prevent it from becoming extinct and to empower emerging communal farmers in the rural areas with cattle and improve their production skills. In Mpumalanga province, the programme established 74 related nucleus herds managed by Communal Property Association (CPA) and privately owned enterprises, with 30 in-calf heifers and one bull per enterprise. Some of the Nguni preservation programmes have previously been established in other parts of the country including the Eastern Cape (Ainslie, 2005; Tada, *et al.,* 2013) and Kwazulu Natal (Bayer, *et al.,* 2004) provinces.

1.2 PROBLEM STATEMENT

The Nguni cattle is an indigenous multi-purpose breed that plays an important role in both commercial and communal farming systems in South Africa (SA). Unfortunately, the breed is currently under threat of extinction due to the farmer's preference of exotic breeds and cross breeding. In comparison with commercial beef production, communal livestock farming systems have been shown in previous studies to have a high level of mortality of up to 30.7%, low reproduction rates (± 48%) (Scholtz & Bester, 2010), low weaning rates (± 45%) (Bembridge & Tapson, 1993) and a low turnover. All these contribute to a very low off-take (± 3%) (Scholtz & Bester, 2010) and poor economic returns from the communal farming system

sector. Reports suggest that the communal and emerging sectors have still a long way to go before reaching its full potential when compared with the commercial sector (Ainslie *et al.,* 2002; Montshwe, 2006; Scholtz *et al.,* 2008; Scholtz & Bester, 2010). Since the allocation of Nguni cattle to the CPA and commercial farmers in Mpumalanga province by DARDLEA and its partners in 2011, no scientifically based evaluation of the programme and animal performance evaluation has been undertaken according to our knowledge. Several generic reports from grey literature indicate that there is a poor performance of Nguni cattle in CPA's compared to individually owned enterprises. Such a finding, however, needs to be scientifically supported taking cognizance that different ecological zones may have an effect on the reproduction and growth performances of the Nguni cattle (Mupawaenda *et al*., 2008).

1.3 AIM AND OBJECTIVES

The aim of the study was to evaluate the reproductive performance of Nguni cattle in the CPA and privately owned enterprises across the three ecological zones of Mpumalanga province. This aim was achieved through meeting the following objectives:

1. Determine the reproductive performance of Nguni cattle in the CPA and Privately owned enterprises across different ecological zones of Mpumalanga province.
2. Evaluate the growth performance of Nguni cattle in the CPA and Privately owned enterprises across different ecological zones of Mpumalanga Province.

1.4 RESEARCH QUESTION

The main research question that forms the basis for this research study was whether different ownerships pattern and different ecological zones have any effect on the reproduction and growth performance of the Nguni cattle in the Mpumalanga province.

1.5 HYPOTHESIS

This study involved testing two hypotheses:

1. Null hypothesis (H0), which assumes the idea of equality in the effect or no effect of ownership types and ecological zones on the cattle growth and reproductive performance traits, and
2. Alternative hypothesis (Ha), which assumes the idea of differences in the effect of ownership types and ecological zones on the cattle growth and reproductive performance traits.

1.6 SIGNIFICANCE OF THE STUDY

The present study provides growth and reproductive information of the Nguni cattle in the CPA and private owned enterprises across different ecological zones of Mpumalanga province. This will assist in the development of guidelines and policies that promote justifiable allocation of Nguni cattle to the beneficiaries thereby ensuring breed preservation and promotion of new technologies in the beef cattle industry.

1.7 OUTLINE OF CHAPTERS

A review of both the background and the introduction pertinent to the topic of this thesis is presented in Chapter 1. Chapter 2 reviews the theoretical and the empirical literature pertinent to the topic of this dissertation. Chapter 3 describes the study area, biophysical environment, ecological zones of Mpumalanga, climate and land use. Chapter 4 describes research methodology, including a brief description of the research setting, data collection procedures and analytical techniques. Chapter 5 reports the results; Chapter 6 discusses the results of the study while Chapter 7 focuses on the conclusions and recommendations drawn from the study.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The Nguni is one of South Africa most popular indigenous cattle breeds (Nguni Cattle Breed Society, 2008). The name Nguni was derived from black African people collectively known as Nguni speaking people (Schoeman, 1989). It is considered as one of sub – types of Sanga that originated from the imported Arabian Peninsula bulls (Hanotte *et al.,* 1998). The breed was brought along to the eastern and southern areas of Africa by nomadic people who migrated from North, Central and West Africa escaping from environmental pressures of war and trade (Bester et al., 2003). The mitochondrial based analysis evidently pointed out that Nguni breed is an admixture of humped *Bos indicus* and humpless *Bos taurus* cattle (Parfitt & Huisman, 1998).

To date, the genotypes of Nguni cattle are traced in Sub-Sahara African countries that include South Africa, Swaziland, Namibia, Mozambique, Zimbabwe, Malawi and Zambia resultant from three migration routes through Southern Africa (Hanotte *et al.,* 1998; Maciel *et al.,* 2013). In South Africa, the Nguni breed is believed to have arrived approximately 2000 years ago via the banks of Limpopo River (Ramsay *et al.*, 2000). The breed then re-evolved and settled with different tribes. The cattle were distributed to Limpopo and Northern Kwa – Zulu Natal. These tribes selected their Nguni cattle based on phenotypes such as horn shape and size; body conformation and coat colour patterns (Oosthuizen, 1996). Accordingly, as tribes were splitting up to settle in different geographic regions of South Africa, distinctive Nguni cattle ecotypes developed and adapted into different environmental regions (Bester *et al.,* 2003).

Decades ago, Nguni cattle were perceived as inferior by the South African industrial beef sector due to low production outputs (Bester *et al.,* 2003). During colonization there was a lack of performance recording schemes, thus, no attention was paid to the potential of indigenous cattle breeds in South Africa, except for the Afrikaner cattle breed. The Afrikaner cattle Breed Society was established in 1912 due to the breed's outstanding qualities that were identified by Potchefstroom College of

Agriculture former Director, Alex Holm (Scholtz & Ramsay, 2007). Apart from that, some commercial farmers valued the Nguni breed's adaptive traits and used it in uncontrolled crossbreeding programs (Matjuda, 2012). A number of events occurred during the early 1900s including failure of exotic breeds. This resulted in crossbreeding initiative to develop breeds that can adapt and perform well under local environmental conditions. The late Professor H.H. Curzon identified this problem and a committee was appointed by the Department of Agriculture to report on the performance of landrace livestock for conservation and preservation (Bonsma *et al*., 1950). The committee aimed to end the decline of landrace cattle and established a 500 Nguni breeding herd to investigate the growth, production and reproduction potential and consequently serve as the pure herd nucleus for stud breeding in Kwa-Zulu Natal province (Kars, 1993).

The Bartlow Combine Station was established in 1954 from Nguni cattle stud dating back to 1931 (Kars *et al.,* 1994). This consisted of one cow, four heifers and one bull purchased from Chief Mtubatuba at Mhlabisa district along with one mature bull, three cows and three heifers purchased from Nongoma district (Kars, 1993). The national recording schemes of all beef cattle were established in 1959 (Hofmeyr, 1994) while Nguni cattle breeders' society was established in 1986 (Scholtz & Ramsay, 2007). A Department of Agriculture research facility in Loskop Limpopo province currently known as Agricultural Research Council Loskop South farm was later established for Nguni cattle research (Matjuda, 2012). Since then, Nguni cattle numbers in commercial sector have grown, well established and recorded in Livestock Improvement Act 25 of 1977.

To date, the importance of Nguni as a "universal breed" has been embraced as demonstrated by large number of stud Nguni herds in the ownership of research institutions, including farmers in Mpumalanga province and Universities where some Nguni populations are kept and conserved. This add to an initiative supported by DARDLEA in Mpumalanga Province in collaboration with IDC and the UL working with emerging farmers to grow Nguni herds in rural communities. The IDC Nguni project is implemented in all provinces of South Africa promoting the farming of Nguni by providing farmers with Nguni cattle (De Waal, 2014).

2.2 ORIGIN AND DISTRIBUTION OF NGUNI CATTLE OF SOUTH AFRICA

Nguni cattle descend from both *Bos taurus* and *Bos indicus* cattle and entered Africa around 8000 years ago. The early development of the breed was shaped by evolutionary forces such as migration, genetic drift and selection. It was introduced to the eastern and southern areas of Africa by the nomadic people who migrated from North Africa (Mwai *et al.,* 2015). According to archaeological evidence the breed dates back 2000 years ago in South Africa and was introduced via three migration routes (Schoeman, 1989).

Over time, different ethnic groups settled in different geographic regions of South Africa and selected cattle based on phenotypes such as horn shape and size, body conformation and coat color patterns (Oosthuizen, 1996). Distinctive Nguni cattle ecotypes developed that were adapted to different environmental regions (Bester *et al.,* 2003). The recognized South African Nguni cattle ecotypes include Bartlow, Makhathini, Pedi, Shangaan and Venda. These ecotypes are linked to the geographic areas where the specific ethnic groups keeping the breed settled and relate to their traditional historic existence and foundation. The majority of Nguni cattle in South Africa consist of large numbers of registered females kept in stud and commercial herds without differentiation into the known ecotypes. Specific ecotypes are kept in small numbers by a number of stud breeders. Selection of the Nguni breed has been primarily based on phenotypic traits and to a lesser extent performance recording.

2.3 PRODUCTIVE CHARACTERISTICS OF NGUNI CATTLE OF SOUTH AFRICA

The Nguni is a breed that has adapted to the African environment over many years and therefore displays functional characteristics (Bester *et al.,* 2003). Bulls are medium sized and weigh between 500 and 600kg. They are muscular and display typical male characteristics with well developed, muscular, cervico-thoracic humps, which mean that the hump is in front of the foreleg. The scrotum is well developed with good pigmentation and thermo-regulatory function.

The cows are small and weigh between 300kg and 400kg. They are feminine with sleek, delicate lines around the neck and forequarter and a prominent wedge shape with the weight in the stomach and hindquarter area. The sloping rump is a distinctive characteristic of the Nguni cow and ensures ease of calving. The udder is small to medium, well attached with small functional teats.

2.4 INDIGENOUS CATTLE PRODUCTION SYSTEMS IN SOUTH AFRICA

A good production system is one of the major drivers of farm economic returns. The IDC has thrown its weight behind a multi-million rand project to kick-start indigenous livestock breeding programmes among emerging farmers in North West province, Mpumalanga, Limpopo, Kwa-Zulu Natal, Eastern Cape, Northern Cape, and Free State and currently in Gauteng. The project, the brainchild of the IDC, involves the supply of 12 Nguni cattle to 12 communal farmers annually over the five-year period (South African Buanews 2006).

The support is further aimed at strengthening the livestock development through viable and vibrant rural farming communities; in which project such as Nguni would ultimately contribute towards rural agri-business development, creation of decent work, sustainable livelihoods and food security for the Department of Agriculture, Rural Development, Land and Environmental Affairs (DARDLEA 2012). The livestock farming communities in these indigenous cattle systems in South Africa ensured that all of those projects are characterized mainly as coming from well-organized land reform beneficiaries. All of the farms do have physical infrastructure like farm boundary fence, partitioned grazing camps equipped and borehole, running perennial water streams and basic handling facilities (holding pens, crush pens and overnight kraals). The comprehensive program is an integrated approach involving different sectors in government, private sector and civil society to ensure that indigenous cattle production systems are well-implemented (Industrial Development Corporation 2012). The support is further aimed at strengthening the livestock development systems through viable and vibrant rural farming communities, in which project such as Nguni would ultimately contribute towards rural agri-business development, creation of decent work, sustainable livelihoods and food security for all (Industrial Development Corporation 2012).

2.5 FUNCTIONAL VALUE OF NGUNI CATTLE IN SOUTH AFRICA

The name Nguni refers to the Xhosa, Zulu and Swazi people of Southern Africa, who, with their cattle, originally migrated here from North, Central and East Africa between 590 and 700 AD. Nguni cattle have been characterized as having high fertility, low maintenance requirements, ease of calving, adaptability, resistance to parasites, resistance to tick-borne diseases, good temperament, longevity, browsing and good walking ability (Scholtz, 1988; South African Livestock Breeding, 2004). Consequently, the breed is viewed as having cost effective capacity for beef production and the ability to thrive under harsh conditions. These characteristics seemingly position Nguni for use as a dam line and has been regarded as a maternal breed. The local environment, cultures and values of communities of emerging farmers are reflected in the key traits and functions of Nguni cattle (Rege, 2001). Nguni cattle are adapted to local environmental stresses, are able to provide traction, and produce meat and milk. Behind these traits are the breeding practices and other indigenous knowledge systems that have been applied to maintain these populations, and the genetic diversity that they represent. However, historical selection practices with respect to economically relevant traits have not been well documented.

Apart from their economic value, Nguni cattle have always played a key role in the rites and rituals of the Nguni people. Through these beloved beasts, their ancestors are consulted, praised or appeased (Heather Dugmore, 2018). Certain cows are associated with the ancestors, notably the *inkomo yamadlozi* (beast of the shades), singled out for its beauty and even temper to keep the ancestors happy. Because of its spiritual importance, the *inkomo yamadlozi* may not be beaten, slaughtered or sold. Bride-wealth is also traditionally measured in cattle. If a man wishes to marry, he has to pay the agreed upon bride price in cattle to the father of the woman he wishes as his wife. This practice still widely applies. Even people living in the cities still calculate the bride price according to the cost of the agreed upon number of cows (Heather Dugmore, 2018).

2.6 CATTLE OWNERSHIP IN SOUTH AFRICA

Rural communal household keeps cattle for multiple purposes. Cattle are for milk production, hides, meat, hides, horns and income (Chimonyo *et al*., 1999; Dovie *et al*., 2006; Musemwa *et al*., 2008). Shackleton *et al*., (1999) and Bayer *et al*., (2004) also mention that cattle provides dung for manure, fuel and floor/seal and draught power for cultivation of crops. Dovie *et al*. (2006) and Musemwa *et al*. (2008) state that cattle are an inflation-free form of banking for resource-poor people and can be sold to meet family needs such as school fees, medical bills, village taxes and household expenses. Some farmers also use them for prestige and pleasure while other uses cattle as a source of employment, collateral and insurance against natural calamities (Shackleton *et al*., 1999).

In some African countries, they use cattle for social cultural functions, which include using them as bride price and to settle fines in communal areas (Chimonyo *et al*., 1999). Cattle are reserved for special ceremonial gatherings such as marriage feasts, weddings, funeral and circumcision (Bayer *et al*., 2004). Livestock plays a multiple role and provides many valuable services and products for rural households (LID, 1999), many of them not captured in standard household surveys and national accounts. A detailed livelihoods study in three districts of Uganda shows that the income from livestock provides only one of many sources of income for rural households, people typically rank livestock as their second or third most important means of livelihood (Ashley & Nanyeena, 2002).

Rural people have a range of reasons for holding the types of animals they keep and these reasons are subject to change over time (Shackleton *et al.,* 2000). Some responses differently, where they keep livestock for cash from sales, form of employment, milk for home consumption, for funeral purposes, as a form of investment, inherited the livestock, slaughter for feasts/ home consumption, for paying bride-wealth, for sale of hides and skins, because land suitable for cattle farming is available, to help others, for cow dung and for draught/ transport purposes (Schmidt, 1992). Cousins (1996) argues that the reasons for keeping certain types of livestock are related to their position in the domestic development cycle where a young man with an eye to aweighting bride wealth may be more interested in the

short-term fertility of his livestock, while an older man is likely to be more concerned with building his retirement herd, and with disposing of older and weaker animals to offset household expenses. In Xhosa culture of South Africa, cattle are kept for conducting a range of slaughter rituals to secure the ancestral blessings deemed necessary for the well-being of the family (Ainslie, 2005).

2.7 FACTORS AFFECTING CATTLE PRODUCTIVITY IN SOUTH AFRICA

Cattle production is affected by several factors including marketing factors, management, animal or genetic factors and diseases (Mupawaenda *et al*., 2008).

2.7.1 Marketing factors

Poor marketing infrastructure, lack of marketing herd size, high transaction costs and low purchased power of buyers are the mainly constraints affecting the efficient of marketing livestock in the Eastern Cape of South Africa (Stroebel, 2004). Jooste (2001) indicates that marketing of livestock is one of the most complex policy issues that must be addressed in order to enhance sustainable smallholder agriculture.

Small scale communal cattle do not meet the market requirement due to the fact that they are not using selective breed to attract buyers in the farms (Nkosi & Kristen 1993). This result in most farmers using informal marketing channels and gets low prices for their animals (Nkosi & Kristen, 1993). Nkosi also suggests that necessary information about cattle prices, right selling time, marketing channels available, cattle breeds and the age of cattle are required to give the highest returns. Lack of marketing facilities such as sale pens and loading ramps are various factors that imposes serious constraint on small scale farmers to market their cattle in South Africa and the poor state of roads networks systems (NERPO, 2016).

On the contrary, Fidzani (1993) indicated that poor infrastructure do not influence livestock marketing since most buyers provide their own loading and transport services. Some farms are located in areas where there is a lack of both physical and institutional infrastructures, which makes them to be isolated from major markets (NDA, 2005). In some communities, marketing facilities exist though are in poor state and non-functional because of insufficient funds for maintenance farmers in

communal areas do not have information on recent production techniques and market conditions, type of product demanded, quality and quantity, price and market opportunities (Bailey *et al*., 1999). However, there is a provision of communication system such as telephone or cell phone and radio but still communal farmers remain uninformed in terms of new production techniques, market prices, trends and auction sale date (Montshwe, 2006). The poor transfer of knowledge and skills makes the information irrelevant, therefore local language is recommended for farmers to access the information (Coetzee *et al*., 2005).

2.7.2 Management factors

Stock management is one important factor influencing cattle productivity. In communal areas, animals are normally left to fend for themselves during winter months with less adoption of supplementary feed or culling and/or effective management of internal and external parasites. In order for government programmes to work in improving the conditions of smallholder farmers, an acceptance of the multipurpose nature of this sector is paramount. Calibrating the support services by government to address the challenges of these farmers stands a good chance of succeeding in increasing the off-take. Currently, the off-take of smallholder farmers in South Africa is estimated to be around 5 % (Myeki *et al.,* 2014). This is slightly lower than that of communal farmers in Transkei in the 1980, which was 6.8 % (Bembridge, 1987) and lower for the whole of Eastern Cape Province that is estimated to be 5.4 %. This off-take was based on the share of animals sold through auctions, excluding sales between community members and lobola payments.

Livestock in communal areas tend to experience higher rate of mortality due to poor management. Commercial agriculture experiences mortality rates of about 3 % as compared to communal farmers whose mortality rates are above 17 %. Mortality rates clearly represent an economic loss to communal farmers. Therefore, policies aimed at reducing mortality (with a seasonal dimension) need to be encouraged such as the National Red Meat Development Programme (NRMDP) run by the National Agricultural Marketing Council.

2.7.3 Animal/genetic factors

In communal areas, some of the challenges affecting productivity are low number of livestock produced and low average weight of the animal due to poor management that results in poor body condition compared to commercial farming sector (Stevens & Jabara, 1988). Makhura (2001) indicated that lack of marketable livestock number and poor body condition resulted in buyers not coming to purchase livestock since they will face very high transactional costs and farmers get low farm gate prices especially during dry spells. Other studies (Van den Bos, 2004; Dzimba & Matoone, 2005) indicated that lack of marketable livestock numbers resulted in livestock theft. Nkhori (2004) added that due to poor body condition, livestock auctioneers and speculators often raise concerns that they cannot pay competitive price of those animals. He further stated that the age of the animals also affects the price, such that old animals contribute to poor prices.

Reproduction in communal areas is generally low, resulting in low levels of calving and weaning and this has been a problem for a long time. Bembridge (1987) noted that the calving rate in three communal areas of the former Transkei (Qamata, Emgcwe and Qumbu) was 38.8%. In the same areas, the aggregate weaning rate was about 27%. It was noted by M Mokolobate *et al.,* (2013) that the aggregate weaning rate was about 31% in the former Ciskei communal areas, which is slightly higher compared to the communal areas of the former Transkei. Knowledge of cattle herd productivity improves the understanding of the functional attributes and is useful in determining the constraints and the potential of communal beef cattle production systems (Mapiye *et al*., 2009). In some communal areas, weaning is controlled by nature where there is no different between calves, heifers, steers and bulls. Steer and ox are used as draught animals, castration does not take place, and some delayed castration in order to improve strength and body conformation for draught usage (Abel & Blaikie, 1989). Age at first calving is three years in communal areas and the cow will remain in breeding herd for eight to nine year. Therefore, it results in unproductivity of the cow and sale at an old age (Scoones 1990). Reproductive measures such as age at first calving and calving interval are estimated under low input in communal cattle production system. Those reproductive measures are influenced by the plane of nutrition, age at puberty, livestock herd size, exposure of heifers or cows to the bull and their health status

(Kanuya *et al.,* 2006). Ainslie (2005), argued that number of livestock herd in the communal areas have a deleterious effect on the availability and condition of communal grazing resources. Therefore, it adversely affects the quality of the livestock and also their reproductive rates and their market value (Kanuya *et al.,* 2006). Cattle herd sizes is observed to be higher in the group owned enterprises, this can be attribute to the lower mortality rates and higher proportion of breeding females in groups and theft in villages. Categories of animals exposed to higher mortalities were heifers and bulls due to lack of breeding soundness evaluation of bulls and inconsistent vaccination of the animals (Ainslie *et al.,* 2002).

Selection of specific breed of cow or bull is not applicable in communal areas. Inferior cows and bulls are reserved for breeding and the rate of inbreeding is high (Hove *et al*., 1991; Moyo *et al.,* 1993). Most of communal farmers prefer indigenous cattle which are well adapt to local conditions. The major breeding problems in communal areas are that the herd always runs as groups and the bull stays with cows. As a result, the owner is unable to identify the superior breed bull to sire the progeny. Swanepoel & De Lange (1993) and Muchena *et al.,* (1997), reported that herd size is a critical factor to determine herd productivity efficiency while Nthakheni (1993) suggests that the smaller the herd, the lesser the chances of making living out of livestock farming. In study conducted by Sieff (1999), breeding females compose of 70% of cattle herd in Tanzania which is not the same as the Southern part of Mozambique where it reported 54% of the total herd size. In the same study, 99% of farmers keep old cows for milk production and reproduction (Rocha *et al.,* 1991). These cows are less productive but still produce milk and calves that is the production system practiced in communal areas. Magadlela & Kadzere (1995) indicated that quality and productivity of the animals is not the main issue in communal areas of South Africa, farmers only concern about the cattle number which reflects their wealth status as African. The proportion of young cows and heifers from the total cattle herds and the percentage of farmers with young cows and heifers in their herds are very low. Therefore, it can limit both productive and reproduction rates of the herd. Some farmers keep high percentage of oxen in the herd structure which indicates the use of animal traction practices such as ploughing and transportation of water and agricultural produce. Nutritional management

practiced is communal grazing, overstocking, and degradation of the natural resource such as veld (Blench, 1987).

2.7.4 Diseases

Diseases are major constraint that need to be improved in livestock farming in communal areas (Devendra *et al*., 2000). Duvel & Stephanus (2000); Mwacharo & Drucker (2005), Chawatama *et al*., (2005), argued that diseases decrease production and increase morbidity and mortality. Poor management in communal areas results in most common diseases such as heartwater, gall sickness, black leg, contagious abortion, tuberculosis and lumpy skin disease (Hanyani-Mlambo *et al.,* 1998). Calves are most affected group especially during the dry season and some die due to poisonous plant (Chawatama *et al*., 2005). Most farmers in communal areas only treat minor diseases using ethno veterinary medicine while medium scale areas use modern veterinary medicine. Though veterinary extension personnel advise communal farmers to dip their cattle weekly during the rainy season and twice per month but 70% of the household in the communal areas could not afford to buy chemicals for treating and dipping their cattle (Francis & Sibanda, 2001). Sometimes cattle spend long periods without being dipped due to either the unavailability of water or dipping chemicals as reported by Mapiye *et al.* (2007).

2.8 LIVESTOCK IMPROVEMENT PROGRAMMES IN COMMUNAL AREAS OF SOUTH AFRICA

In the Limpopo province communal livestock production by the smallholder livestock farmers is currently underway in the Greater Tzaneen Municipality (http://gteda.co.za/index.php/livestock-improvement). The GTM intends to assist smallholder cattle farmers by improving their animal productivity and sustainability on communal lands. Cattle herd size on communal land in the municipality is currently estimated to be 29,000 with a composition of 43% cows (http://gteda.co.za/index.php/livestock-improvement). With proper management, the proportion of cows as well as that of calves is expected to increase. The main purpose of this project was to assist livestock owners on communal land to increase the commercial value of their cattle. The feasibility study exercise that was undertaken by the GTM involves:

- Identification of viable livestock related enterprises for emerging livestock framers.
- Identification of key role players on livestock improvement programme.
- Identification and establishment of institutional Structuring for the implementation of the livestock improvement programme.
- Undertake the development of business plans for viable livestock enterprises development of skills plans to address skills shortage.

In Mpumalanga province, DARDLEA embarked on a Livestock Improvement Programme by breeding the Drakensberger, Sangana and Boran, and Dohne' Merino stud and commercial breeding cattle and sheep herd under the Bull & Heifer and Ram & Ewe projects, respectively. These projects are taking place in two of the departmental research stations, namely, Nooidgedacht farm situated in Ermelo and Athole farm situated in Amsterdam, and these projects started more than ten years ago. The department has recently took an advantage of good quality animal gene bank of large- and small-ruminants available in both of its research farms to embark on a plan to improve genetic material of livestock farmers with Drakensberger, Dohne' Merinos and other area specific adaptable livestock bloodlines (Department of Agriculture Mpumalanga province 2003) whereas the DARDLEA in partnership with the IDC and the UL recently signed a Memorandum of Understanding (MoU) in terms of which Nguni Cattle Development project is implemented by re-introducing indigenous Nguni bloodstock in the province (DARDLA 2012).

CHAPTER 3: DESCRIPTION OF THE STUDY AREA

3.1 LOCATION

This study was conducted in Mpumalanga province, which is located in the Northeastern part of South Africa (Figure 3.1). It is bounded by eSwatini and Mozambique countries to the east, Kwazulu Natal and Free State provinces to the south, Gauteng province to the west and Limpopo province to the north. The province covers an approximate area of 76 495 km^2, making it the second smallest province in SA after Gauteng (Lentsoane, 2016). Mpumalanga cover approximately 6.5% of SA's land surface area and is home to a population of about 4.5 million. The province is divided into seventeen local municipalities across three district municipalities as per the most recent 2016 determination by the Municipal Demarcation Board (MDB) – an independent authority responsible for the demarcation of municipal boundaries in SA. These district municipalities include Gert Sibande, Nkangala and Ehlanzeni. Gert Sibande district is the largest of the three, making up almost half (31 841km^2) of Mpumalanga province geographical area. Ehlanzeni district makes up just over a third of the province's geographical area whereas Nkangala district is the smallest of the three, making up 22% of Mpumalanga province geographical area. However, Nkangala is the economic hub of Mpumalanga, and is rich in minerals and other natural resources.

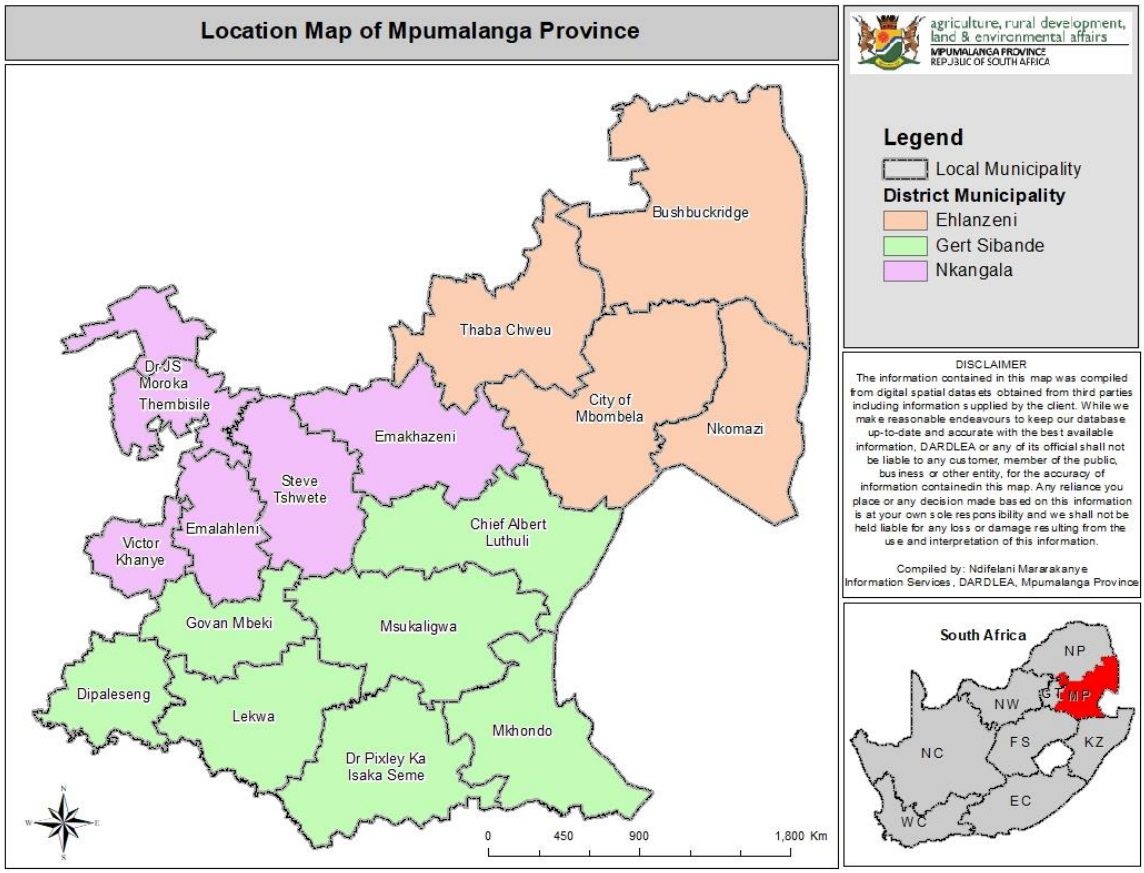

Figure 3.1: Location map of the Mpumalanga province in South Africa

3.2 BIOPHYSICAL ENVIRONMENT

3.2.1 Topography and landscapes

The topography of Mpumalanga province varies, comprising mainly of the Highveld (high lying), the Lowveld (low lying) and the Midveld physiographic regions (Figure 3.2). These three regions form a less clearly defined ecological zones with their own unique environmental characteristics. The Highveld occupies a significant portion of the Mpumalanga province and is mainly defined by elevation greater than 1200 m above sea level (Tooth *et al*., 2004; Kimble *et al*., 2014). It is a relatively flat or gently undulating plain with a few rocky ridges that protrude the landscape. Lowveld region lies at an elevation of less than 600 m above sea level and is comprised of by low ridges, which appear to be an island of mountains (Kimble *et al*., 2014). Midveld lies in the transition zone between the Highveld and the Lowveld regions at an altitude between 600 and 1200 m above sea level. The relief is characterised by a series of high plateaus which are broken by relict mountains and kopjes (Cooks *et al*., 2019).

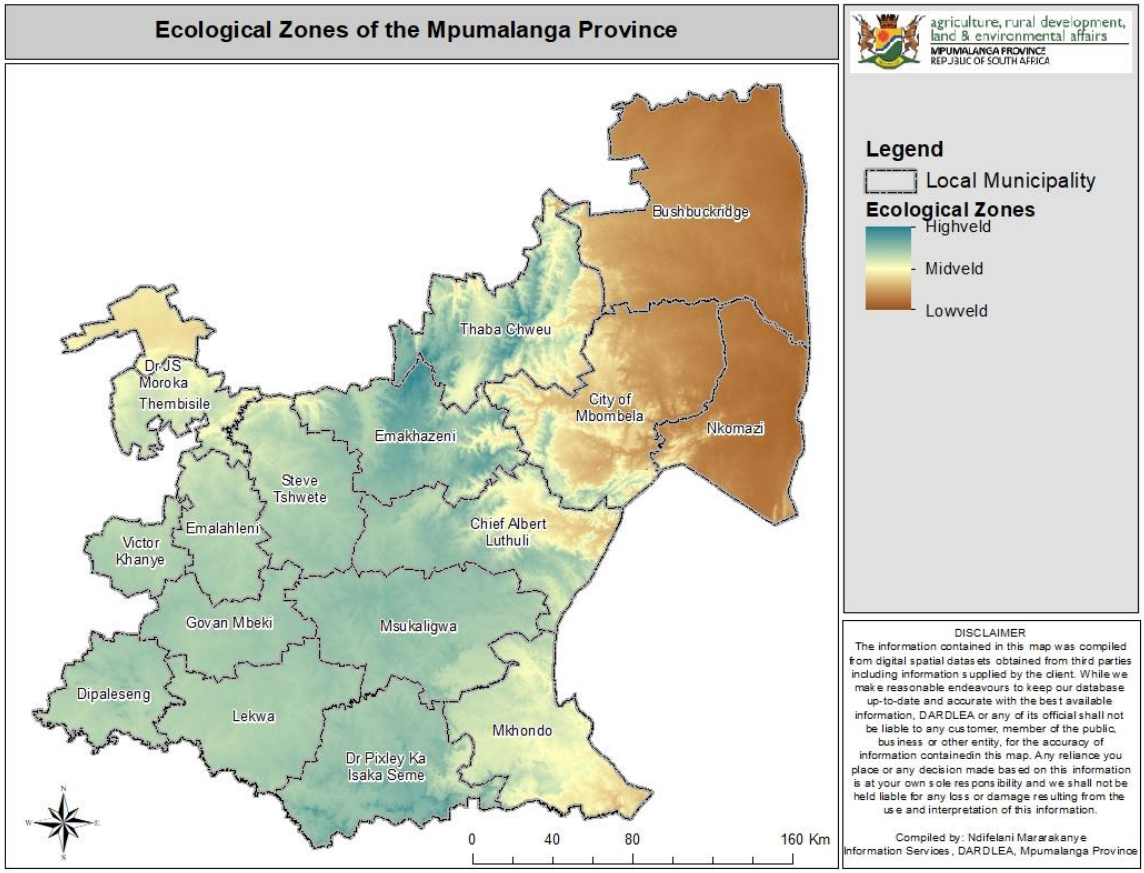

Figure 3.2: Ecological zones or regions of the Mpumalanga province

3.2.2 Geology and soils

The most important characteristic geological feature of the Mpumalanga province is the occurrence of the metamorphosed volcano-sedimentary rocks known as the greenstone belt of the Barberton super-group stretching from the Midveld to Lowveld ecological regions (Figure 3.3). The Barberton super-group contains some of the the oldest rocks exposed on earth and is well-known economically as the most significant gold producing area in SA (Wilson, 1998). Mpumalanga province is also characterized by the occurrence of the Ecca geological group of the main Karroo Super group in the Highveld region consisting of grey micaceous shale, course grained sandstone and subordinate grit and coal beds (Johnson, 1976; Turner, 2000). As a result, the Highveld region of the Mpumalanga province host some of the major coalfields in the country, namely, Witbank, Highveld and Ermelo coalfields (Jeffrey, 2005).

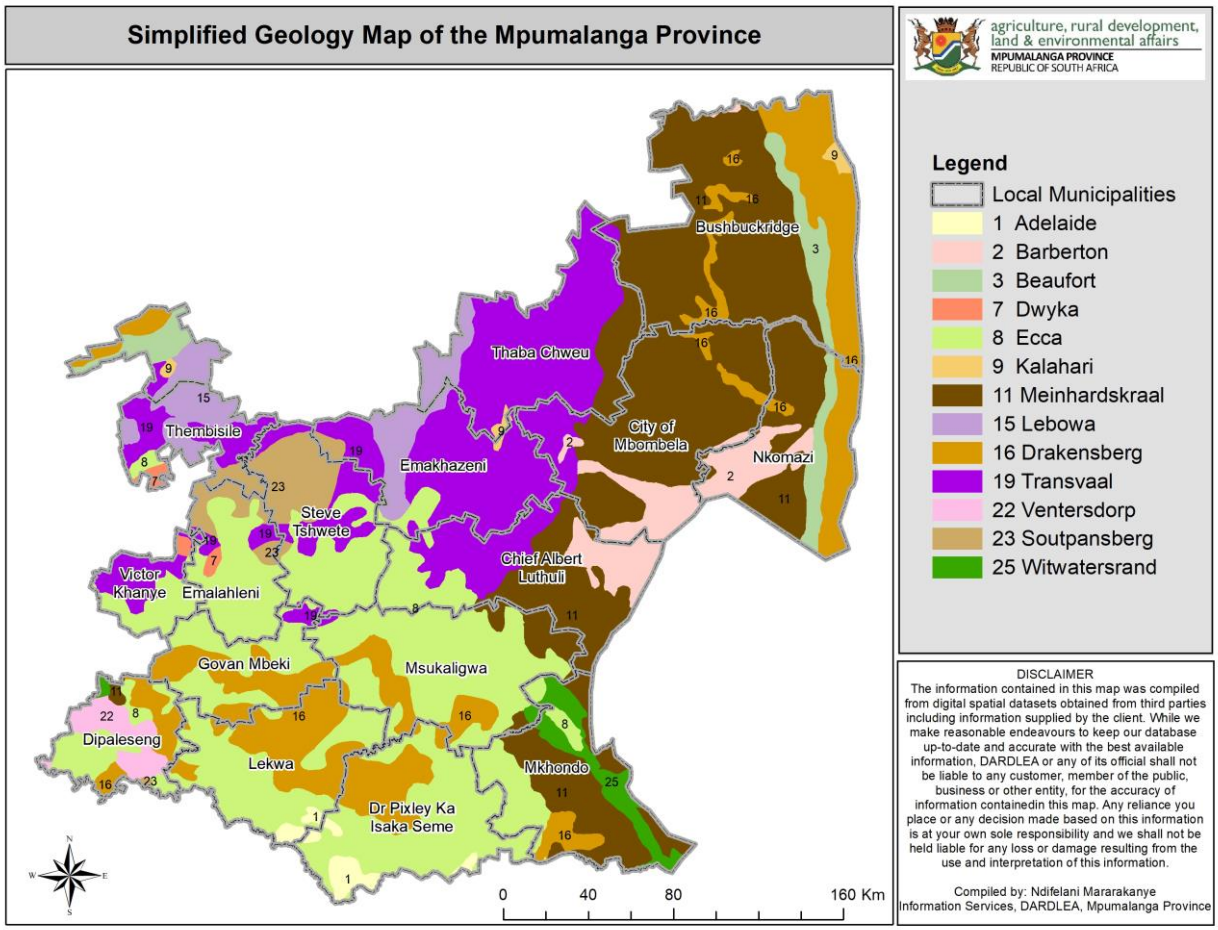

Figure 3.3: Geology map of the Mpumalanga province

Soils in the Mpumalanga province varies in in types and hence in terms of agricultural potential. The majority of soils with high potential arable agriculture are found in the Highveld region which always results in a competing interest between mining and agriculture (Figure 3.4). According to the Bureau for food and Agricultural Policy (2012) report, of the 1.5% high potential arable soils in SA, approximately 46.4% are found in the Mpumalanga province. Soils in the other regions (Lowveld and Midveld) are generally shallow and have low potential for arable agriculture, and often require irrigation to improve productivity.

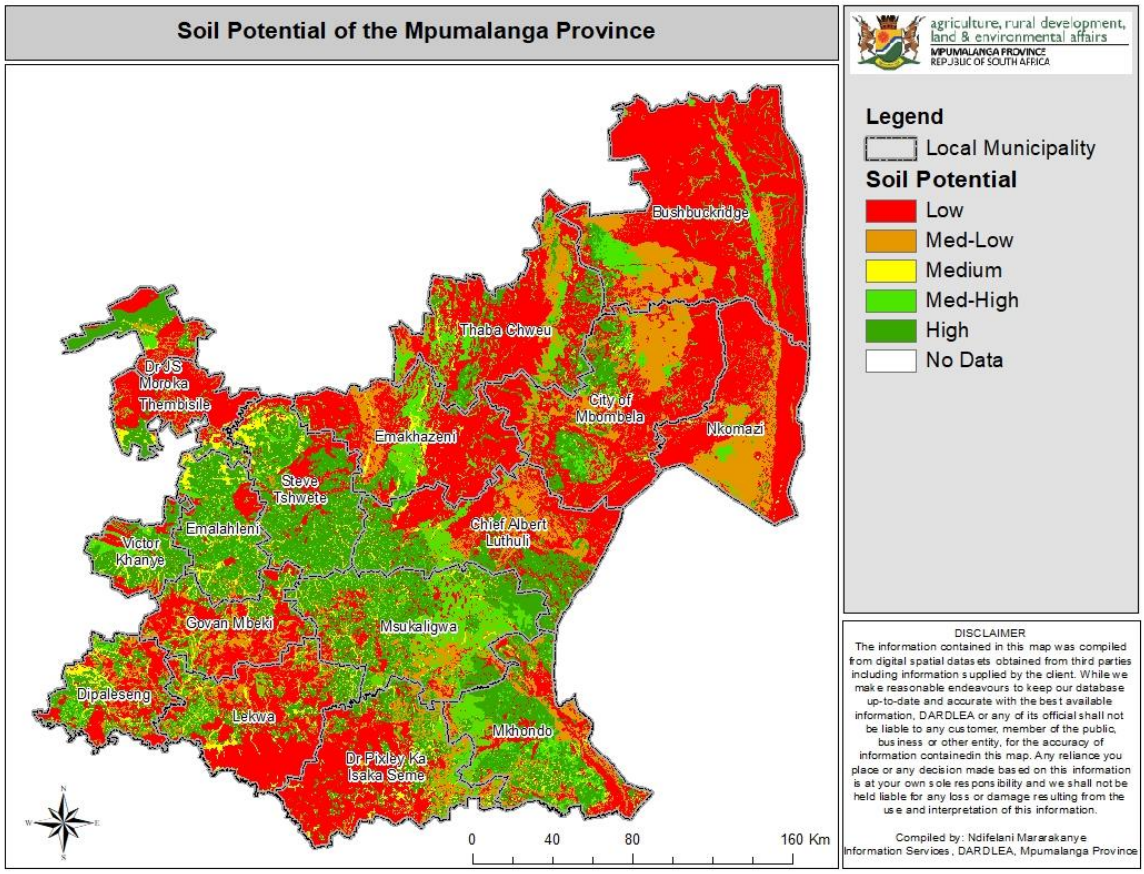

Figure 3.4: Soil agricultural potential map of the Mpumalanga province

3.2.3 Hydrology

Mpumalanga province is comprised of four primary catchments, drained by four primary rivers which largely contribute to surface water resource availability in the province. These river systems include the Vaal, Olifants, Komati, Crocodile, and Usutu Rivers. In order to protect the scarce water resources from over-exploitation and pollution, various Water Management Areas (WMAs) were established for these river systems including the Inkomati WMA, the Upper Vaal WMA, Usutu WMA and Olifants WMA (Figure 3.5). Mpumalanga province has plenty of dams which hold up to 2 538 million m^3 of water when they have reached the full storage capacity. These water resources are however threatened by many environmental problems such as acid mine drainage, pollution from agriculture and sewerage water treatment works.

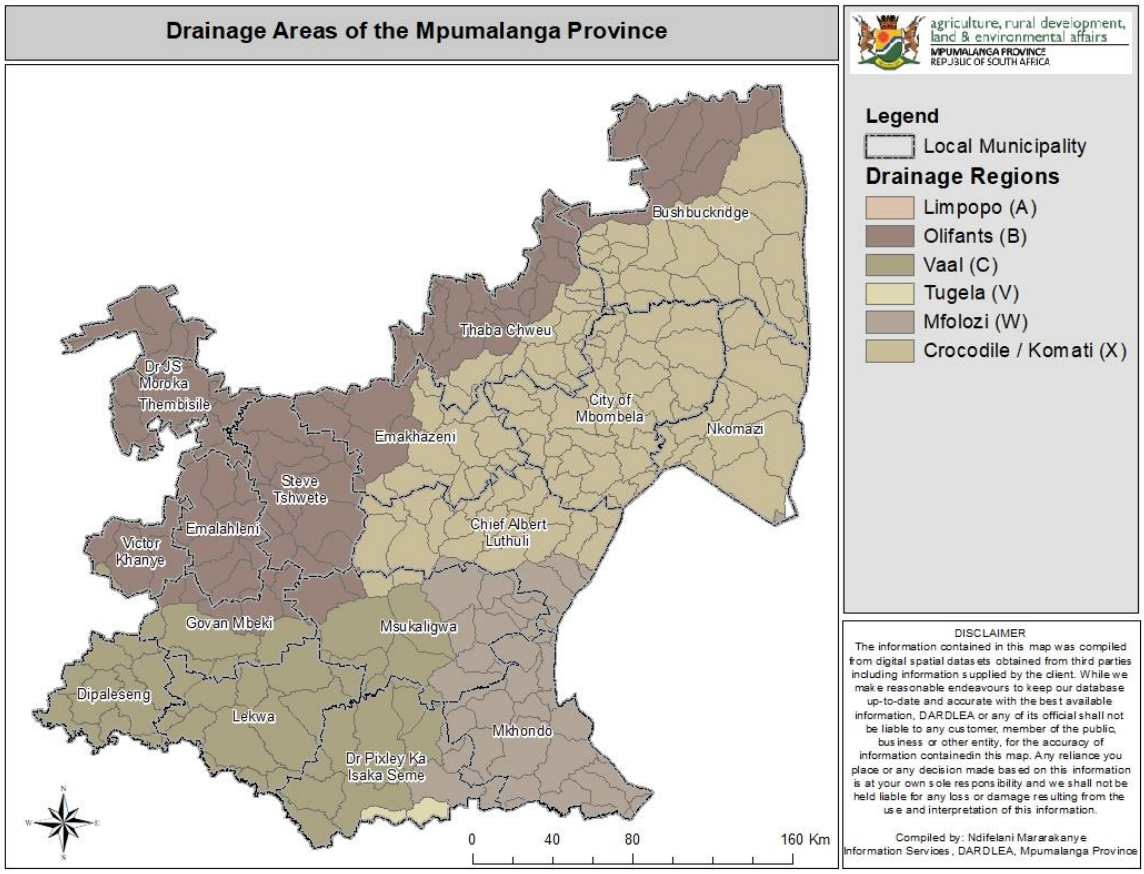

Figure 3.5: Drainage regions of the Mpumalanga province

3.2.4 Vegetation

Generally, vegetation of the Mpumalanga province falls into pure and false grassveld, tropical bush and savanna type, and coastal and inland tropical forest types (Figure 3.6). The Highveld region is mainly comprised of the pure grassland veld types, whereas the Lowveld is comprised of the tropical bush and savanna type as well as the inland tropical forest. The Midveld region falls in the transitional zone between the savanna and grassland biomes, and is dominated by false grassveld type of vegetation. Vegetation in the Midveld and Highveld regions is generally sour usually due to high water supply and parent material or geology that gives rise to soils with a low base status. On the other hand, sweetveld occur mainly at lower altitudes (Lowveld), in areas with lower water supply and where parent material gives rise to soils with a high base status (Mucina & Rutherford, 2006).

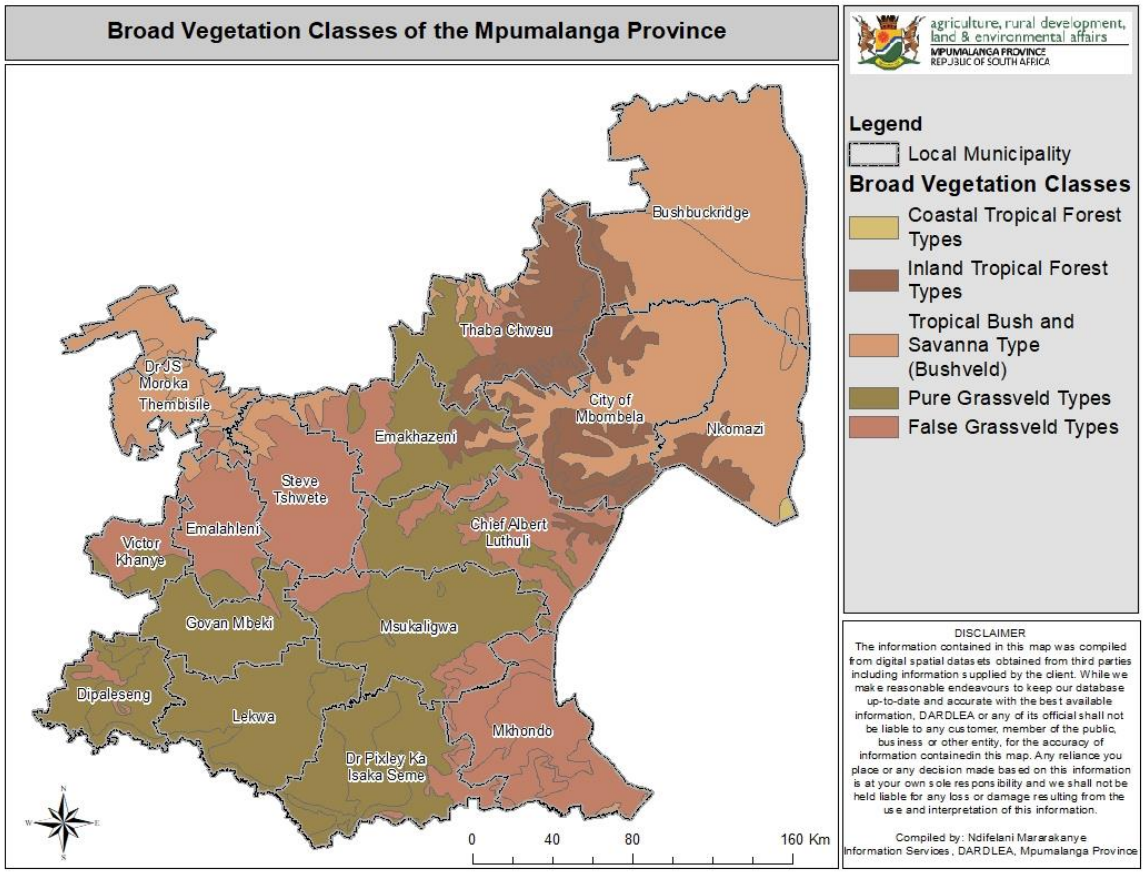

Figure 3.6: Vegetation map of the Mpumalanga province

3.3 CLIMATE

The Mpumalanga province can be categorized into three climatic characteristics or zones based on the Köppen-Geiger Classification System (Schultz, 2017), namely (1) winters long, dry and hot, (2) winters long, dry and cool, and (3) semi-arid, hot and dry. These climatic zones follow similar boundaries as the ecological or physiographic zones since altitude has a strong influence on most climatic variables. Winter long, dry and hot zone is the main climatic characteristics of the Midveld region, whereas winters long, dry and cool as well as semi-arid, hot and dry zones dominate the Highveld and Lowveld regions respectively. The Midveld region receives rainfall of up to 1 700 mm per annum, while the Highveld region mainly receives mean annual rainfall between 500 to 900 mm and the Lowveld receives the lowest mean annual rainfall ranging from 300 to 700 mm (Figure 3.7). The majority of rainfall in the Mpumalanga province is received during summer months (October to February).

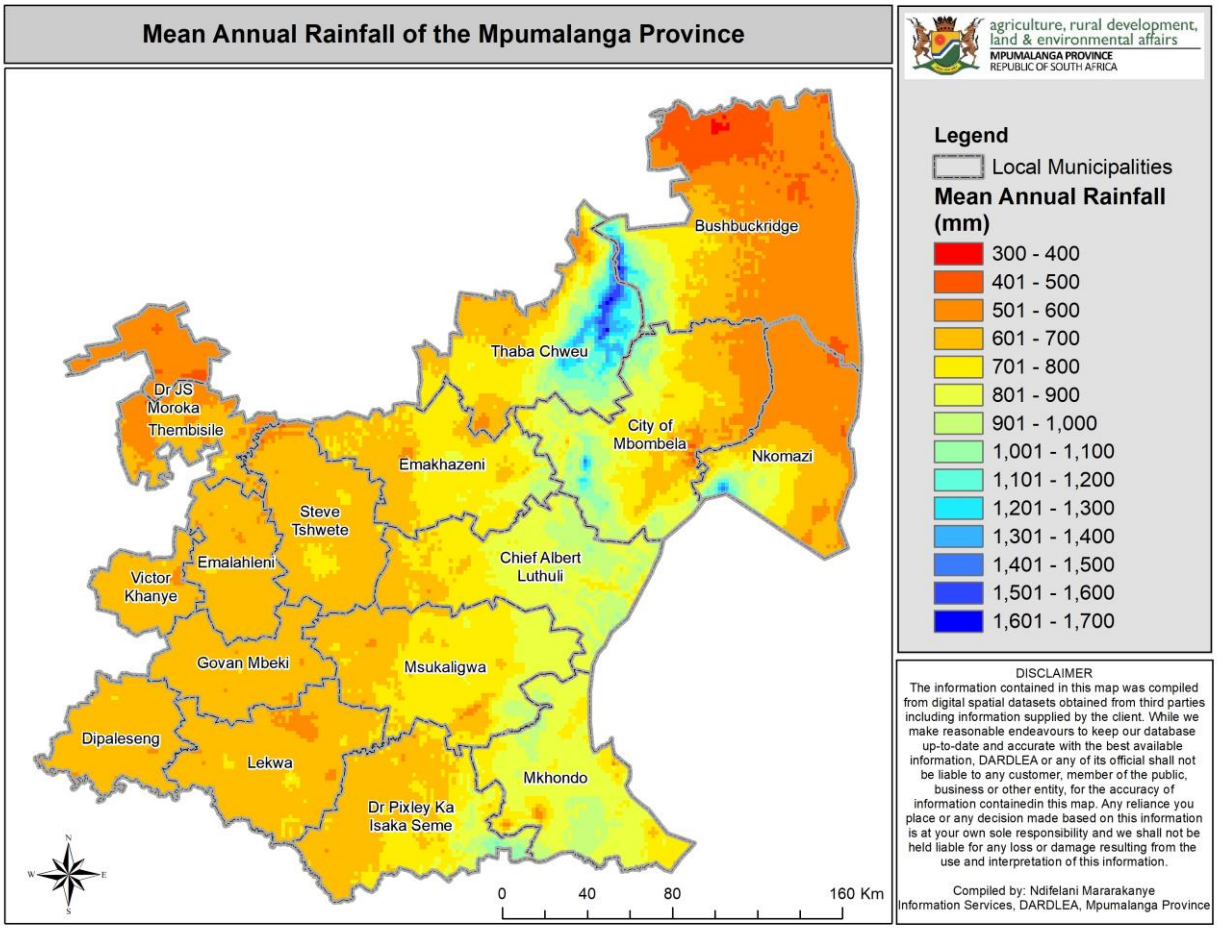

Figure 3.7: Mean annual rainfall map of the Mpumalanga province

3.4 LAND USE

The climatic contrasts between the cold, dry conditions of the Highveld region, and the hot, humid Lowveld region allow for a variety of agricultural production in the two regions (Figure 3.8). Agriculture is a dual, in a sense that the province has well developed commercial farming on one hand and subsistence based farming in communal areas. The majority of communal lands are susceptible to overgrazing and the associated land degradation due to the poor veld management. In privately owned commercial farms however, land degradation seems to be well under control due to the implementation of management practices such as rotational grazing and adherence to veld carrying capacity. Generally, maize, sorghum and wheat are the most dominant grain crops planted in the Highveld and Lowveld regions. The Lowveld region is also well known for the production of sugarcane, a variety of

vegetables, citrus (e.g. oranges, nartjies and lemon), nuts (e.g. macadamia and pecan) and subtropical fruits such as mangoes, avocados, litchis, bananas, papayas, granadillas and guavas. In the Highveld region, crops such as soybean and sunflower are also prominent (Tibane & Lentsoane, 2016). Due to the high elevation and mountainous nature, the Midveld region is generally used for plantation purposes and livestock grazing.

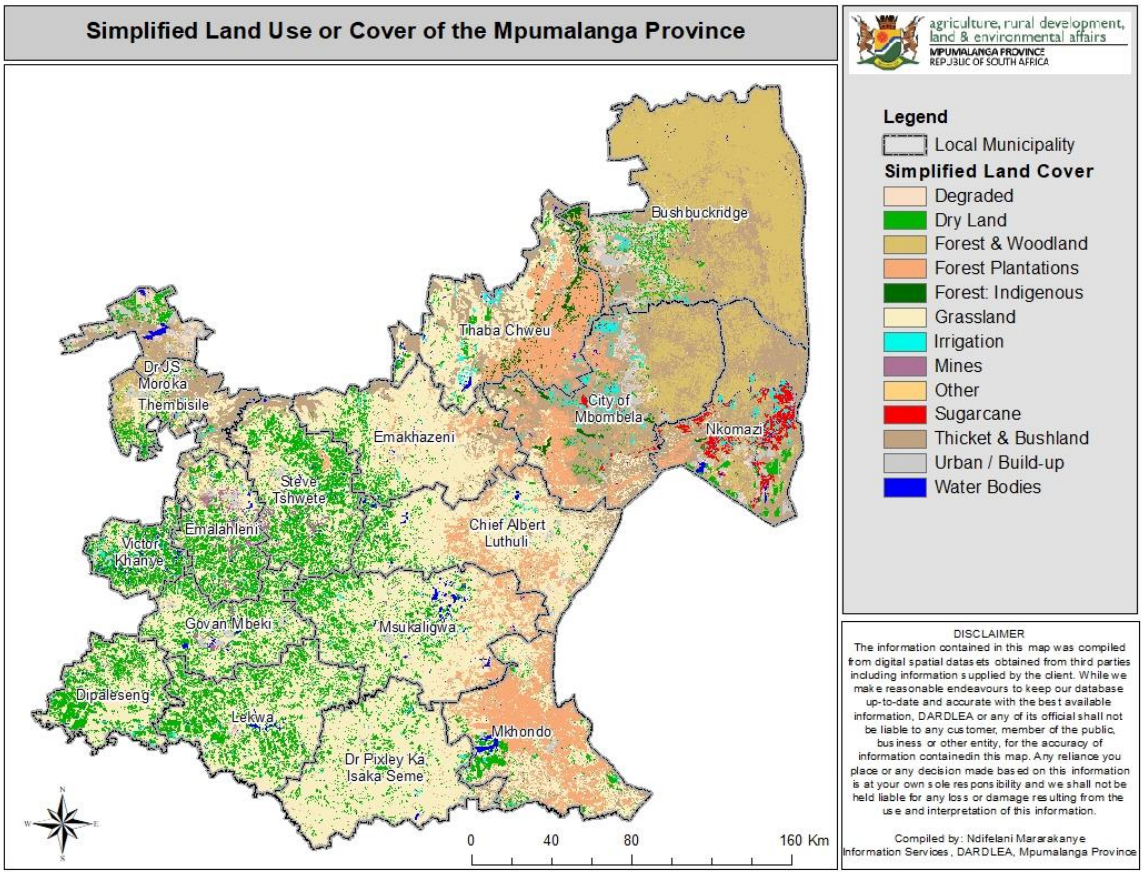

Figure 3.8: Simplified Land Use or Cover map of the Mpumalanga province

3.5. RESEARCH METHODOLOGY

3.5.1 Introduction

This study investigated the growth and reproductive performance of the Nguni cattle in the CPA and privately owned enterprises across the three different ecological zones of Mpumalanga province. The aim was to evaluate various Nguni cattle growth performance and other production traits such as the conception rate, calving rate, calves birth weight, weaning rate, weaning weight and age at first calving. Various methods were used for data collection, including a qualitative semi structured research interviews and the direct measurement method. The study also used statistical tools to analyse the data collected.

3.5.2 Samples selection

The animals were sourced from different kinds of environments across South Africa, which include the Highveld, Midveld and Lowveld. While Nguni cattle are known to have adaptive capabilities to changes in the environment, the animals were allocated to the project beneficiaries in the similar environment to the original source in order to avoid any possible issue with animal adaptation. Very often, when animals are moved from one ecological region to the other, they tend to take longer to adapt to the new environment increasing risks in the longer term that affects livestock production. According to Smit *et al*. (1996), animals fail to adapt to the new environment due to the impact of changes on livestock feed availability, impact of livestock pastures and forage quality, changes in livestock diseases and pests, and the direct effects of weather and extreme events on animal health, growth and reproduction.

Non probability purposive sampling was used to select 9 CPA's and 9 privately owned farming enterprises from a total list of 74 Nguni cattle project beneficiaries in the Mpumalanga province. In purposive sampling, samples are selected according to the purpose of the study and characteristics of the population (Singh and Masuku, 2013; Etikan *et al*., 2016). While the disadvantages of purposive sampling are acknowledged, this was considered an appropriate technique in this study since the candidate projects had to meet certain criteria that can only be realized through purposive sampling. Thus, the following predetermined characteristics were used

for the selection of projects: lifespan (where only those enterprises that are 36 months or older were considered), gender and age representations, willingness to participate and proper record keeping. Projects with longer lifespan greater than 36 months were appropriate for the study of traits such as the conception rate, calving rate and age at first calving. Whereas the aim here was not to compare the performance of the projects by gender and age, these were used as a criterion in order to ensure that there is a fair representation of both men and women of the various age groups. Njuki *et al*. (2013) single out gender inequality as one of the major constraint to economic growth and poverty reduction. Project beneficiaries who are willing to participate and having proper records possessed important characteristics required for this research. Table 4.1 illustrates characteristics of the final selected eight CPA's and eight privately owned farming enterprises.

Table 3.1. Characteristics of the selected Nguni livestock projects

Project Name	Locality	Ownership type	Lifespan (Months)	Ecological Zone	Farm size (Ha)	Herd size
Magudulela	Barberton	Private	36 months	Lowveld	807	30 +1
Bliko	Barberton	Private	36 months	Lowveld	691	30 +1
Dokoza	Hectospruit	Private	36 months	Lowveld	600	30 +1
Shembring	Kamhlushwa	CPA	36 months	Lowveld	702	30 +1
Sthrathmore	Malelane	CPA	36 months	Lowveld	685	30 +1
Khethwa Ekhaya	Strydom	CPA	36 months	Lowveld	800	30 +1
Emaphephetheni	Dalmanuta	Private	36 months	Midveld	5403	30 +1
Nzimande	Amsterdam	Private	36 months	Midveld	600	30 +1
Haversfont ein	Carolina	Private	36 months	Midveld	6103	30 +1
Khumalo	Badplaas	CPA	36 months	Midveld	8243	30 +1
Sizabonke	Badplaas	CPA	36 months	Midveld	625	30 +1
Botleng	Delmas	CPA	36 months	Midveld	625	30 +1
Mlangeni	Morgenzon	Private	36 months	Highveld	1300	30 +1
Manzi	Balfour	Private	36 months	Highveld	869	30 +1
Sibeko	Leandra	Private	36 months	Highveld	600	30 +1
Hlanganani	Mabola	CPA	36 months	Highveld	1500	30 + 1
Isigwnyamani	Daggakraal	CPA	36 months	Highveld	1500	30 + 1
Ubuhle Uyazenzela	Machado	CPA	36 months	Highveld	600	30 + 1

Notes: *CPA project leaders

3.5.3 Data collection

Most of the growth and reproductive traits parameters of the Nguni cattle except birth weight and weaning weight were collected using a qualitative research interviews conducted between July 2017 to July 2018. Interviews were conducted with the key informants from the 18 farming enterprises grouped according to the ownership type and ecological zones as shown in Table 4.1 above. The interview was semi-structured in a sense that the interviewer did not strictly follow a formalized list of questions and thus more open-ended questions were asked, allowing for a discussion with the interviewee rather than a straightforward question and answer session (see Blandford, 2013). The informants were comprised of farmers or beneficiaries of the Nguni project, laborers and the agricultural extension service with knowledge of the project. The data collected included the Nguni animal conception rate, calving rate, weaning rate and age at first calving. The data collected was obtained from the animal records kept by the farmers

The birth and weaning weight were measured using cattle weight measuring tape during the research period (July 2017 to July 2018). Weighing was carried out in the mornings, within a day after the calves were born and six months after (when the calves have started weaning). Measurements were repeated five days after the calves were born and seven days after they have started weaning. For the newly born calves, the final weight was considered as the average weight of the calves at birth and five days later. For the weaning calves the final weight was the average of the initial measurement with the measurements taken seven days' after.

3.5.4 Statistical analysis

This study used a two-way Analysis of Variance (ANOVA) statistics in XLSTAT 2019.1.2 extension or tool for the Microsoft Office Excel version 16.0. An ANOVA is one example of the General Linear Model (GLM) which determines the statistically significance level of the relationship between independent and dependent variables (Gomez & Gomez, 1984) using the factors effect model described in Equation 1. In this study, the aim was to determine whether cattle growth and reproductive performance traits (conception rate, calving rate, weaning rate, age at first calving of Heifers, calves birth weight and calves weaning weight) are affected by the ownership types (CPA and private) across the three different ecological zones.

$$\gamma_{jik} = \mu + T_i + Z_j + T_i \times Z_j + \varepsilon_{ijk} \quad (1)$$

Where γ_{jik} is the observations (e.g. conception rate, calving rate, weaning rater, age at first calving, birth weight and weaning weight), μ is constant, T_i is the effect of enterprises (CPA and Private farms), Z_j is the effect of ecological zones (Highveld, Midveld and Lowveld), $T_i \times Z_j$ is the interaction effect of enterprises and ecological zones and ε_{ijk} is the residual error.

An ANOVA model was set up with the main effects and interactions of the ownership types and ecological zones as independent variables and the cattle growth and reproductive performance traits as dependent variables. An alpha factor of 0.05 was used as the cut-off for significance level determination. Thus, if the p-value is less than the alpha factor of 0.05, the null hypothesis that there's no difference between the means is rejected, concluding that a significant differences exist in the effect of ownership types and ecological zones on the cattle growth and reproductive performance traits. If the p-value is larger than the alpha factor of 0.05, it can be concluded that the effect of ownership types and ecological zones on the cattle growth and reproductive performance traits do no vary.

In addition, the Tukey's pairwise multiple comparison test was used to determine which of the means amongst a set of means derived from ANOVA differ from the rest.

3.5.5 Ethical consideration

The rational for ethical approval as to ensure that the research process is conducted ethically was followed. This involved ethical standards of animal handling and establishing procedures for the informed consent of Nguni Cattle project beneficiaries involved in the research as well as appropriate handling of research findings (secure storage of data, confidentiality where agreed).

CHAPTER 4: RESULTS AND DISCUSIONS

4.1 REPRODUCTIVE TRAITS

Nguni reproductive traits (age at first calving of Heifers, conception rate, calving rate, weaning rate) performance per ownership pattern, ecological zone and the interaction of ownership patterns and ecological zones are shown in Table 4.1.

There were similar effects ($p>0.05$) of ownership patterns on the age at first calving of Heifers. However, the effects differ ($p<0.05$) per ecological zones and per the interaction of ownership patterns and ecological zones. Heifers in the Midveld zone gave birth at an early age (24 months) than those in the Highveld (27 months) and Lowveld (28.3 months) zones. Both CPA and private enterprises Heifers at Lowveld zone together with private enterprises Heifer in the Highveld zone have similar ($p>0.05$) age at first calving of 28.42, 28.35 and 28.09 months respectively. These differ significantly ($p<0.05$) with age at first calving of Heifers in the Highveld CPA (26 months), Midveld CPA (24 months) and Midveld private enterprise (24 months). Both farming enterprises have similar performance in terms of the age at first calving (i.e. 24 months) in the Midveld zone.

The conception rate was similar ($p>0.05$) for CPA and private ownership enterprises as well as for the Highveld, Lowveld and Midveld ecological zones. Table 4.1 also shows similar ($p>0.05$) interaction effect of ownership enterprises and ecological zones on conception rate. Nguni conception rate in this study ranged from 84 – 94%, with those in the Highveld region under private enterprise management particularly doing well at 90% and above. Although death of a calf was recorded at birth in the private enterprise of the Lowveld zone, this did not affect the statistical results significantly. All other zones except the private enterprise of the Lowveld zone, have 100% calving rate, out of all Heifers that managed to conceive. Thus, similar to conception rate, the calving rate was statistically similar ($P>0.05$) across the ownership types and ecological zones.

Not all the calves that were born reached the weaning stage and this affected the ANOVA results significantly. Weaning rate in this study differs ($P<0.05$) according

to the ownership types, ecological zones and the interaction of ownership types and ecological zones. The performance on the Lowveld (75%) and Midveld (76%) was statistically similar (P>0.05), but different (P<0.05) with the Highveld zone (86%). The interaction effect differences were mainly between the Lowveld CPA (67%) and Highveld private enterprise (93%) as well as Midveld CPA (75%) and Highveld private enterprise (93%).

4.2. GROWTH TRAITS

The Nguni growth traits (calving and weaning weights) results of the two-way ANOVA are presented in Table 4.2. The average weight of the calves between the CPA and private ownership enterprises was similar (P>0.05), however the weight differs (P<0.05) per ecological zones. The Midveld zone performed poorly compared to the other zones with average calves weight of 22 kg compared to an average of 24 and 26 kg observed in the Highveld and Lowveld zones respectively. The statistical comparison of the Highveld and Lowveld zones weight suggest that the results are not significantly different (P>0.05). The interaction effect of ownership enterprises and ecological zones on calves' birth weight was similar (P>0.05), where the average weight range from 22 kg in the Midveld CPA to 26.8 kg in the Lowveld CPA.

Weaning weight differs significantly (P<0.05) per ownership types, ecological zones and the interaction between ownership types and ecological zones. The CPA had lower weaning weight of 176 kg compared to 181 kg observed in the private ownership enterprise. The Highveld zone performed better, with average weaning weight of 188 kg compared to 183 and 163 kg observed in the Lowveld and Midveld zones respectively. The Midveld average weaning weight is statistically different (P<0.05) from the Lowveld and Highveld average weaning weight. Private enterprises of the Lowveld and Highveld zones performed very well with average weaning weight of 193 and 190 kg respectively. The Midveld zones for both CPA and private enterprises performed poorly and have statistically different (P<0.05) weaning weight compared with the Lowveld and Highveld private enterprises as well as Highveld CPA.

Table 4.1: Tukey pairwise comparison for Nguni reproductive traits (age at first calving, conception, calving and weaning rate) per ownership, ecological zone and the interactions between the ownership types and ecological zone

Reproductive traits	Statistics	Ownership		Ecological Zone			Interactions: Ownership/ Ecological Zone					
		Private	CPA	Low	High	Mid	CL	PL	PH	CH	CM	PM
Age at first calving	LS means	26.81^{A}	26.14^{A}	28.38^{A}	27.04^{B}	24.00^{C}	28.42^{A}	28.35^{A}	28.09^{A}	26.00^{B}	24.00^{C}	24.00^{C}
	Standard error	0.27	0.27	0.34	0.33	0.34	0.48	0.47	0.46	0.47	0.48	0.48
Conception rate	LS means	0.90^{A}	0.87^{A}	0.86^{A}	0.92^{A}	0.87^{A}	0.84^{A}	0.88^{A}	0.94^{A}	0.90^{A}	0.87^{A}	0.86^{A}
	Standard error	0.01	0.01	0.24	0.02	0.02	0.33	0.03	0.03	0.03	0.03	0.03
Calving rate	LS means	0.89^{A}	0.87^{A}	0.86^{A}	0.92^{A}	0.87^{A}	0.84^{A}	0.87^{A}	0.94^{A}	0.90^{A}	0.87^{A}	0.86^{A}
	Standard error	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03
Weaning rate	LS means	0.84^{A}	0.74^{B}	0.75^{B}	0.86^{A}	0.76^{B}	0.67^{B}	0.83^{AB}	0.93^{A}	0.80^{AB}	0.75^{B}	0.76^{AB}
	Standard error	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04

^{ABC} *Means that do not share a superscript letter are significantly different (P<0.05)*

Table 4.2: Tukey pairwise comparison for Nguni growth traits (Calves' birth and weaning weight) per ownership, ecological zone and the interactions between the ownership types and ecological zone

Growth traits	Statistics	Ownership		Ecological Zone			Interactions: Ownership/ Ecological Zone					
		Private	CPA	Low	High	Middle	CL	PL	PH	CH	CM	PM
Calving weight	LS means	24.27^{A}	24.32^{A}	26.04^{A}	24.72^{AB}	22.12^{B}	26.80^{A}	25.29^{A}	25.85^{A}	24.09^{A}	22.07^{A}	22.17^{A}
	Standard error	0.68	0.69	0.85	0.82	0.85	1.22	1.20	1.15	1.18	1.21	1.20
Weaning weight	LS means	181.42^{A}	176.43^{B}	183.97^{A}	188.86^{A}	163.94^{B}	174.24^{B}	193.70^{A}	190.16^{A}	187.55^{A}	167.50^{BC}	160.39^{C}
	Standard error	1.40	1.49	1.82	1.82	1.81	2.71	2.44	2.31	2.49	2.56	2.55

^{ABC} *Means that do not share a superscript letter are significantly different (P<0.05)*

4.3 DISCUSSIONS

Nguni Heifers in this study showed positive performance in terms of the age at first calving which ranged from 24 to 28 months. Notwithstanding differences in other environmental and socio-economic factors contributing to cattle productivity, these figures are much better than 35 months of age at first calving reported for Nguni cattle in the southern part of Mozambique (Maciel *et al.,* 2012), and 28 to 33 months observed in the commercial Nguni cattle in Namibia (Agra, 2005). Cows that give birth at an early age have short subsequent calving interval signalling high productivity and more desirability (Gutierrez and Goyache, 2002). Similar to Tada *et al.* (2013) we found that ownerships did not play a role in influencing the age at first calving. The Midveld zone performed better (24 months) for both private and CPA enterprises than other ecological zones in terms of age at first calving. This implies that Nguni heifers adapted better in the Midveld zone than the other ecological zones.

Conception rate did not vary according to the ownership patterns, ecological zones and the interaction between ownership patterns and ecological zones, with the rate ranging from 84 to 94%. Our results are higher than the conception rate of 55.96±0.31% reported for various breeds in India comprising mainly of Holstein Friesian, Jersey cross animals and non-descript breeds (Bhagat and Gokhale 2016) and 57.7% conception rate of the non-descript Zebu cows in Bangladesh (Mollah *et al*., 2015). The high conception rate in this study may be attributed to the fact that mating of these cows occurred during the same breeding period of the year. It can be concluded that Nguni cattle in these three ecological zones and enterprises are performing well in terms of conception rate.

Previous studies have shown that the reproductive performance of cows under communal farming conditions is low in terms of the calving rate (e.g. Bembridge, 1987; Nthakheni, 1993; Mokantla *et al*., 2004). In this study, all Heifers that conceived managed to give birth in the CPA. Only one death was reported in the private ownership enterprise. This is far better compared to the calving rate of 43 to 64% reported by Madzivhandila *et al*. (2007) for beef cows in Limpopo province. Gizaw (2013) reported an average calving rates of between 64 and 91% and 68 and

87% in various herds of Sanga cattle in Southern Africa under similar conditions. Lepen (1998) also reported an average calving rate of 84.3% in the Nguni herd studied.

One of the key production and performance indicators for a cow herd is the number of weaners produced. In this study, most of the CPA's suffered high mortality rate before reaching weaning stage as demonstrated by 74% weaning rate compared to the 84% weaning rate in the private ownership enterprise. Mortality rate was higher in the Lowveld (25%) and Midveld (24%) than in the Highveld zone (14%). This can be attributed to the pre-weaning illness associated with hotter temperatures in the Lowveld and Midveld zones than the Highveld zone where temperatures are mostly cooler. According to Dairy Australia Limited (2017), heat stress is the major cause of pre-weaning calf deaths, especially for calves exposed in the last six weeks of pregnancy since the ability of the calf to acquire passive immunity from colostrum becomes reduced.

The ownership patterns did not have any significant influence on the average weight of the calves but the weight differs in accordance with ecological zones. It is generally accepted that ecological zone has a large influence on the quality and quantity of forage (Snyman, 1999, Tainton and Hardy, 1999; Fynn and O'Conner, 2000) and have a huge impact on milk production (Henry *et al.,* 2012) which in turn influence the body weight of calves. The Lowveld is generally characterized by sweetveld type and thus performed better with the average of 26 kg of calves' birth weight compared to the sourveld Highveld (24 kg) zone and the mixveld Midveld zone (22 kg).

Both the ownership types, ecological zones and the interaction between ownership types and ecological zones have significant impact on the weaning weight. The CPA generally performs poorly because the low input communal production system, thought to be ideal for indigenous cattle, is characterized by multiple cattle ownership patterns which affect production efficiency from a management point of view (Ainslie, 2005; Palmer and Ainslie, 2006). Differences in calves weaning weight performance across the ecological zones depict sensitivity of calves to postnatal stress and can be attributed to nutritional differences between the ecological zones

(Mpofu *et al*., 2017). The low average weaning weight in the Lowveld zone for example, may be the results of overgrazing, since sweetveld is sensitive to overgrazing during the growth season resulting in low forage quality and quantity. Although vegetation in the Highveld zone is sour, its ability to produce palatable grazing with a fairly high nutritive value during the growth season and the ability to withstand overgrazing may have contributed to high weaning weight. In addition, high weaning weight may also be attributed to the low heat stress in the Highveld zone (Dairy Australia Limited, 2017).

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

Results of the current study suggests that ecological zones seem to be the most determining factor on most of the growth and reproduction performance traits of the Nguni cattle in the Mpumalanga province where the Highveld seems to perform better than the other zones followed by the Lowveld zone. The private ownership type across the three ecological zones appears to have good results in terms of growth and reproductive performance of the Nguni cattle in Mpumalanga province. The CPA ownership types seem to have poor performance of Nguni cattle, thus more attention needs to be paid regarding the performance of Nguni cattle. Strategies need to be put in place when allocating Nguni cattle to projects in order to ensure similar growth and reproductive performance in different zones. A full range of backup services offered to the communities by stakeholders in the form of a beef package that includes veld and pasture management, nutrition management, beef performance, animal recording keeping, genetic evaluation and animal health management program needs thorough attention.

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APPENDICES

Appendix A: Summary statistics (Quantitative data

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
Age at First Calving	540	61	479	24.000	36.000	26.493	4.660
Conception Rate	540	0	540	0.000	1.000	0.887	0.317
Calving Rate	540	0	540	0.000	1.000	0.885	0.319
Weaning Rate	540	0	540	0.000	1.000	0.794	0.404
Calves Weight at Birth	540	64	476	18.000	252.000	24.311	10.746
Calves Weaning Weight	540	111	429	48.000	224.000	179.70	24.446

Appendix B: Summary statistics (Qualitative data)

Variable	Categories	Counts	Frequencies	%
Ownership	CPA	270	270	50.000
	Private	270	270	50.000
Zone	High	180	180	33.333
	Low	180	180	33.333
	Middle	180	180	33.333

Appendix C: Goodness of fit statistics

C:1 Age at First Calving

Observations	479.000
Sum of weights	479.000
DF	473.000
R^2	0.171
Adjusted R^2	0.162
MSE	18.199
RMSE	4.266
MAPE	11.308
DW	0.000
Cp	6.000
AIC	1395.708
SBC	1420.738
PC	0.850

C:2 Conception rate

Observations	540.000
Sum of weights	540.000
DF	534.000
R^2	0.010
Adjusted R^2	0.000
MSE	0.100
RMSE	0.317
MAPE	11.188
DW	0.635
Cp	6.000
AIC	-1235.523
SBC	-1209.773
PC	1.013

C:3 Calving rate

Observations	540.000
Sum of weights	540.000
DF	534.000
R^2	0.010
Adjusted R^2	0.000
MSE	0.102
RMSE	0.319
MAPE	11.371
DW	0.626
Cp	6.000
AIC	-1227.852
SBC	-1202.103
PC	1.013

C:4 Weaning rate

Observations	540.000
Sum of weights	540.000
DF	534.000
R^2	0.037
Adjusted R^2	0.028
MSE	0.159
RMSE	0.399
MAPE	19.785
DW	0.415
Cp	6.000

AIC	-987.193
SBC	-961.443
PC	0.984

C:5 Calves birth weight

Observations	476.000
Sum of weights	476.000
DF	470.000
R^2	0.025
Adjusted R^2	0.015
MSE	113.770
RMSE	10.666
MAPE	7.886
DW	1.945
Cp	6.000
AIC	2259.432
SBC	2284.424
PC	1.000

C:6 Weaning weight

Observations	429.000
Sum of weights	429.000
DF	423.000
R^2	0.258
Adjusted R^2	0.249
MSE	448.609
RMSE	21.180
MAPE	9.609
DW	1.568
Cp	6.000
AIC	2625.497
SBC	2649.866
PC	0.763