Soil and forage mineral status and farmers' perceptions of livestock husbandry and rangeland management practices in two communal coastal areas of the Eastern Cape Province, South Africa

By

Matshawule Sinethemba

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P/Bag X1314

Alice

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Approved as to style and content by:

Prof. S.T Beyene

(Supervisor)

Prof. V. Muchenje

(Co-Supervisor)

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Declaration

I, Sinethemba Matshawule, declare that dissertation titled SOIL AND FORAGE MINERAL STATUS AND FARMERS' PERCEPTIONS OF LIVESTOCK HUSBANDRY AND RANGELAND MANAGEMENT PRACTICES IN TWO COMMUNAL COASTAL AREAS OF THE EASTERN CAPE PROVINCE, SOUTH AFRICA is my own work, and has not been submitted to any other University. All the assistance towards the production of this work and all references contained herein have been fully accredited.

MTS 04/07/2016

Mr Matshawule Sinethemba **Date**

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Abstract

This study was conducted to determine the mineral status in the soil, forage and farmer's perceptions of livestock husbandry and rangeland management in two communal coastal areas (Dyamdyam and Machibi) of the Eastern Cape, South Africa. In each area, grass and soil samples were collected from three grazing sites located around homesteads. On each study site two homogeneous vegetation units of 20 m x 50 m was marked and six 0.25 m^2 quadrants were laid randomly in each HVU to record vegetation and soil data during summer and winter seasons. Herbaceous species found within each quadrant were identified, counted, their height and tuft diameter measured and eventually harvested. Herbaceous species were also classified according to their palatability, life form and ecological status. Both grass and soil data were analysed using General Linear Model (GLM) procedure of SAS (2010). Forage and soil samples were analysed for N, Ca, Mg, K, P, Cu, Zn, Mn and Fe. For farmers' perception survey, a total of 100 farmers from both Dyamdyam and Machibi were interviewed using a structured questionnaire. Results showed that at Dyamdyam soil P, Fe and Mn contents were significantly different ($P < 0.05$) among the study sites, with near sites having greater values than middle and far sites. At Machibi soil N, P, Fe, Cu, Mn and Zn showed a significant difference ($P < 0.05$) among the study sites, with bottom sites having greater levels than midslope and top sites. Soil sampled from study areas contained inadequate amounts of Mg, Ca and Zn for optimum pasture growth.

As for the vegetation cover, a total of 20 herbaceous species were identified in the study areas. The common or dominant grass species were *T. triandra, C. dactylon, E. capensis, E. plana* and *S. africanus*. In both areas, biomass production was significantly highest ($P < 0.05$) in the summer compared to the winter season. The biomass production was also found to be highest at far and top sites in the Dyamdyam and Machibi communal areas, respectively. Forage N, P and Fe avalues at Dyamdyam and Machibi were significantly higher ($P < 0.05$) in summer than winter in all the study sites. Forage Fe levels were highest ($P < 0.05$) in the near and bottom sites than other sites at Daymdyam and Machibi respectively. Forage samples harvested from both study areas contained inadequate levels of P, N and Cu required for optimum livestock performance.

In both villages household respondents indicated that the primary challenges faced to keep their livestock are stock theft, feed shortage and animal diseases. They unanimously indicated that rangelands are primarily used for grazing, followed by the collection of wood and grass for building, fire and medicines. All respondents agreed that they practiced continuous grazing due to the absence of fence on their rangelands. It can be concluded from this study that season, distance gradient, landscape from homestead and livestock are important factors driving the changes in soil and forage nutrients availability, species composition and biomass production. Therefore, these factors should be considered in planning rangelands management programs in communal grazing areas. Mineral concentration in the forages were low (deficient) in the study areas, and therefore, supplementing grazing animals with feed containing high concentration of P, CP and Cu is highly recommended. Communal farmers at Dyamdyam and Machibi have a poor understanding in managing their rangelands. They also do not control livestock movements due to vandalised fences in their rangeland. Therefore, fencing and educating communal farmers

about their rangeland management practices should be given prior attention any rangeland cattle production development interventions.

Keywords: Biomass, household respondents, macro-minerals, micro-minerals, season, species composition, supplementation.

Dedication

I dedicate this work to my father, mother and my siblings who were with me spiritual during this work. This is for you.

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List of abbreviations

BCMM	Buffalo City Metropolitan Municipality
CEC	Cation Exchange Capacity
CP	Crude Protein
CRBD	Completely Randomized Block Design
DAFF	Department of Agriculture Forest and Fisheries
ECDC	Eastern Cape Development Cooperation
EDTA	Ethylenediaminetetraacetic Acid
EMG	Environmental Monitoring Group
GLM	General Linear model
GMRDC	Govan Mbeki Research and Development Centre
ICP	Inductively Coupled Plasma
IDC	Industrial Development Corporation
KCL	Potassium Chloride
MD	Dry Matter
NDA	National Department of Agriculture
NRC	National Research Council
SAS	Statistical Analyses System
SE	Standard Error
SPSS	Statistical Package for the Social Sciences

CHAPTER 1. GENERAL INTRODUCTION

1.1. Background

Communal rangelands occupy about 15.5 % of the entire land surface of South Africa with 12.7 million people residing in these areas (Benett and Barrett, 2007; Vetter *et al.*, 2006; Benett *et al.*, 2012). Livestock production, a vital source for rural livelihood is reliant on these rangelands for grazing and browsing. A recent report on the livestock population of South Africa showed that the country has 6.4 million goats, 25 million sheep and 13.8 million cattle (DAFF, 2011). Of these 36 % of sheep, 66 % of cattle and 60 % of goats are found in communal areas (NDA, 2004).

The Eastern Cape Province is well-known for livestock production and is the home of indigenous livestock breeds such as Nguni cattle, Boar goat and Dorper sheep (ECDC, 2011). The Eastern Cape is the second-largest province of South Africa, taking up 13.9 % of the country's land area and has a human population of around 8.5 million (SSA, 2003). The majority of human population in the Eastern Cape lives in communal regions, where poverty and food insecurity is high (Delali *et al.*, 2006). The unreliable rate of rainfall and the occurrence of drought in the province could explain why many people in the province depending more on livestock than crop farming for their livelihood (Musemwa *et al.*, 2008). Livestock production is a foremost and old agricultural practice that historically verified and able to assist the livelihoods of the rural communal people. In most communal areas, farmers raise different livestock species such as cattle, sheep, goats, pigs and chickens (Mapiye *et al.,* 2009). The estimated number of cattle, sheep and goats found in communal areas of the Eastern Cape is 3.2 million, 8.1 million and 2.9

million, respectively (NDA, 2008). According to Delali *et al.* (2006), cattle are the most important livestock species due to their multiple functions.

Natural pasture is the major source of nutrients for grazing livestock on the extensive rangelands, and yet it rarely satisfies the nutrients required by grazing animals throughout the year, in particular the minerals (Espinoza *et al.*, 1991; Gwelo *et al.*, 2015). Indeed, livestock performance on natural rangelands is affected by the spatial and seasonal fluctuations in the quality and quantity are of available forage including the minerals concentration of the forage. Spatially, the concentration of forage minerals varies with soil type, topography such as elevation, slope and aspect, plant species composition and grazing management practices applied (McNaughton *et al.*, 1997; Gizachew *et al.*, 2002). Seasonally, variations are mainly due to differences in the stage of plant maturity of grazeable plants and structural components in the proportion of forage species mainly on dry matter basis and grazing management applied (McDowell *et al.*, 1983; McNaughton *et al.*, 1997; Undersander, 2003).

Natural rangelands found in coastal areas of South Africa have distinctive climatic and topographic conditions (Li *et al.*, 2012). Plant species growth on coastal rangeland can be highly different from year to year and is generally restricted by the reduction of soil moisture and cool temperature in winter (Li *et al.*, 2012). According to George *et al.* (2001) reported that the growth rate of coastal grasses is fast in the late fall after the first rains have turned, slow growth in winter and fast growth again in spring. Coastal rangelands are one of the most important economic and livelihood source for the communal people. They provide forage for grazing and browsing animals, thatch grass for building and medical plants (Kepe, 1997). However, many coastal rangelands in South Africa are threatened by degradation (Ward *et al.*, 2000). The extent of degraded coastal rangelands is estimated to be 25% of the total communal rangelands in South

Africa (EMG, 2000). According to Palmer *et al.* (1997), rangeland degradation is the major challenge in the communal coastal areas of Eastern Cape, because it diminishes rangeland primary production and soil protection.

1.2. Problem statement

Poor forage quality and low forage supply have been identified as the most significant factors limiting livestock production in the semi-arid areas of South Africa (Gwelo *et al.,* 2015) As a result, livestock fail to meet their nutrients required both for maintenance and production in the entire grazing period (Collinns-Luswet, 2000). Most communal farmers in coastal and inland areas are beneficiaries of the Nguni cattle project. In 2004, the University of Fort Hare in collaboration with Industrial Development Corporation (IDC) and the Eastern Cape Department of Agriculture agencies initiated the Nguni cattle development project (Musemwa *et al.*, 2008). The aim of the project is re-introducing the Nguni cattle in communal areas (Mapiye *et al.*, 2007). Farmers have complained about the poor performance of Nguni cattle, however, the contributing factors (except the recognized fact of their genetic potential) are not exactly known. One factor may be related to feed availability and quality, and it is therefore imperative to determine the spatial and temporal patterns of both forage quality and quantity produced on rangelands. In these areas the chemical properties of soil are not well understood, and thus it is vital to investigate the macro and micro soil elements. Many researchers conducted elsewhere recognise the importance of documenting the indigenous knowledge and perceptions possessed by communal farmers regarding rangeland resources and livestock management (Solomon *et al.*, 2007; Kgosikoma *et al.*, 2012; Ghorbani *et al.*, 2013). Hence, it is desirable to assess farmers' perceptions of rangeland and livestock management to combine the findings with field studies.

1.3. Justification

Results from this study would have a significant impact on the management of rangelands and development of feeding and supplementing strategies. The foremost findings would provide guidelines on the provision of supplementary feed to livestock. This study would also be helpful in increasing productivity and further economic benefits of livestock to the communal farmers. The outcomes of this study would help the communal farmers to manage and utilize the available feed resources for increasing and sustaining livestock production to meet the demand of food security in South Africa. The study would also deliver the opportunity to identify possible nutrient deficiencies in plants and soil in the communal coastal rangelands. In addition, the findings of this study would contribute towards planning possible range management and rehabilitation programs to improve forage and fodder production for livestock.

1.4. Objectives

General objective:

Evaluation of soil and forage nutrients in two communal coastal areas (Dyamdym and Machibi) of the Eastern Cape, South Africa and famers' perceptions of livestock husbandry and rangeland management practices.

Specific objectives:

1. To assess indigenous knowledge and farmers' perceptions of livestock performance, herd management, rangeland condition and indigenous feed resource management in communal areas.
2. To determine the mineral status of soil and forage in two communal coastal areas over two seasons.

3. To determine species composition and biomass production of herbaceous plants in two communal coastal areas over two seasons.

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CHAPTER 2. LITERATURE REVIEW

2.1. Introduction

Cattle production is the most significant animal farming in South Africa and it accounts for about 25-30 % of agricultural output per annum (Musemwa *et al.*, 2008). The importance of the livestock sector in the agricultural industry may be explained from numerous perspectives. Livestock products have significant contribution to agricultural output which is not surprising since nearly 80 % of the agricultural land in South Africa is used for livestock husbandry (DAFF, 2011). Livestock production in rural areas contributes significantly to food security and income generation. Livestock also meet other multiple objectives that are required by resource limited farmers. These include provision of draught power, manure and other social and economic functions

There are two livestock production sectors in South Africa namely communal and commercial sectors. The communal livestock production system is sedentary and small scale, primarily based on extensive grazing and browsing on communal lands (Gwelo *et al.*, 2015). These communal grazing lands are characterized by the multiple ownership of land by all community members and raising different livestock species on the same grazing land (Mapekula, 2009). This makes it quite difficult for livestock farmers to make decision for sustainable use and management of natural pastures as discussed in the theory of the tragedy of common established by Hardin (1968). Regardless of the wildly recognised tragedy of the common hypothesis, it is accepted that some communal farmers worldwide have in-depth knowledge of grazing land management, rangeland condition evaluation and livestock management (Millis *et al.*, 2002; Solomon *et al.*, 2007; Ghorbani *et al.*, 2013).

The study of Palmer *et al.* (1997) indicated that about 0.5 million ha of grazing lands in the Eastern Cape communal areas was in good condition, 10.6 million ha in moderate condition and 2.6 million ha in poor condition. The authors reported that communal rangelands have a lowest biomass production, compared to commercial rangelands (Palmer *et al.*, 1998).

2.2. Brief overview of communal rangeland

Everson and Hatch (1999) defined communal rangelands as those areas that are communally used as the source of forage for livestock. Rangeland is a collective term used to describe native grasses and shrubs that grow in arid and semi-arid regions. Communal rangelands are also used for collection of wood fire and building. Some studies in southern Africa reported that communal rangelands provide services such as timber, pharmaceuticals, human food, animal feed, income and fresh water (de Oliveira *et al.*, 2003; Dovie *et al.*, 2007). Communal rangelands in South Africa are classified into sweet, mix and sour veld based on vegetation type and amount of precipitation received per annum (Ellery *et al.*, 1995; Lesoli, 2008). Most communal rangelands are freely in access by every community members with little attention given to manage the common property (Kotze *et al.*, 1999).

According to Shackleton (1993), communal rangelands are continuously grazed due to absence of fence and poor rangeland management practices. Consequently, large areas of communal grazing lands in South Africa are degraded (Hoffman and Todd, 2000). According to Ramirez *et al.* (2001), livestock performance on communal rangelands is mainly affected by the seasonal fluctuation in forage quantity and quality. During the dry seasons forage rarely meet all nutrients required by ruminants (Espinoza *et al.*, 1991; Khan, 2003). In particular, mineral imbalance in forage has been reported as the main driving factor that causes low production rate and reproduction failure in communal livestock (McDowell, 1983).

2.3. Livestock productivity and its constraints in communal areas

The productivity of livestock in communal areas is comparatively low compared to commercial farms (NDA, 2004). The major production constraints in communal regions are related to management of farming, diseases complex, nutrition, stock theft and seasonality of feed availability (Mapiye *et al.*, 2006). Feed shortage in communal rangelands is worsened by reduction in the areas of available grazing land and rangelands degradation (Mngomezulu, 2010). Other reasons comprise population pressure, increase in livestock numbers, expansion of farming and bush encroachment (Gemedo-Dalle *et al.*, 2006; Solomon *et al.,* 2007). According to Mapiye *et al.* (2009), lack of adequate skill for livestock and rangelands management results in increased feed shortage, stock theft and animal health problems.

Several managerial practices in communal areas, such as weaning, selection of animals for breeding, grazing management, planned mating and parasites control are not practised. In most cases, this is due to lack of knowledge and existing condition such as infrastructure and land tenure rights within communal farming system (Montshwe, 2006). Low reproduction rate and high level of mortality are other contributing factors to the low livestock productivity in communal areas.

2.4. Farmers' perceptions on livestock management and communal rangeland condition assessment

Communal farmers worldwide have in-depth knowledge of traditional methods of rangeland condition evaluation and livestock management (Millis *et al.*, 2002; Ghorbani *et al.*, 2013). This knowledge is obtained and maintained through continuous keeping of farm livestock (Angasa and Oba, 2010) and the use of natural rangelands as the source of feed for the livestock (Abate *et al.*, 2010). Communal farmers do not have only the understanding of rangelands dynamics and livestock performance but also their causes (Kgosikoma *et al.*, 2012). Communal farmers consider a diversity of indicators such as vegetation, soils and livestock. This knowledge varies from place to place and may also vary from individual to individual within the same location. Some communal herders evaluate the status of rangelands and determine grazing for different animal species (Cotton, 1996). Some farmers in communal areas do so without any assistance of the modern science of rangeland and livestock management and combination of the traditional system of evaluations into scientific methods.

Many scientists worldwide have recognised the indigenous knowledge possessed by communal farmers and their perceptions on rangeland and livestock management (Solomon *et al.*, 2007; Kgosikoma *et al.*, 2012; Ghorbani *et al.*, 2013). However, modern science of rangeland and livestock management has neglected the communal famer's perceptions and participation, largely due to the perceptions of official resource managers that communal farmer's knowledge lacks objectivity (Brown, 1999). Indeed, there have been several attempts to justify that this knowledge is important for local resources management although some criticise communal farmers for being the resource degraders (Thebaud and Batterbury, 2001). Other scientists concluded that, a combination of indigenous and scientific knowledge can provide more useful evaluation of environment change and its implication for local land users (Thomas and Twyman, 2004). Recently, the application of indigenous knowledge has been viewed as a solution to restore and use properly the communal rangelands for sustainable livestock production (Thomas and Twyman, 2004). This comes from the fact that communal farmers are knowledgeable about the grass species composition and palatability of these species to their livestock (Kgosikoma *et al.*, 2012). Nevertheless, in many other ecological studies, indigenous knowledge has been ignored and disapproved (Brown, 1999; Abate *et al.*, 2010). In South Africa, the communal farmers are considered by extension officers as being uninformed with regard to application of accurate grazing systems (Allsorp *et al.*, 2007).

2.5. Factors affecting nutritive value of forage

2.5.1. Stage of plant maturity

Forage nutritive value is defined as the chemical composition, digestibility and nature of digested products (Mott and Moor, 1985). Stage of plant maturity is the foremost factor that affects the nutritive value of forage (Marten, 1988; Stokes and Prostko, 1998). Many studies worldwide reported that, when the plant is matured crude protein (CP) and other minerals decline (Gizachew *et al.,* 2002; Khan, 2003; Mountousis *et al.*, 2008 and Gwelo *et al.*, 2015). Low levels of forage nutrient during the maturity stage is due to the fact that some plant tissues become dead when plant is matured and therefore, the concentration levels of forage elements in dead tissues is relatively low (Greene *et al.,* 1987).

2.5.2. Season

Season has been found to have great impact on the availability of nutrients in forage (Mountousis *et al.*, 2008). In most cases nutrients availability in forage is higher in summer than winter due to presence of optimum temperature and moisture (McKaffe, 2008; Xin *et al.*, 2001). In summer soil temperature increase and this result to an increase in plant metabolic activities which in turn increases absorption of nutrients from the soil by roots (McKaffe, 2008). In addition, during the rainy season availability of moisture become higher and concentration levels of both macro and micro elements tend to be higher in forage (Khan *et al.*, 2006). On the other hand, during winter many grass species become dead due to climatic conditions and therefore, the concentration levels of phosphorus (P), potassium (K), nitrogen (N), iron (Fe) and manganese (Mn) in dead plants become relatively low (Greene *et al.,* 1987). The decline in the concentration of these macro and micro elements in forage with advancing growing season was also reported by other researchers from eastern Africa (Gizachew *et al.,* 2002) and southern Africa (Gwelo *et al.*, 2015). However, some authors reported high levels of forage macro and micro elements in winter than summer. For instance, Khan *et al.* (2006) in Pakistan reported high concentration of forage Cu and N in winter than summer.

2.5.3. Plant species

Plant species is the most significant factor than soil or season in determining the mineral composition of the forage. In natural pastures mineral levels varies from species to species. Legumes have more calcium (Ca) and nitrogen (N) than grasses and their Ca:P ration is higher (McKaffe, 2008). Leguminous species contain their own nitrogen and are capable to building up nitrate reserves in the soil which may become available to associated forage species. High palatable grass species contained high nutrients than the less palatable species (Quattrocchi, 2006). It has also reported that plant species that have deep roots species have higher nutrients because they absorb more nutrients form soil than species that have shallow root system (Brown, 2003). In addition, woody species are generally high in protein than grasses and forbs (Espinoza *et al.,* 1991).

2.5.4. Topography

Regarding with topography, large amount of soil nutrients are transported from uplands due to rough soil erosion and accumulation on bottomlands (Gizachew *et al.*, 2002). Therefore, this can result to higher nutritive value on grass species grow on bottomlands. For instance, Gizachew *et al.* (2002) from highlands of Ethiopia and Gwelo *et al.*, (2015) from semi-arid savannas of South Africa reported high forage Ca and Fe levels in bottomlands than uplands. This may be due to a high organic matter in bottomlands. Bottomland soil are deeper and darker in colour, this attests high organic matter.

2.5.5. Soil type

High nutritive value of forage can be found in soils that have high organic matter and high nutrient availability such as loam and clay soil. Loam soils contain more nutrients than clay and sandy soils and it have a better drainage and infiltration of water and ability to hold nutrients than clay and sandy soils (Brown, 2003). Clay soils are dark and this indicates high organic matter, high content of cation exchange capacity (CEC) and high capability to hold nutrients than sandy soil (CUCE, 2007). Sandy soils have low organic matter, low CEC, can be easily leached and have low nutrients retaining ability (CUCE, 2007). Therefore, forages grow on loam and clay soils have higher nutrients than forage grow on sandy soil (Brown, 2003). Other studies reported that, Zn, Mg, K and Cu concentrations are low in acid sandy soil and highly leached areas such as coastal areas and this tend to results in low levels of these elements in forage (CUCE, 2007).

2.6. Rangeland soil and factors affecting soil nutrients

Many communal rangelands soils are considered to be degraded and unproductive (Solomon, *et al.*, 2007). The extent of rangeland soil degradation is estimated to be 25 % of the total communal rangeland in South Africa (EMG, 2000). Soil degradation in communal rangelands can be attributed by a combination of many factors of which most of them are associated with human activities and overgrazing (Hoffman and Todd, 2000). Most of communal rangeland soils are unproductive due to degradation and poor composition of soil nutrients (Oztas *et al.*, 2013). Rangeland soil nature and its physic-chemical properties affects the ruminants as it cause mineral deficiency in them (McDowell, 1985). It has been reported that there is high leaching of minerals in most communal rangeland soils found in coastal areas due to dominance of sandy soil (Espinoza *et al.*, 1991).

Some authors reported that most communal rangelands soil in Pakistan has a deficiency of nitrogen (N) and phosphorus (P) (Hussain and Durani, 2008) and in South Africa has a deficiency of magnesium (Mg) (Drewes *et al.*, 1999). However, micro elements such as iron (Fe) and manganese (Mn) in rangeland soil were sufficient (Khan *et al.*, 2006; Beyene and Mlambo, 2012). The main factors that affect the availability of nutrients from the soil are grazing land management, topography, soil type, chemical properties and seasonal variation (Jones, 2001).

2.6.1. Grazing land management

Livestock grazing or browsing affects the soil mineral, carbon and including nitrogen dynamics and storage (Gao *et al.*, 2009). Livestock grazing can improve mineral status of soil because animal urine and feaces add large amount of soluble nitrogen and other minerals in soils (McNaughton *et al.,* 1997). Many studies reported that concentrations of soil nitrogen (N) and available phosphorus (P) are higher on part of rangeland that is heavily grazed due to deposition of more animal manure and urination (Yates *et al.*, 2000; Gao *et al.*, 2009). However, some authors reported that heavy grazing results in decline in several soil nutrients (He *et al.,* 2011). For instance, Congdon and Hebohn (1993) in north Queensland reported that, availability of P concentration in soil was lower in heavily grazed areas compared to effectively grazed areas. In addition, Sigua *et al.* (2011) reported that livestock grazing and suitable rangeland management play a vital role in soil P dynamics as it affects P cycling because of the return of P through mineral excretion. Other authors reported that effective grazing management practices and correct stocking rate increase the above biomass that can add soil organic matter (OM) and other soil nutrients (Conant *et al.*, 2001).

2.6.2. Topography

Topography is the one of the most important factor that can affects the nutrient status of soil. According to Gizachew *et al.* (2002) in Ethiopia reported that large amount of soil nutrients are transported from top lands through soil erosion during high rainfall and accumulated on bottomlands. Bottomlands contained high soil Fe than slope and uplands (Gizachew *et al.,* 2002). This may be due to a high organic matter in bottomlands. Most of the time livestock likely to graze on bottomlands due to easy access (Senft *et al.*, 1985). Thus, this may results to higher accumulation of animal manure on bottomland, which eventually lead to a high concentration level of soil minerals and organic matter (Lesoli, 2008). In contrast, Gwelo *et al.* (2015) in South Africa reported that landscape does not have any significant effect on soil elements concentration.

2.6.3. Soil type

Soil type also has on effects on the mineral status of soil. Soil texture affects the soil's capability to hold water and nutrients. Loam soils contain more nutrients than sandy soils and have a better drainage and infiltration of water and ability to hold nutrients than silt soils. The texture in loam soil ideally is about 40 % sand, 40 % silt and 20 % clay by weight (Brown, 2003). Clay soils contain high organic matter (OM), high cation exchange capacity (CEC) and high capability of holding macro nutrients (CUCE, 2007). Sandy soils have low organic matter, low cation exchange capacity, easily leaching and low retaining ability of potassium (K^{+}), magnesium (Mg^{2+}) (CUCE, 2007). Cation exchange capacity (CEC) is a measure of the soil's ability to retain positively charge ions (Matlhoahela *et al.*, 2006).

2.6.4. Chemical properties of soil

Soil pH and moisture availability have great impact on the mineral status of the soil. Soil pH is defined as the comparative concentration of hydrogen ions in the soil solution (CPHA, 2002). Mineral availability in soil is dependent on soil pH values. The optimum range of pH is 6 to 7 and at this range macronutrients such as N, P, K, Cu and Mg are more ready available in soil (Matlhoahela *et al.*, 2006). Micronutrients such as Fe and Mn are less available in soil with pH above 5 and more available in soil with pH less than 5 (Matlhoahela *et al.*, 2006). Biological activity of macronutrients (such as N, P, K, Mg and Ca) and accumulation in the soil depends on moisture availability (Rasaei *et al.*, 2012). For instance, Xin *et al.* (2001) in China reported decomposition materials that can add soil nutrients are higher in summer due to availability of soil moisture.

2.6.5. Season

Season has great effects on soil nutrients availability. Many studies worldwide found that most macro and micro elements concentration in soil are higher in summer than winter due to soil moisture availability and optimum temperature (McKaffe, 2008; Xin *et al.*, 2001; Gwelo *et al.*, 2015). For instance, the study of Khan *et al.* (2006) in Pakistan reported higher soil Cu and Zn levels in summer than winter. However, concentration levels of soil Fe and Mn, in Pakistan, were higher in winter than summer (Khan *et al.*, 2006). In addition, other studies reported that high levels of some soil nutrients in winter is because of high dead plant material that add soil OM and other soil minerals in to the soil (Jones, 2001).

2.7. Species composition and biomass production of pastures in communal rangelands

Species composition and biomass production are indicators of the productivity and health status of rangelands (Oztas *et al.,* 2003). Species composition and biomass production on communal rangeland varies according to grazing system (Shackleton, 1993), seasonal variation (Angassa and Oba, 2010), soil type (O' Farrell *et al.*, 2007), topography (Lesoli, 2008) and grazing intensity (Smet and Ward, 2003; Maki *et al.*, 2007).

Species composition is defined as the relative frequency of occurrence of herbaceous species in a rangeland (Trollope *et al.,* 1990). In addition, it is one of the factors that indicates the rangeland condition because herbaceous species are different significantly in their palatability, ecological status, life form and their response to grazing (Abule *et al.*, 2007). Overgrazing caused by livestock has been regarded as the main degrading factor of natural rangelands because it changes the vegetation structure and composition (Yates *et al.*, 2000; Maki *et al.*, 2007). Increaser and Decreaser species dominate with high grazing pressure and decline in number when the rangeland is overgrazed respectively (Sisay and Baars, 2002). Communal extensive natural rangelands are overgrazed and selectively grazed due to absence of fence and poor rangeland managerial practice (Shackleton, 1993). Therefore, this results in a decline of decreaser species that may vanish or replaced by increaser (Sisay and Baar, 2002; Hein, 2006). However, Laughlin and Abella (2007) reported that, in non-equilibrium system species composition change is determined more by rainfall than by grazing pressure. This is because rain is the main factor that promotes the activities of the [illegible]ous species.

Other studies reported that high palatable species dominate in a rangeland that is well managed and decrease with poor management such as over utilization and selective grazing (Danckwerts, 2001; Morris and Kotze, 2006). Continuous removal of highly desirable grass species by livestock give an opportunity for less palatable grass species to get more chance to grow and produce seeds and eventually become dominant in the area (Nsinamwa *et al.,* 2005). The dominance of strong perennial grass species shows that the rangeland is protected against soil erosion and degradation (Morris and Kotze, 2006).

Biomass production is define as accumulation of total dry matter of living material which is actively and structurally functional in a given area and is normally used as source of energy for livestock and for fuel (Bond-Lamberty *et al.*, 2002). Noellemeyer *et al.* (2006) pointed out that biomass production on natural rangelands varies according to the availability of moisture. Therefore, biomass production on rangelands increases with the increasing average annual rainfall. According to Angassa and Oba (2010), biomass production during dry season becomes less than during wet season. This is allied with high amount of rainfall, organic matter, moisture and nutrients availability during wet season than dry season (Angasa and Oba, 2010). However, on natural rangelands biomass production varies depending on dominant species, grazing system and physiological stage of the grass (McDonald *et al.,* 1987). In addition, mineral imbalance in soil reduces productivity of rangeland and results in low biomass production for livestock. Overgrazing has been considered to have an impact on biomass production in communal rangelands (Savadogo *et al.*, 2007). Overgrazing diminishes biomass production not only by repeated forage consumption but also through physical damage (Savadogo *et al.*, 2007). Overgrazing may cause reduction of new shoot production through direct removal of the apical meristems of forage plants and this may result to low production of biomass (Noy-Meir, 1993).

Soil type and topography have been reported to have effects on biomass production in communal rangelands. Biomass production in silt and clay soil was reported to be higher than in sandy soil in areas with similar climates and topography (O' Farrell *et al.*, 2007). Topography is also regarded to have an impact on biomass production. Biomass production in bottom grazing lands is low due to heavily grazing because are easy access by livestock (Senft *et al.*, 1985; Lesoli, 2008). However, other authors reported that biomass production is high on bottomlands land due to high accumulation of soil nutrients on bottomlands (Coronato and Bertiller, 1996) that in turn promote plant activities.

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CHAPTER 3

Farmers' perceptions of livestock husbandry and rangeland management practices in two communal coastal areas of the Eastern Cape Province, South Africa

Abstract

This study assessed indigenous knowledge and farmer perceptions of livestock performance, rangeland condition and indigenous feed resource management in two communal coastal areas of the Eastern Cape Province, South Africa. A total of 100 farmers from both Dyamdyam and Machibi were interviewed using a structured questionnaire to determine farmer's perceptions. The respondent included both female and male farmers who owned livestock. About 82 % and 74 % of households at Machibi and Dyamdyam, respectively, were male-headed. The avarage population of livestock species at Dyamdyam was cattle (6.0), sheep (1.2) and goats (3.1), whereas at Machibi it was cattle (8.9), sheep (1.0) and goats (5.8). Cattle and sheep are primarily raised for sale and food, while goats are primarily raised for traditional purposes such as circumcision. The primary challenges faced by farmers to raise their livestock include stock theft followed by feed shortage and animal diseases. All the respondents reported that they practice continuous grazing due to the absence of fence on their rangelands. In both villages rangelands are primarily used for grazing followed by the collection of wood and grass for building, fire and medicines. About 30 % and 32 % of the respondents at Dyamdyam and Machibi respectively, perceived that their rangelands were in poor conditions. Communal farmers do not control their livestock movements due to vandalised fences in their rangelands. Therefore, it can be concluded communal rangelands are continuous grazed due to the absence of fence.

Keywords: Grazing, fencing, household respondents, livelihood, poor conditions, villages.

3.1. Introduction

In South Africa, rural areas are mainly populated by small scale farmers who raise livestock on common land and practice crop farming for consumption and sale on local markets (Wessels *et al.*, 2004). Communal rangelands provide natural resources that support the multiple livelihood strategies of the resource poor rural people (Peden, 2005). Several communal farmers in Africa use their indigenous knowledge and perceptions to make decisions on livestock farming and grazing land management. This local knowledge has allowed them to keep livestock under challenging biophysical environments, which are highly variable in space and time, and with little support as well as modern farming technologies (Angasa and Oba, 2010). Local knowledge and perceptions of communal farmers may vary from place to place and also from individual to individual within the same location.

Many scientists worldwide have recently recognised the indigenous knowledge and perceptions of communal farmers regarding their livestock husbandry and rangeland management (Solomon *et al.*, 2007; Kgosikoma *et al.*, 2012; Ghorbani *et al.*, 2013), while others have ignored and disapproved (Abate *et al.,* 2010). As a result, many development projects in Africa that are trying to improve the communal rangeland condition and livestock production have failed (Abate *et al.,* 2010). Twyman *et al.* (2004) reported that combination of indigenous and scientific knowledge can bring more useful evaluation of environmental changes and its implication for local land users. Some South African communal herders have indigenous knowledge and skills that can be used in developing the livestock production by sustainably using and managing the rangeland resources (Allsopp *et al.*, 2007). It is an advantage to acquire the perceptions of communal farmers related to rangeland conditions and livestock management because many communal farmers are able to classify the grass species that are more palatable and less palatable to livestock (Gemedo-Dalle *et al.*, 2006; O'Farrell *et al.*, 2007; Kgosikoma *et al.*, 2012).

In an attempt to improve livestock production and achieve ecological stability in communal rangelands, an investigation of famers' indigenous knowledge and perceptions about their livestock husbandry and rangelands management practices is significant (Brown and Havstad, 2004). Therefore, the objective of this study was to evaluate the farmers' perceptions of livestock husbandry and rangeland management practices in two communal coastal areas (Dyamdyam and Machibi) of the Eastern Cape Province, South Africa.

3.2. Materials and methods

3.2.1. Description of study areas

The study was conducted in two communal grazing lands namely Dyamdyam and Machibi located in the coastal areas of the Eastern Cape, South Africa. These communities are beneficiaries of the Nguni Cattle project. In 2004, the University of Fort Hare in collaboration with Industrial Development Corporation (IDC) and the Eastern Cape Department of Agriculture agencies initiated the Nguni cattle development project (Musemwa *et al.*, 2008). The objective of the project is re-introducing the Nguni cattle in communal areas (Mapiye *et al.*, 2007). The Nguni cattle development project operates in a 'pay it forward system' in which the project selects communal areas and supply them with two bulls and ten heifers which are then passed to second community after five years (Musemwa *et al.*, 2008).

Machibi is located at the coordinates of 33° 00.088''S and 027° 27.605''E and an elevation ranging from 362–364 m above sea level. It has a semi-arid climate and receives average annual rainfall of 700–800 mm, with most rainfall occurring during summer (November to January).

Temperature ranges from 20 °C to 26 °C in summer and in winter it ranges from 9 °C to 12 °C (Buffalo City Metropolitan Municipality (BCMM), 2007). The soil is fine textured and dominated by sandy soil that has low moisture holding capacity and high tendency of getting waterlogged after heavy rainfall. Machibi falls under the Thorn-veld savanna biome. The dominant grass species are *Thermeda Triandra, Sborobolus Africanus, Cynodol dactylon* and *Eragrostis plana*. The common woody species are *Acacia Karoo* and *Scutia Myrtina* (Mucina and Rhutherford, 2006).

Dyamdyam is located at the coordinates of 33° 12.611''S and 027° 13.918''E and an altitude that range from 62–64 m above sea level. It has a humid climate and receives mean annually rainfall of 800–1000 mm, with most rainfall occurring during summer (November to January). The temperature ranges from 20 °C to 24 °C in summer and in winter 8 °C to 10 °C (Acocks, 1988; World Atlas, 2012). The soil is fine texture and predominated by sandy soil with low moisture retention capacity. The common grass species are *Themeda Triendra, Sporobolus Africunus, Erograstis Plana, Tristachya leacothrix* and *Elulia vilosa*. The dominated woody species are *Diospyros Cyciodis* and *Acacia Karoo* (Buffalo City Metropolitan Municipality (BCMM), 2011).

3.2.2. Selection of Farmers

A total of 50 households who kept livestock species were randomly selected from each communal area. These included both female and male farmers. Prior to the selection of households, a meeting was held with the Chairman of each community to introduce the purposes of the study. These two villages were selected because they are the beneficiaries of the Nguni Cattle Project and communal farmers complained about poor performance of Nguni Cattle.

3.2.3. Data collection

Household respondents were interviewed using structured questionnaires consisting of open-ended and closed questions. Closed questions in the current study were defined as a multiple response questions where the household respondents could make more than one choice. Open-end questions were added in this study to inspire free and spontaneous answers from interviewees. Therefore, when the respondents answering such questions were not limited to choices encoded by the designer of questionnaire and they explained their own facts and opinions. Each farmer was interviewed individually in the homestead. The questionnaire was structured into three sections-: (1) Demography, (2) Livestock role and husbandry and (3) Rangeland condition and management. Interviews were conducted in Xhosa language by trained enumerator. The study protocols were approved by Govan Mbeki Research and Development Centre (GMRDC) in accordance with University of Fort Hare and Ethical Committee.

3.2.4. Statistical analyses

The data pertaining to farmer's perceptions and demographics were analyzed using the SPSS statistical software program (SPSS, 2011). For ranked data Friedman's Chi-square test was employed (Steel and Torrie, 1980). When Friedman's test showed significant variation, a set of sign test for multiple comparisons of means were made. For other data, descriptive statistics such as frequencies, means, standard deviations and percentage were used where applicable.

3.3. Results

3.3.1. Demographic information

About 82 % and 74 % of the households at Machibi and Dyamdyam, respectively were male headed. The majority of the respondents at Dyamdyam (56 %) and Machibi (68 %) were married. Most of the interviewed communal farmers at Dyamdyam (66 %) and Machibi (70 %) were above 50 years of age (Table 3.1). Mean households size at Dyamdyam was (2.1), whereas at Machibi it was (3). About 50 % and 42 % of household respondents at Dyamdyam and Machibi respectively were not employed (Figure 3.1). They mainly relied on social grants followed by pension and small businesses (Figure 3.1). Most of the respondents at Dyamdyam (74 %) and Machibi (64 %) attended the primary education and only 6 % of farmers at Dyamdyam and 2 % at Machibi attended tertiary education (Figure 3.1).

Table 3.1: Age distribution (%) of respondents at Dyamdyam and Machibi communal areas (respondents, n= 50 per village)

	Dyamdyam	Machibi
Age distribution (years)		
<30	6	4
30-40	8	12
40-50	20	14
>50	66	70

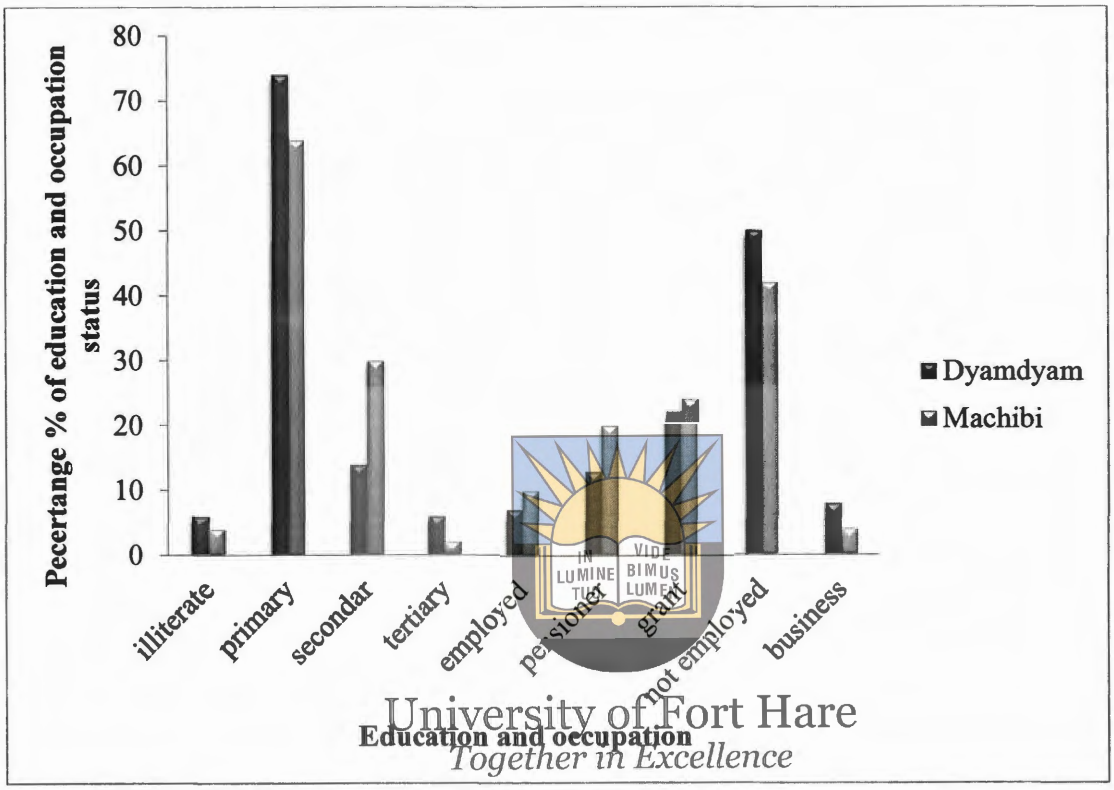

Figure 3.1: Education and occupation status of communal farmers at Dyamdyam and Machibi areas.

3.3.2. Livestock population and trend

The mean population of livestock species at Dyamdyam was cattle (6.0), goats (3.1) and sheep (1.2), whereas at Machibi it was cattle (8.9), goats (5.8) and sheep (1.0) (Table 3.2). There was a significant ($P < 0.05$) difference in mean numbers of cattle and goats kept between the study areas, being higher at Machibi than Dyamdyam. Most household respondents kept non-descript cattle breed at Dyamdyam (64 %) and Machibi (70 %), while 24 % and 16 % kept Nguni cattle, respectively. About 78 % and 86 % of respondents at Dyamdyam and Machibi respectively perceived a declining trend of cattle population over the past ten years. Similarly, household respondents at Machibi (82 %) and Dyamdyam (52 %) observed the decreasing trend of sheep population over the past ten years. However, about 38 % and 37 % of respondents at Dyamdyam and Machibi respectively, perceived an increasing trend of goats population over the past ten years.

Table 3.2: Livestock population (mean ± SE) at Dyamdyam and Machibi (respondents, n= 50 per village)

	Dyamdyam	**Machibi**
Cattle population		
Bulls	$0.3^{a} \pm 0.1$	$0.2^{a} \pm 0.1$
Heifers	$2.2^{a} \pm 0.5$	$1.3^{b} \pm 0.3$
Cows	$1.9^{b} \pm 0.4$	$3.7^{a} \pm 0.9$
Calves	$0.8^{b} \pm 0.3$	$1.7^{a} \pm 0.4$
Oxen	$0.8^{b} \pm 0.4$	$1.5^{a} \pm 0.3$
Total	$6.0^{b} \pm 1.6$	$8.6^{a} \pm 1.6$
Sheep population		
Rams	$0.2^{a} \pm 0.1$	$0.3^{a} \pm 0.2$
Ewes	$0.6^{a} \pm 0.3$	$0.6^{a} \pm 0.2$
Castrated rams	$0.3^{a} \pm 0.1$	$0.2^{a} \pm 0.1$
Lambs	$0.2^{a} \pm 0.1$	$0.1^{a} \pm 0.1$
Total	$1.2^{a} \pm 0.6$	$1.1^{a} \pm 0.5$
Goats population		
Does	$1.6^{b} \pm 0.7$	$3.1^{a} \pm 0.6$
Bucks	$0.2^{a} \pm 0.1$	$0.3^{a} \pm 0.1$
Kids	$0.6^{b} \pm 0.2$	$1.8^{a} \pm 0.4$
Castrated Bucks	$0.6^{b} \pm 0.2$	$0.8^{a} \pm 0.2$
Total	$3.1^{b} \pm 1.1$	$5.8^{a} \pm 1.1$

[ab]Means with different superscript within the same row are significantly different ($P < 0.05$)

3.3.3. Purposes of keeping livestock

As ranked by the interviewed farmers in both communities, cattle are primarily raise for sale, traditional purposes (circumcision and wedding) and *lobola*. Secondly, they raise their cattle for food and traction (Table 3.3). Interviewed communal famers at Dyamdyam and Machibi keep goats primarily for traditional ceremonies such as circumcision followed by sale, food and *lobola* (Table3.3). In both communities the principal reason for raising sheep is for sale followed by food, *lobola* and traditional ceremonies (circumcision and wedding).

Table 3.3: Relative importance (mean rank ± SE) for keeping livestock in Dyamdyam and Machibi (respondents, n= 50 per village)

	Dyamdyam			Machibi		
Purposes	Sheep	Goats	Cattle	Sheep	Goats	Cattle
Sale	$1.5^{a} \pm 0.1$	$1.7^{a} \pm 0.2$	$1.4^{a} \pm 0.1$	$1.7^{a} \pm 0.1$	$1.9^{a} \pm 0.2$	$1.3^{a} \pm 0.2$
Food	$2.2^{b} \pm 0.2$	$3.3^{c} \pm 0.3$	$3.8^{c} \pm 0.5$	$2.3^{b} \pm 0.3$	$3.5^{c} \pm 0.3$	$3.8^{c} \pm 0.6$
Lobola	$3.1^{c} \pm 0.4$	$2.4^{b} \pm 0.3$	$2.7^{b} \pm 0.8$	$2.4^{b} \pm 0.3$	$2.5^{b} \pm 0.3$	$3.0^{c} \pm 0.4$
Traditional ceremonies	$3.2^{c} \pm 0.3$	$2.6^{b} \pm 0.3$	$3.7^{c} \pm 0.6$	$3.5^{c} \pm 0.3$	$2.1^{b} \pm 0.3$	$2.4^{b} \pm 0.4$
Traction			$4.7^{d} \pm 0.8$			$5.7^{d} \pm 0.5$

[abc]Means with different superscript within the same column are significantly different ($P < 0.05$). Purpose that has low mean value is more important and is given the first letter. (1= most important, 5= least important).

3.3.4. Challenges faced by communal farmers in rearing their livestock

Communal farmers are faced with various challenges in rearing their livestock. Household respondents at Dyamdyam reported that, the primary challenges faced by farmers in raising their cattle and sheep are feed shortage and stock theft followed by animal diseases. Drought is ranked third while predators and water scarcity were ranked the least (Table 3.4). In the same village, their view of challenges in raising goats is differently ranked with animal diseases and stock theft ranked as the primary challenges (Table 3.4). The respondents at Machibi reported that the primary challenges faced in raising their sheep are stock theft, feed shortage and animal diseases followed by predators, water scarcity and drought. For raising goats, stock theft is still the major challenge followed by animal diseases and predators. For raising cattle, stock theft, feed shortage and animal diseases were regarded as the primary challenges (Table 3.4). About 62 % of respondents at Dyamdyam and 68 % at Machibi reported that their livestock have poor performance in terms of production and reproduction with only 12 % and 16 % indicated that, their livestock have a good performance, respectively.

Table 3.4: Challenges of raising livestock (mean rank ± SE) as perceived by communal farmers at Dyamdyam and Machibi (respondents, n= 50 per village)

	Dyamdyam			Machibi		
Challenges	Sheep	Goats	Cattle	Sheep	Goats	Cattle
Feed shortage	$2.5^{a} \pm 0.5$	$3.4^{a} \pm 0.9$	$1.9^{a} \pm 0.3$	$3.1^{b} \pm 0.8$	$4.1^{c} \pm 1.1$	$3.1^{c} \pm 0.8$
Water scarcity	$4.5^{d} \pm 0.7$	$4.4^{b} \pm 0.8$	$4.7^{c} \pm 0.7$	$4.2^{c} \pm 0.5$	$4.3^{c} \pm 0.5$	$4.2^{d} \pm 0.5$
Drought	$3.9^{c} \pm 0.7$	$3.7^{a} \pm 0.7$	$3.8^{b} \pm 0.7$	$4.9^{c} \pm 0.6$	$4.1^{c} \pm 0.6$	$4.3^{d} \pm 0.6$
Predators	$4.1^{d} \pm 0.8$	$3.2^{a} \pm 0.6$	$4.1^{c} \pm 0.8$	$4.2^{c} \pm 0.8$	$3.2^{b} \pm 0.7$	$4.2^{d} \pm 0.8$
Animal diseases	$3.2^{b} \pm 0.7$	$3.1^{a} \pm 0.7$	$3.3^{b} \pm 0.8$	$3.0^{b} \pm 0.8$	$3.1^{b} \pm 0.7$	$2.2^{a} \pm 0.8$
Stock theft	$2.6^{a} \pm 0.5$	$4.1^{b} \pm 0.8$	3.2 ± 0.7	$2.1^{a} \pm 0.4$	$2.3^{a} \pm 0.4$	$2.1^{a} \pm 0.4$

[abc]Means with different superscript within the same column are significantly different (P< 0.05). The lower the rank of a challenge, the greater is its importance and is given the first letter. (1= most important, 6= least important).

3.3.5. Feed supplementation

About 14 % of the respondents at Dyamdyam and 28 % at Machibi reported that they offer supplementary feed to their livestock, whereas 86 % and 74 % respectively did not offer their livestock with supplementary feed. All the farmers at Dyamdyam and Machibi indicated that they give feed supplements to their livestock in the winter season (May to July). Household respondents at Dyamdyam (8 %) and Machibi (12 %) used lucerne and lick to supplement their livestock, whereas only 2 % and 3 % use maize stalk respectively. All the respondents at Dyamdyam and Machibi indicated that their livestock obtained water from dams and rivers.

3.3.6. Uses of communal rangelands

Respondents from both villages showed slight differences in terms of their perceptions of the uses of rangeland. At Dyamdyam respondents reported that rangelands are used primary for grazing and collection of woods and grass for building and fire, whereas at Machibi, the respondents considered grazing as the most important use (Table 3.5). The majority of respondents at Dyamdyam (62 %) and Machibi (66 %) indicated that their livestock start grazing near the homesteads. About 54 % of household respondents at Dyamdyam and 64 % at Machibi reported that their livestock spend most of the time grazing near to the homesteads. They agreed that the reason livestock spend most of time grazing near the homestead is because it is easily reached by the animals and distribution of drinking areas. The majority of respondents in both villages reported that water drinking areas are mostly found near the homestead. Most household respondents at Dyamdyam (98 %) and Machibi (96 %) reported that, their livestock spend about 9 hours on rangelands. In addition, they further stated that, they keep mixed livestock species on their grazing lands.

Table 3.5: Uses of communal rangelands (mean ranked ± SE) at Dyamdyam and Machibi (respondents, n= 50 per village)

	Dyamdyam	Machibi
Uses of rangelands		
Grazing	$2.2^{a} \pm 0.1$	$1.4^{a} \pm 0.1$
Fire wood	$3.2^{b} \pm 0.1$	$2.1^{b} \pm 0.1$
Building	$2.4^{a} \pm 0.1$	$2.9^{b} \pm 0.1$
Medicine	$3.1^{b} \pm 0.1$	$3.2^{c} \pm 0.1$

^{abc}Means with different superscript within the same column are significantly different ($P < 0.05$). (1= most important, 4= least important).

3.3.7. Farmers' perceptions of rangeland condition and rangeland management

About 54 % of household respondents at Dyamdyam and 30 % at Machibi indicated that they do not know the current condition of the rangelands. About 30 % of the interviewed farmers at Dyamdyam and 32% at Machibi reported that their rangelands are in poor condition whereas 0 % and 2 % reported that their rangelands are in good condition respectively (Figure 3.2). All respondents from both villages indicated that they practice continuous grazing system. They explained that they used continuous grazing due to the absence of fence and camping system on their rangelands. Household respondents at Dyamdyam (20 %) and Machibi (14 %) perceived that the current state of their rangelands is caused by overgrazing followed by the lack of rainfall, whereas the rest do not know the driving factors to current state of rangeland condition.

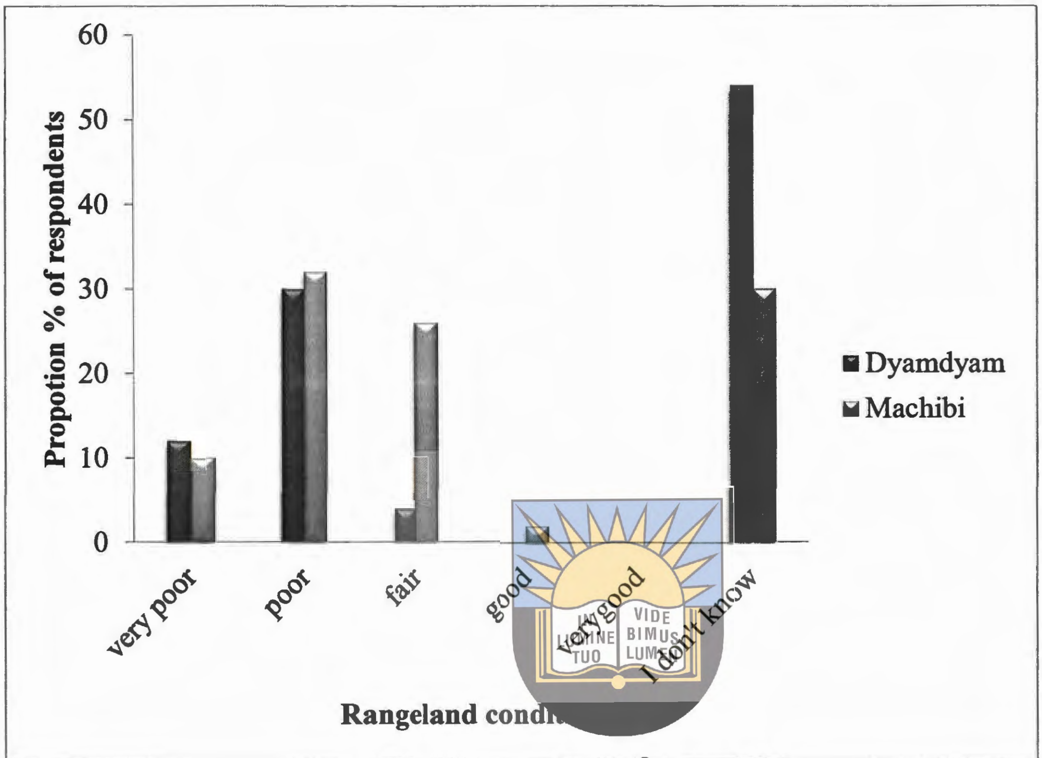

Figure 3.2: Proportion (%) of household respondents who perceived different state of the current rangeland condition at Machibi and Dyamdyam.

3.4. Discussion

3.4.1. Household demography

The current study revealed that the majority of household respondents were above 50 years of age. Similar results were reported by Mapiye *et al.* (2009) in communal areas of the Eastern Cape Province of South Africa. This indicates a lack of commitment and interest in agriculture among the youth in communal areas of the Eastern Cape Province of South Africa. This also showed that farming in communal areas is mostly practiced by elderly people. These results are further supported by Rumosa-Gwaza (2009), Lesoli (2011) and Gwelo (2012) who reported that youth in communal areas of the Eastern Cape showed a lack of interest and participation in livestock farming. Indeed, from the different point of view the involvement of youth in farming may increase the risk of food insecurity because of limited farming experience (Mbata, 2001). According to Lesoli (2011) less involvement in agriculture by rural youth is associated to the failure of the transfer of indigenous knowledge from the elders to the youth. On the other hand, Hofferth (2003) reported that the age of the household head is a vital driving factor in agricultural productivity as it determines farming experience. The higher the age of the farmer, the more the productivity because of more experience developed from farming (Joubert and Simalanga, 2004).

The majority of respondents participated in this study were married. According to Mphale *et al.* (2002), married communal farmers are able to reduce food insecurity in their families because they can work together to expand crop and livestock farming. The mean household size reported in this study was small and slightly similar to other studies reported in the same province but in different communal areas (Chimonyo *et al.*, 1999; Mapiye *et al.*, 2009). However, it was relatively low compared to the mean household size reported by Solomon *et al.* (2007) in Ethiopia. According to Paddy (2003), large household size tends to put pressure on the consumption of livestock products within the household. However, Hayes *et al.* (1997) suggested that large household size could provide enough farm labour to expand household livestock and crop farming. In addition, availability of labour within a household plays a vital role in determining the number of livestock to be held per household (Snyman *et al.*, 2008).

The educational status of household respondents showed that most communal farmers did not go beyond primary education. The poor status of education in communal areas could be attributed to the shortage of schools in rural areas of South Africa. This is a common occurrence in many rural areas of South Africa for historical reasons. The poor level of education may negatively affect agricultural productivity in communal areas (Mapaye *et al.,* 2007), because access to information with regard to good management skills for livestock, rangelands and crop farming depend on the level of literacy. This is supported by Kabirizi *et al.* (2009) who reported that, well-educated communal farmers have a better opportunity to manage their livestock and crops. They can acquire information for livestock, crops and rangeland management from new technologies rather than the poor educated communal farmers. This is further supported by Nyangito (1986) adoption of new technology to improve agricultural practices in rural areas depends on the educational status of the farmers. In addition, communal farmers need to combine indigenous skills and educational skills and approaches in order to improve their rangelands and livestock production. This view is supported by [illegible] *et al.* (2004) that the combination of indigenous and educational knowledge can bring more useful evaluation of environmental changes and its implication in rangelands and livestock production. Thus, improved educational level of communal farmers can speed up the adoption of new skills and proven and recommended farming practices to increase livestock and crop production in communal areas (King and Bembridge, 1988).

This study also showed that many household respondents at Dyamdyam and Machibi were not employed, they mainly relied on social grants followed by pensions, livestock sale and small businesses for their livelihood. Many studies conducted in rural areas of South Africa reported similar results (Condill, 2005; Dovie *et al.*, 2006). According to South African Statistics (2001), the Eastern Cape has the highest level of unemployment in the whole country. Therefore, expanding livestock production and crop farming could reduce food insecurity a point from creating employment opportunities in communal areas of the Eastern Cape Province, South Africa.

3.4.2. Livestock population trend and its importance

Respondents perceived a declining trend in cattle and sheep population over the past ten decades and increasing trend in goats population over the past ten years. This declining trend may be due to an increase of feed shortage and animal diseases, whereas the increase of goats is associated with the increase of woody plants on communal rangelands (Smit, 2004). The total mean population of cattle and sheep reported in this study was higher than the results reported by Gwelo (2012) in the same province but in different villages. However, the total mean cattle population recorded in this study was lower than the values reported by Mapiye *et al.* (2009) and Mngomezulu (2010) in the same province, but in different villages and by Shackleton *et al.* (2005) in different province. In addition, the total mean population of goats found in this study was relatively lower than the total mean population reported by Mapiye *et al.* (2009) and Gwelo (2012) in the Eastern Cape Province of South Africa. The majority of household respondents in this study raise non-descript cattle breeds. The reason for raising non-descript breeds might be due to a lack of breeding practices in communal areas. In most cases, this is due to a lack of knowledge and existing conditions such as infrastructure and land tenure rights within the communal farming system (Montshwe, 2006).

In terms of livestock structure, heifers and cows have the largest mean population at Dyamdyam and Machibi, respectively. Higher mean population of heifers and cows in study areas may be due to the fact that communal farmers prefer to hold cows and heifers for milk production and breeding purposes. The mean population of cows and heifers reported in this study was relatively higher than the mean population reported by Gwelo (2012) in the same province but in different villages. The mean population of bulls reported in the current study was very low. This could be attributed to the fact that communal farmers castrate their male animals, slaughter for traditional ceremonies such as wedding and circumcision, and make them docile for traction (Dovie *et al.*, 2006). In addition, communal farmers prefer selling the oxen to generate income. Similar results were reported by Musemwa *et al.* (2007) in communal areas of the Eastern Cape Province of South Africa. In the present study, ewes and does have the largest mean population. This may be due to the fact that communal farmers slaughter the castrated rams and bucks for meat consumption, sale and traditional ceremonies (Katjiuna and Ward, 2007). The mean population of ewes and does found in this study was slightly higher than the values reported by Gwelo (2012) in the same province.

Communal farmers at Dyamdyam and Machibi raise livestock for different purposes. They raise cattle primarily for sale, food (meat and milk) and traditional ceremonies (circumcision, wedding and pacification of ancestors) and *lobola*. In this study traction was regarded as the least important reason for raising cattle. These findings agree with the studies of Musemwa *et al.* (2010) and Mngomezelu (2010) in South Africa and Solomon *et al.* (2007) in southern Ethiopia. Interviewees in this study reported that sheep and goats were primarily raised for cash generation, food, and traditional purposes (circumcision and wedding) and *lobola.* Similar results were reported by Katjiuna and Ward (2007) and Dovie *et al.* (2006) in southern Africa and by Nthakheni (2006) in the Limpopo Province of South Africa.

3.4.3. Challenges faced by communal farmers in raising their livestock

Communal farmers were faced with various challenges in raising their livestock. Feed shortage, stock theft, animal disease and predators in this study were cited as the main challenges faced by communal farmers to raise their livestock. These findings agree with many studies conducted in communal production system of Africa (Solomon *et al.,* 2007; Mapiye *et al.*, 2009; Mngomezulu, 2010 and Gwelo, 2012). However, communal farmers regarded feed shortage as the least challenge faced in raising their goats. This may be due to the fact that communal rangelands have a relatively high density of woody species, therefore the browser species such as goats may not be affected by feed shortage (Katjiua and Ward, 2007). Drought and water scarcity were regarded as the least challenges faced by communal farmers in raising their livestock. This might be due to the fact that both study areas are found in coastal areas where the rainfall is high and there is less risk associated to drought and water scarcity.

Furthermore, household respondents at both villages perceived that feed shortage is worsened by reduction of available grazing land areas and rangelands degradation. These findings agree with the findings reported by Mngomezulu (2010) in the same province and contrary to the report of Retzer (2006) in Sahelian. Other reasons comprise of population pressure, increase in livestock numbers and bush encroachment (Gemedo-Dalle *et al.,* 2006; Solomon *et al.,* 2007). According to Mapiye *et al.* (2009), the lack of adequate skill for livestock and rangelands management results in feed shortage, stock theft and animal health problems. In the current study, poor performance of livestock in terms production and reproduction due to lack of adequate feed is reported. These results are corresponding with the study of Mengistu (2012) in Ethiopia who reported that feed shortage causes a loss of body weight, less milk production and poor fertility in livestock. In addition, household respondents further suggested that the provision of management skills for rangelands and livestock, supplementary feed, kraals and fencing the rangelands would assist to reduce feed shortage, animal diseases, predators and stock theft. These plans pointed out by the household respondents to reduce these challenges are similar with plans used by communal farmers in Ethiopia (Abule, 2003).

3.4.4. Feed supplementation and rangeland condition

In the current study, many communal farmers at Dyamdyam and Machibi did not provide supplemental feed to their livestock and they depend on natural rangeland in order to feed their animals during the year roudd. Similar results were reported by Solomon *et al.* (2007) in Ethiopia. Communal farmers who offered supplements to their livestock indicated that they supplement during the dry season (May to July) due to the lack of feed during this season and they use lucerne, licks and maize stalk. In addition, all the respondents in this study indicated that, they experience shortage of feed during the dry season (winter). The shortage of feed during the dry season might be due to the lack of rainfall and cold temperatures. This view is supported by MacDowell (1992), it is rare to have enough feed and meets the entire minerals required by the livestock during the dry season (winter) due to the weather conditions.

The majority of respondents in this study do not know their rangeland condition. This might be due to a lack of adequate training and educating skills in communal farmers about their rangeland management and conditions. The minority of interviewed communal farmers reported that their rangelands are in poor condition and this is caused by overgrazing, the lack of rainfall and human activities. Many studies reported that some communal famers in rural areas of Africa believe that the condition of their rangeland is poor whereas others rate their rangelands to be in good condition (Ward *et al.,* 2000; Abule *et al.*, 2005). Similarly, Palmer *et al.* (1997) found that about 0.5 million ha of the Eastern Cape rangelands was in good condition and 2.6 million ha in poor condition. All the interviewees in the present study reported that they practice continuous grazing system due to the absence of fence and camping system in their rangelands. Similar results were reported by Shackleton (1993) in the eastern Transvaal Lowveld. In addition, Ward *et al.* (2000) further stated that grazing areas in several communal rangelands of Namibia are not sub-divided into camps for effective utilization of rangeland. This does not permit for recovery of vegetation after grazing because the control of animals is not easy (Arnalds and Backrson, 2003).

3.4.5. Uses of communal rangelands

In the present study, communal rangelands are primarily used for grazing followed by the collection of wood and grass for building, fire and medicine. This is because extensive natural rangelands are the primary source of forage for poor resource livestock farmers in communal areas (Solomon *et al.*, 2007). These results are strongly agreed with the report of Homewood (2004) in communal production of Africa. In addition, Dovie *et al.* (2007) further stated that over 90 % of resource poor rural households in the southern Africa depend on the natural rangeland resources for food, income and other services. According to de Oliveira *et al.* (2003), communal rangeland provides services such as timber, pharmaceuticals, human food, animal feed and fresh water. Communal farmers in this study reported that their livestock spend most of time grazing near the homestead since it is easily reached by the animals and the distribution of drinking areas. Similar results were report by Lesoli (2008) in the same province but in different villages.

3.5. Conclusion

The present study revealed that livestock plays a vital role in the livelihood of poor resource farmers at Dyamdyam and Machibi by generating income and provision of food. However, it is constrained primarily by feed shortage, stock thefts and animal disease. Many communal farmers did not offer their livestock with supplementary feed and they depended on natural rangelands for feed throughout the year. Therefore, there is a need for intervention to identify other sources of fodder that can be used by resource limited farmers during the dry seasons. In addition, all the household respondents indicated that, they practice continuous grazing system due to vandalised fence on their rangelands. Thus in turn leads to over utilisation of communal rangelands. Therefore, fencing and application of appropriate grazing system in communal grazing area is highly recommended.

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Chapter 4

Species composition and biomass production in two communal coastal rangelands around the homesteads areas

Abstract

This study investigated species composition and biomass production of herbaceous plants in two communal rangelands surrounding homesteads areas. In each study area, the rangelands were divided based on the distance from homesteads into near (up to 1 km), middle (> 1–2 km) and far (> 2–3 km) sites. On each site a HVU of 50 m x 20 m was used and six 0.25 m^2 quadrants were laid randomly on each HVU. Herbaceous species found within a quadrant were identified, counted and their height and tuft were measured. Herbaceous species were also harvested, bulked and placed into well labeled brown paper bags and oven-dried for 48 hours at 60 °C to determine biomass production. Herbaceous species were also classified according to their palatability ecological status and life form. Data were collected for two seasons over 2014/15 (winter and summer). A total of 20 herbaceous species were identified in the study areas. Of these 17 were grass species. The most common or dominant grass species were *T. triandra, C. dactylon, E. capensis, E. plana* and *S. africanus*. At Dyamdyam *T. triandra* showed the greatest frequency of occurrence at far site than middle and near homesteads sites. The frequency occurrence of *S. africanus* at Machibi was relatively similar in all the study sites. Density of herbaceous species was significantly lowest on near and bottom sites at Dyamdyam and Machibi, respectively. In both winter and summer, grazing site far and top from homestead had greatest (P <0.05) biomass production at Dyamdyam and Machibi respectively. The biomass production was significantly highest in the summer than the winter across the study sites in both study areas. It can be concluded that composition of herbaceous species and biomass production are significantly dependent on distance and topography from homesteads and seasons. Therefore, any rangeland management practices in communal grazing lands should consider these factors in to consideration during the planning of development progress.

Keywords: Distance gradient, livestock, topography, summer, soil, vegetation, winter

4.1. Introduction

Communal rangelands are used mainly as sources of forage for livestock and collection of wood for fire and building (Everson and Hatch, 1999). These rangelands have different species composition and biomass productions (Oztas *et al.,* 2003). Species composition and biomass production on communal rangeland vary according to grazing system (Shackleton, 1993), seasonal variation (Angassa and Oba, 2010), soil type (O' Farrell *et al*., 2007), topography (Lesoli, 2008) and grazing intensity (Smet and Ward, 2003; Maki *et al*., 2007).

Species composition is defined as the relative frequency of occurrence of heterogeneous herbaceous species in a rangeland (Trollope *et al*., 1990). In addition, it is one of the factors that indicate the rangeland condition because herbaceous species differ significantly in their acceptability, ecological status, life form and response to grazing (Abule *et al*., 2007). It has been reported that, high grazing pressure on natural rangelands causes changes in species composition (Maki *et al*., 2007). Decreaser species disappear in response to heavy continuous grazing pressure and are replaced by increaser and invader species that are less palatable and adapted to withstand over utilization (Sisay and Baars, 2002). Most rangelands in communal areas of South Africa are continuously grazed due to the absence of fence and this affects distribution of herbaceous species (Shackleton, 1993). In addition, high grazing intensity can alter vegetation from being dominated by perennial species to being dominated by annual species due to the high stocking rate on grazing lands (Smet and Ward, 2003). Other researchers such as Laughlin and Abella (2007) reported that species composition change is determined more by rainfall rather than by grazing pressure. In summer there is more rainfall that promotes height, diameter and basal cover of grass species.

Biomass production is a total dry matter of living material which is actively and structurally functional in a given area and is normally used as source of energy for livestock and for fuel (Bond-Lamberty *et al.*, 2002). According to Angassa and Oba (2010), biomass production during the dry season is lower than during the wet season. This is allied with high amount of rainfall and availability of moisture during wet season than dry season (Angasa and Oba, 2010). The part of rangelands that is heavily grazed for long period of time has lower biomass production (Shackleton, 1993). In addition, biomass production in silt and clay soil is higher than in sandy soil due to the high organic matter and minerals in clay and silt soils than sandy soils (O' Farrell *et al.*, 2007).

Landscape positions have significant effects on the biomass production with several reports showing bottomlands having higher biomass production than slope and top lands (Coronato and Bertiller, 1996; Lesoli, 2008). In contrast, other researchers reported bottomlands have lower biomass due to the presence of heavy grazing pressure because of easily access by livestock than the plants found on top lands (Snft *et al.,* 1985; Belsky and Blumenthal, 1997; Lesoli, 2008). Studies that are conducted on communal coastal rangelands of South Africa to investigate the change in species composition and biomass production along the gradient distance from homestead are limited. There is also no information regarding the seasonal variations in the above variables along distance gradient from homesteads. The availability of such information would contribute towards of planning management and rehabilitation programs in the communal rangelands to improve fodder production for livestock.

Therefore, the objectives of this study were 1) to assess herbaceous species distribution and biomass production along distance gradient from homesteads in two communal rangelands, 2) to investigate the effects of season on biomass production and species distribution.

4.2. Methods and Materials

4.2.1. Selection of study sites and layout

Two long transect radiating away from the homesteads in each communal area was established and divided into three main grazing site. The transects were established in the directions of the main grazing activities. Dyamdyam is situated on relatively plain land and; hence the rangeland was simply divided according to the distance from homesteads into near (up to 1 km), middle (> 1–2 km) and far (> 2–3 km) sites. Machibi is set on a gentle steep slope, and therefore three grazing sites were identified to represent the bottom (near), slope (middle) and top (far) sites from homestead. On each study site a HVU of 20 m x 50 m was marked to record vegetation data from six 0.25 m^2 quadrants that were laid [illegible]

4.2.2. Data collection

Data on herbaceous species composition, tuft diameter, height, density and biomass were collected from two different directions where the livestock are grazing in each study area. In each 0.25 m^2 quadrants herbaceous species found within a quadrant were identified, counted and recorded. Height and tuft diameter of herbaceous species were measured using 30 cm ruler and recorded. Total density was obtained by adding all the herbaceous species found in each sites. Density for each herbaceous species found in study areas were then calculated as the percentage to obtain the frequency of occurrence of each herbaceous species. Herbaceous species found within a quadrant were harvested, bulked and placed into well label brown paper bags. Harvested herbaceous samples were then oven-dried for 24 hours at 60 °C. Dried grass samples were weighed to determine dry matter (DM) production. Data was collected in winter and summer in 2014 and 2015.

4.2.3. Species classification

Classification of herbaceous species was based on the succession theory described by Dyksterhuis (1994) and on the ecological information for the arid to semi-arid region of South Africa (Vorster, 1982). Herbaceous species were classified according to their ecological status and response to grazing such as: (i) highly palatable: those species occur in rangeland that is in good condition and decrease with heavy grazing (decreaser species); (ii) palatable species: those species occur in rangeland in good and increase with moderate overgrazing (increaser IIa); (iii) less palatable species: those species which occur in rangeland in good condition and increase with high overgrazing (increaser IIb and IIc) and (iv) poorly palatable: those species which occur in rangeland in poor condition and increase with extreme overgrazing (invaders). Herbaceous species were also grouped according to their life form as annual and perennial (van Oudtshoon, 1992). Grasses were further identified to species level, while other herbaceous plants belonging to other families were categorised as forbs, sedges and karoo species.

4.2.4. Statistical analyses

Data on biomass and species composition were analysed using General Linear Model (GLM) procedure of SAS (2010). Mean separation was done using PDIFF option of SAS (2010). Data analyses for two study areas were done separately because they had different landscape, geology, altitude and vegetation types. Descriptive statistics such as percentage and means were used where applicable. Species composition, biomass, density and height of herbaceous species show significant interaction between site and seasons in both study areas.

4.3. Results

4.3.1. Ecological status, life form, palatability and frequency of occurrence of herbaceous species

A total of 20 herbaceous species were identified in the study areas. Three of the identified herbaceous species were categorized as forb, sedge, and karroo species whereas seventeen were grasses In terms of their life form, all the identified herbaceous species were perennial (Table 4.1). In terms of their palatability, six herbaceous species were highly palatable, one was moderately palatable and thirteen were low palatable. According to their ecological index, four grass species were classified as Decreaser species, four Increaser I, nine Increaser II, two Increaser III and one invader species (Table 4.1). Of the total grass species identified, 4 grass species were classified as most common or dominant grass species over the study sites (Table 4.1). These include *T. triandra, C. dactylon, E. capensis, E. plana* and *S. africanus*. One of the common or dominant species was highly desired by livestock (*T. triandra*).

Table 4.1: Ecological status, life form, palatability and frequency occurrence of herbaceous species identified in the study areas.

				Dyamdyam			Machibi		
rass species	ES	LF	Pa	Near	Middle	Far	Bottom	Slope	Top
hemeda triandra	De	P	HP	LC	LC	C	C	D	D
ynodon dactylon	Inc II	P	HP	LC	D	C	C	LC	C
lionurus muticus	Inc III	P	LP	R	R	LC	R	R	+
ragrostis capensis	Inc II	P	LP	R	R	LC	R	R	+
ragrostis plana	Inc II	P	LP	LC	C	C	LC	LC	D
etropogon contortus	Inc II	P	HP	LC	R	R	R	R	LC
icrochloa cafra	Inc II	P	MP	LC	LC	R	R	R	+
arpochloa falx	IncII	P	LP	R	+	R	-	-	-
oorobolus africanus	IncII	P	LP	LC	C	D	C	C	C
ristachya leacothrix	Inc I	P	HP	LC	LC	LC	-	-	-
lulia vilosa	Inc I	P	LP	R	LC	LC	-	-	-
yperrhenia hirta	IncI	P	LP	R	+	+	-	-	-
igitaria eriantha	De	P	HP	-	-	-	R	R	D
ıspalum dilatatum	Inv	P	LP	LC	R	R	R	R	R
taria megaphylla	De	P	HP	LC	R	R	R	R	LC
achiaria serrate	De	P	HP	LC	R	R	R	R	R
ymbopogon excavatus	IncI	P	LP	LC	R	R	R	R	R
edges	IncIII	P	LP	R	R	R	-	-	-
orbs	IncII	P	LP	R	LC	R	R	R	LC
ırroo	IncII	P	LP	R	R	R	LC	R	R

ES= ecological status, LF= life form, Pa= palatability, De= decreaser, IncI= increaser I, IncII= increaser II, Inc III= increaser III, Inv= invader, P= perennial, HP= high palatable, MP= moderate palatable, LP= low palatable, D= dominant (>15 %), C= common (10 %-15 %), LC= less common (5 %-10 %), R= rear (1 %-5 %) + = present (<1 %) and – = absence

4.3.2. Common or dominant species

Common or dominant grass species in this study are defined as those species recorded along the distance gradient from homesteads in each study area and had >15 % (dominant) and >10 %– 15 % (common) frequency occurrence at least in one of the study sites.

Results for frequency of occurrence of common or dominant grass species identified at Dyamdyam rangeland are presented in Figure 4.1. At Dyamdyam frequency occurrence of *T. triandra* was significantly higher on far site than middle and near sites. Along the distance gradient from homestead *C. dactylon* had the greatest occurrence on middle site followed by the far and near sites. The frequency occurrence *E. plana* was relatively similar on middle and far sites however were higher than near site. The proportion occurrence of *S. africanus* was significantly higher on far site followed by the middle and near sites.

Results for frequency occurrence of common or dominant grass species identified at Machibi rangeland are presented in Figure 4.2. At Machibi the frequency occurrence of *T. triandra* was significantly highest on slope site followed by the top and bottom sites. Along the landscape from homestead *E. plana* had greatest proportion occurrence on top site than slope and bottom sites. On bottom and top sites the frequency occurrence of *C. dactylon* was greatest and lowest on slope site. Frequency occurrence of *S. africanus* has similar values on slope and top sites but was higher than bottom site.

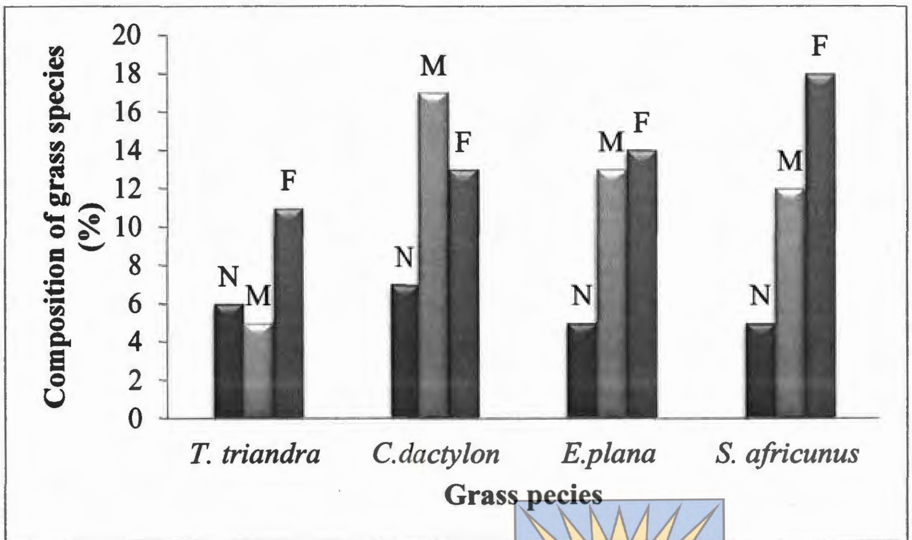

Figure: 4.1: Species composition (%) of common or dominant grasses based on frequency of occurrence at Dyamdyam. N= near, M= middle and F= far

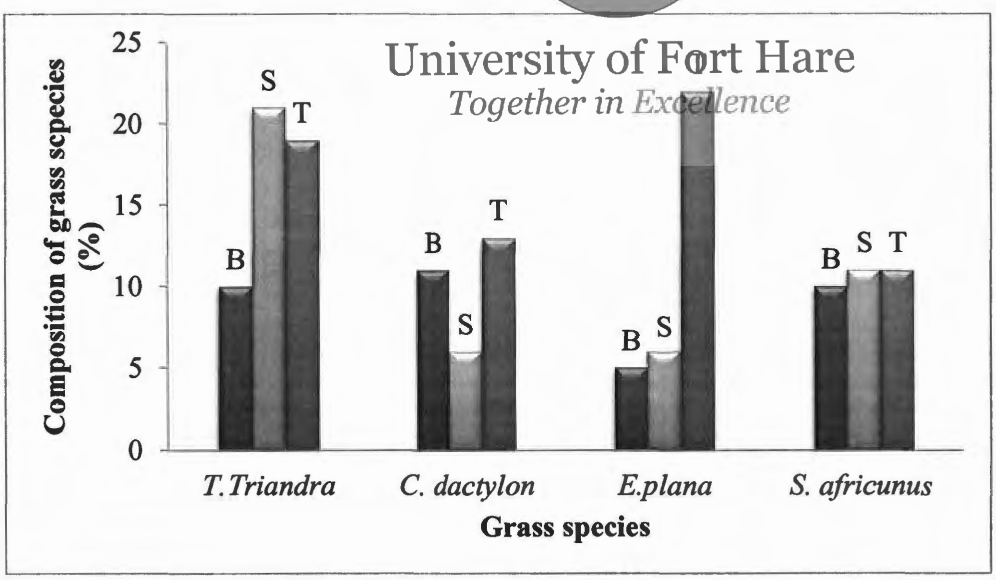

Figure: 4.2: Species composition (%) of common or dominant grasses based on frequency of occurrence at Machibi. B= bottom, S= slope and T= top

4.3.3. Biomass production of herbaceous species

In winter, far grazing site from homesteads at Dyamdyam had the greatest ($P < 0.05$) biomass production followed by middle and near sites. In summer, far and middle grazing sites had higher biomass production than near site (Table 4.2).

In winter, top grazing site at Machibi had highest ($P < 0.05$) biomass production followed by midslope and bottom sites. In summer, top and midslope grazing sites had higher biomass production than bottom site. Biomass production in all the study sites was significantly different between winter and summer season except for far and top sites at Dyamdyam and Machibi respectively (Table 4.2).

Table 4.2: Mean biomass production (kg ha^{-1}) of herbaceous species harvested from study areas.

Areas/Sites	**Biomass**	**Biomass**
Dyamdyam	Winter	Summer
Near	715.5^{Cb}	1015.0^{Ba}
Middle	1042.1^{Bb}	1127.5^{Aa}
Far	1106.3^{Aa}	1113.0^{Aa}
SE	67.5	67.5
Machibi		
Bottom	405.9^{Cb}	669.6^{Ba}
Slop	780.4^{Bb}	857.8^{Aa}
Top	809.1^{Aa}	840.4^{Aa}
SE	79.6	79.6

^{abc}Lowercase superscripts are used to compare means between seasons within each site. ^{ABC}Uppercase superscripts are used to compare site averages within each season. Means with different superscript within the columns and rows are significantly different (P < 0.05).

4.3.4. Height and tuft diameter of common or dominant species

The results for plant height and tuft diameter of common or dominant grass species are presented in Table 4.3 and 4.4 respectively. The plant height and tuft diameter was significantly different across the study sites in some common or dominant grass species, while in other species they were not significantly different between the study sites. *Themeda triandra* at Dyamdyam had the highest (P <0.05) height in middle site followed by the far and near sites. Highest plant height for *C. dactylon* and *E. plana* at Dyamdyam was recorded in far site. Plant height of *S. africunus* was highest (P <0.05) in middle site followed by the near and far sites.

At Machibi plant height of *T. triendra* was highest (P <0.05) in the slope and top sites than the bottom site. Plant height of *E. plana* was significantly highest in slope site followed by bottom and top sites. Plant height of *S. africanus* was significantly highest in top site followed by slope and bottom sites. Plant height of *C dactylon* was highest (P <0.05) on samples collected from top site followed by bottom and slope sites.

Table 4.3: Mean height (cm) of common grass species found in study areas

	Dyamdyam				Machibi			
Grass species	Near	Middle	Far	SE	Bottom	Slope	Top	SE
T. triandra	11^c	18^a	12^b	2.3	9.0^b	11^a	11^a	2.0
C. dactylon	13^c	15^b	17^a	2.3	12^b	9.3^c	14^a	4.0
E. plana	14^c	15^b	20^a	2.3	11^b	13^a	9.0^c	2.1
S. africanus	13^b	20^a	11^c	2.3	9.0^b	9.2^b	11^a	1.9

[abc]Different superscripts for each species in a row denote significant differences at $p < 0.05$ between different distances and landscape. SE= Standard Error

At Dyamdyam tufts diameters of *T. triandra* and *E. plana* were not significantly different (P> 0.05) between the sites. Tuft diameter of *C. dactlyon* was highest (P<0.05) on near site than middle and far sites. For *S. africunas* tuft diameter was not significantly different (P> 0.05) across the study sites.

At Machibi tuft diameter of *T. triandra* and *C.dactylo* were not significantly differ (P> 0.05) between slope and top sites, however, it was slightly highest on bottom sites. For *S. africunus* tuft diameter was not significantly different (P > 0.05) between bottom and slope sites. Tufts diameter of *E. plana* was not significantly different (P > 0.05) between all the study sites.

Table 4.4: Mean tufts diameter (cm) of common grass species found in study areas

	Dyamdyam				Machibi			
Grass species	Near	Middle	Far	SE	Bottom	Slope	Top	SE
T. triandra	2.1^{a}	2.3^{a}	2.0^{a}	0.3	3.0^{a}	2.0^{b}	2.4^{b}	0.4
C. dactylon	3.0^{a}	2.3^{b}	2.4^{b}	0.4	3.4^{a}	2.1^{b}	2.0^{b}	0.7
E. plana	3.0^{a}	3.4^{a}	3.0^{a}	0.3	2.0^{a}	2.0^{a}	2.2^{a}	0.3
S. africanus	3.1^{a}	4.0^{a}	3.0^{a}	0.7	2.2^{a}	1.2^{b}	2.0^{a}	0.5

[abc]Different superscripts for each species in a row denote significant differences at $p < 0.05$ between different distances and landscape. SE= Standard Error

4.3.6. Total density of herbaceous species

The results for total mean density of herbaceous species identified in study areas are presented in (Table 4.5). Both in summer and winter at Dyamdyam total mean density was highest (P <0.05) in far site followed by middle and near. Similarly, at Machibi the total density of herbaceous species was significantly highest in top site followed by slope and bottom in winter and summer. Total density of herbaceous species was highest (P <0.05) in summer than winter across the study sites in both study areas.

Table 4.5: Mean density (m^{-2}) of herbaceous species identified in two study areas.

Areas/Sites	**Total Density**	**Total Density**
Dyamdyam	Winter	Summer
Near	30^{Cb}	43^{Ca}
Middle	51^{Bb}	63^{Ba}
Far	67^{Ab}	74^{Aa}
SE	1.9	1.9
Machibi		
Bottom	33^{Cb}	50^{Ca}
Slope	57^{Bb}	65^{Ba}
Top	66^{Ab}	72^{Aa}
SE	2.2	2.2

^{abc}Lowercase superscripts are used to compare means between seasons within each site. ^{ABC}Uppercase superscripts are used to compare site averages within each season. Means with different superscript within the columns and rows are significantly different ($P < 0.05$).

4.4. Discussion

4.4.1. Ecological status, life form and palatability of herbaceous species

In the present study herbaceous species in the study areas were dominated more by increaser and less palatable species. Many studies conducted elsewhere in Africa reported similar findings (Danckwerts, 2001; Sisay and Baar, 2002; Hayes and Holl, 2003; Hein, 2006; Gemedo-Dalle *et al.*, 2006; Morris and Kotze, 2006; Anderson and Hoffman, 2006; Solomon *et al.*, 2007). These findings could be an indication that communal rangelands are overgrazed (Shackleton, 1993) because palatable and decreaser species decline in numbers when the rangeland is over or selectively grazed and replaced by increaser and less palatable species (Sisay and Baar, 2002).

The present study also showed that study sites were dominated by perennial species. Similar results were reported by Morris and Kotze (2006). Ruminants can alter vegetation from being dominated by annual species to being dominated by perennials species due to the high stocking rate on communal grazing lands (Smet and Ward, 2003).

4.4.2. Composition of common or dominant grass species

Common or dominant grass species identified in the present study were similar to species recorded in the previous study conducted in the Eastern Cape Province of South Africa (Lesoli, 2008), however, they were different in their frequency of occurrence. As observed in the results of this study, it is clear that the proportion of occurrence of highly palatable species (*T. triandra*) is relatively low on near and bottom sites at Dyamdyam and Machibi, respectively. These findings suggested that these sites were selectively grazed or overgrazed. This is because palatable grass species are very much under pressure from selective grazing and over utilization and are the first species that are removed under heavily grazed rangelands. This view is supported by Quattrocchi (2006) who reported that, *T. triandra* is an indicator of a good rangeland condition and it quickly disappears in part of rangeland where overgrazing and selective grazing occurs. In addition, *T. triandra* is growing well and most commonly occurs in undisturbed open grasslands with an optimum amount of rainfall. *Cynodon dactylon* was found to be slightly higher on bottom and near sites than other sites. This indicates that bottom and near sites were heavily grazed because *C. dactylon* is the dominant key species in rangeland that is heavily grazed (Van Oudtshoorn, 1992). In addition, *C. dactylon* is the perennial grass that grows well in all types of soil, more especial in sandy soil and disturbed areas (Xu *et al.*, 2011). Frequency of occurrence of *E.plana* and *S. africanus* were relatively low on near and bottom sites compared to other grazing sites. However, these species were expected to be high on these sites because they grow well in disturbed soil such as trampled part of rangeland by livestock as well as near the homestead, roads and drinking areas (Van Oudtshoon, 2012).

4.4.3. Biomass production

The current study showed that mean biomass production in all the study sites was higher in summer than in winter. High biomass production in summer could partly be explained by high rainfall and optimum temperature that promote tropical and subtropical vegetation growth. These results concur with the reports of Noellemeyer *et al.* (2006) in semi-arid areas of Argentina and Angassa and Oba (2010) in southern Ethiopia, who observed seasonal variation in biomass production. This was however not in agreement with the study of McDonald *et al.* (1987) who did not find any seasonal variation in biomass production.

Biomass production at Dyamdyam was low on near site from homesteads than the other sites. The present results correspond with earlier findings by Savadogo *et al.* (2007) in the savanna woodlands of Burkina Faso. This can be explained by the fact that near site was heavily grazed due to easy access by ruminants and availability of the drinking areas. Energy requirement of ruminants is different depending on the distance which livestock walk. Therefore, this might lead to declined movement of livestock which in turn would result in high density of livestock on easily accessible grazing sites (Bailey *et al.,* 1996).

In the current study biomass production at Machibi was higher on top and slope sites than bottom site. Similar results were reported by Senft *et al.* (1985) and Lesoli (2008) in communal grazing lands of South Africa. This indicates that livestock spend most of the time grazing in bottom lands due to easy access. For grazing sites found on heterogeneous landscape, animal grazing distribution pattern might be impacted by variations in landscape (Lesoli, 2008). However, the bottom site in the present study was expected to have high biomass production than slope and top positions due to the high accumulation of nutrients on bottomlands (Coronato and Bertiller, 1996) because nutrients promote plant activities.

4.4.4. Height and diameter of common or dominant grasses

In the current study all common or dominant grass species, except *S. africanus* at Dyamdyam, had the highest mean height in the middle and far sites than the near site. As discussed previously near site had been grazed more intensively than other sites. Therefore, this may cause a short grass height on this site due to high grazing pressure. According to Bilotta *et al.* (2007), heavily grazed areas are dominated by short grass height. Similarly, at Machibi all the common or dominant grass species, except *C. dactylon*, had the highest height on top and slope sites than the bottom site. This is associated with physical damage caused by ruminants. *Cynodol dactylon* had highest height on bottomland than slope. This confirms the fact that *C.dactylon* grow well in overgrazed and disturbed areas (Van Oudtshoorn, 1992) and is common in sandy soil (Xu *et al.*, 2011).

Plant height of *S. africanus, T. triandra* and *E. plana* across the study sites and in both study areas was below the maximum growth range of 28–150 cm, 30–150 cm and 40–100 cm respectively suggested by Van Outshoorn (2012). Plant height of *C.dactylon* across the study and in both study areas was within the maximum growth range of 5–40 cm reported by Van Outshoorn (2012).

This study showed that average tuft diameters of *T. triandra* and *E. plana* at Dyamdyam were not significantly different amongst all the sites. This indicates that a tuft diameter of these species in the present study did not influenced by distance from homestead. However, the difference was expected due to differences in grazing intensity and accumulation of nutrients along the distance gradient from homesteads.

In the current study average tufts diameter of *T. triandra* and *C. dactylon* at Machibi did not show significant difference between slope and top sites. These results contradict with the report of O' Connor and Pickett (1999) in the semi-arid savannas of East Africa who reported that, there is steady change in grass species along grazing gradients usually characterized by a decline in tuft size. Tufts diameter of *T. triandra* and *C.dactylon* was bigger in bottom site than slope and top sites. This can be attributed to the high accumulation of soil nutrients in the bottomlands (Coronato and Bertiller, 1996) because nutrients promote plant activities. Plant tuft size of *C.dactylon, S. africanus, T. triandra* and *E. plana* across the study sites and in both study areas was below the maximum tuft diameter range of 5–10 cm, 10–14 cm, 5–15 cm and 5–10 cm respectively reported by (Van Outshoorn, 2012).

4.4.5. Density of herbaceous species

The total mean density of herbaceous species in all the study sites and in both study areas was significantly higher in summer than in winter. Similar results were reported by Bailey *et al.* (1996). This can be attributed by a higher amount of rainfall in summer and the availability of soil nutrients. This is because plant density increases with an increase in rainfall and soil nutrients availability (Ahmad *et al.*, 2007).

In the current study, total mean density of herbaceous species strongly influenced by the distance gradient from homesteads. Dyamdyam and Machibi plant density was low on near and bottom sites respectively than other sites in both seasons. Similar results were reported by Senft *et al.* (1985) and Lesoli (2008) in South Africa. High grazing intensity and human activities on bottom and near sites can result in bare patches and veld degradation which in turn results in low density of herbaceous species (Senft *et al.*, 1985; Lesoli, 2008). Lower plants density on the near and bottom site could also be partially explained by the fact that small stock such as sheep and goats kraaled during night and released in the morning. This could have an effect on plant density during the livestock movement (Lesoli, 2008).

4.5. Conclusion

The present study showed that most palatable species such as *T. triandra* had low frequency of occurrence in near grazing sites than middle and far sites. The study sites were dominated by *T. triandra, C. dactylon, E. capensis, E. plana* and *S. africanus*. The biomass production was significantly higher in summer than in winter season. Density of herbaceous species was low on near grazing site than middle and far. Therefore, it can be concluded that season, landscape and distance from homesteads are the most important factors that affect vegetation change and the composition of herbaceous species. Therefore, any veld condition assessment and rangeland management practices in communal rangelands should take into consider often these factors. In addition, application of suitable grazing systems in communal grazing areas is recommended to inhibit the declining trend of highly palatable species and biomass production near the homestead to improve fodder production for ruminants.

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CHAPTER 5

Mineral status of soil and forage in two communal coastal rangelands of the Eastern Cape Province, South Africa

Abstract

The current study was conducted with the aim of determining the mineral status of forage and soil in two communal areas (Dyamdyam and Machibi) located in the coast areas of the Eastern Cape Province, South Africa. In each study area, the rangelands were divided based on the distance from homesteads into near (up to 1 km), middle (> 1–2 km) and far (> 2–3 km) sites. In each site, two HVUs of 20 m x 50 m were established. On each HVU, six 0.25 m^2 quadrants were laid randomly and forage found within a quadrant were harvested. Collection of grasses was carried out in winter and summer in 2014 and 2015. Soil samples were collected once at the end of the winter season in 2014.

Forage and soil samples were analysed for N, Ca, Mg, K, P, Cu, Zn, Mn and Fe. At Dyamdyam soil P, Fe and Mn contents differed ($P < 0.05$) among the study sites, with near site having greater values than middle and far sites. At Machibi soil N, P, Fe, Cu, Mn and Zn differed ($P < 0.05$) among the study sites, with bottom sites having greater concentration than midslope and top sites. Soil sampled from both study areas contained insufficient levels of Mg, Ca and Zn concentration compared to amount needed for plant growth. Forage N, P and Fe values at Dyamdyam and Machibi were significantly higher ($P < 0.05$) in summer than in winter among the study sites. Forage Fe levels at Dyamdyam were highest ($P < 0.05$) in the near and middle sites during winter and summer respectively. Forage Fe levels at Machibi were highest ($P < 0.05$) in the slope and bottom sites during winter and summer respectively. Forage collected from the slope and top sites at machibi had the highest ($P < 0.05$) Zn levels in winter and in summer

respectively. Forage sampled from the study sites contained low concentration of P, N and Cu than required by grazing livestock for growth in both seasons. Therefore, supplementation with feed containing concentration of the above minerals throughout the year is recommended. Season and landscape are the most important factors that influence forage and soil nutrients availability. Therefore, these factors should be considered during the planning of grazing management and fodder flow plan in communal grazing areas.

Keywords: Livestock, macro-minerals, micro-minerals, supplementation, summer, winter

5.1. Introduction

Natural pastures in semi-arid rangelands of Africa are the primary source of feed for livestock in resource limited communal farmers production systems (Solomon *et al.,* 2007; Lesoli, 2008). These rangelands are characterized by both spatial and temporal variability in soil and forage nutrients (Gizachew *et al.*, 2002). Spatial variation in forage nutrients results mainly from variations in soil (Ramirez, *et al.,* 2001), topography (Gizachew *et al.*, 2002), climate, plant species composition and grazing management practices applied (McDowell *et al.,* 1983; Jones, 2001). Temporal variations occur mainly as a result of differences in stage of plant maturity (Stokes and Prostko, 1998; Undersander, 2003) brought about by change in rainfall and temperature with the advancement in season and/or yearly variations (Zewdu *et al.,* 2002; Mountousis *et al.*, 2008; Nyamukanza *et al.,* 2010) and also as the results of management practice applied.

It has been reported that clay soils have high organic matter that can add more nutrients in soil and therefore forage grown on clay soil have more nutrients (CUCE, 2007). In addition, nutrients availability in forage is higher in summer than in winter due to the presence of optimum temperature and moisture (McKaffe, 2008; Xin *et al.*, 2001). Many studies worldwide reported that, when the plant is matured crude protein (CP) and other minerals declined (Gizachew *et al.,* 2002; Khan, 2003; Mountousis *et al.*, 2008 and Gwelo *et al.*, 2015). With regards to topography, large amounts of soil nutrients are transported from uplands through soil erosion and accumulated on bottomlands (Gizachew *et al.*, 2002). Therefore, this can result in higher uptake of soil nutrients by plants and higher nutritive value of pastures that grow on bottomlands.

Soil nutrients in rangelands may also differ greatly in space and time as a result of natural and anthropogenic disturbances (Mcgrath and Payton, 2010). On natural rangelands, soil nutrients availability can be affected by soil pH and texture (Matlhoahela *et al.,* 2006), soil type (CUCE, 2007), livestock grazing or browsing (Gao *et al*., 2009) and topography (Gizachew *et al.*, 2002). With regard to texture, clay soils have high organic matter, content of cation exchange capacity (CEC) and capability to hold nutrient (CUCE, 2007). In contrast, sandy soils have low organic matter, CEC and nutrient retaining ability (CUCE, 2007). Furthermore, irregular deposition of cow dung and urine on communal rangelands may lead to inconsistency in the concentration of soil nutrients (Drewes *et al.,* 1999). According to Gizachew *et al.* (2002), concentration levels of many minerals in soils tend to be higher in low lying regions than uplands. High mineral concentration in bottomlands is mostly due to the gradual movement of topsoil particles and litter from the surrounding sloping areas to the bottomlands (Gizachew *et al.*, 2002; Kagabo *et al.*, 2013).

Few studies have been conducted to determine the nutrients concentration of soil and forage in communal coastal rangelands of South Africa. There is also no information investigating the effects of season and landscape on these nutrients in the coastal grazing lands. Therefore, the objective of this study was to determine the mineral status of soil and forage in communal grazing lands surrounding homestead areas, and identify deficient minerals in soil and forage for future intervention in the communal coastal rangelands.

5.2. Materials and Methods

5.2.1. Selection of study sites and layout

Details of description of the two communal areas are presented in Chapter 3. Dyamdyam is set on a plain land and the rangeland was divided based on the distance from homesteads into near (up to 1 km), middle (> 1–2 km) and far (> 2–3 km) sites. On the other hand, Machibi is situated on a gentle steep slope and the rangeland was divided into bottom (up to 1 km), middle (> 1–2 km) and top (> 2–3 km) lands (near, middle and far from homesteads, respectively). In each communal area, two long transects that crossed the above sites were established in two directions that were identified to be the routes for main grazing activities.

5.2.2. Vegetation sampling and chemical analysis

In each site of both study areas two 50 m x 20 m homogenous vegetation units plot (HVU) were marked. In each HVU six quadrants of 0.25 m^2 were laid randomly for forage sampling. Harvesting of herbaceous species was carried out in winter and summer in 2014 and 2015 respectively. Herbaceous species found within each quadrant were harvested and oven-dried for 24 hours at 60 °C. Dried samples were ground to pass through a 1 mm sieve and stored in plastic bags at room temperature pending chemical analysis. Forage samples were analysed in the Department of Agriculture Western Cape for Nitrogen (N), Calcium (Ca), Magnesium (Mg), Potassium (K), Phosphorus (P), Copper (Cu), Zinc (Zn), Manganese (Mn) and Iron (Fe). Determination of Mn, P, Ca, Mg, Fe, Zn, Cu and K status was done using the dry ashing macro and micro method for forage [Agri Laboratory Association of Southern Africa (ALASA), 1998]. Forage N level was determined using the Kjehadahl digester method (ALASA, 1998). Crude protein (CP) was calculated by multiplying N content with 6.25 (Linn and Martin, 1999).

5.2.3. Soil sampling and chemical analysis

Soil samples were collected at the same time when grass sampling was done. The soil samples were collected at a depth of 20 cm and this was done by making use of soil auger in each quadrant. Soil samples were collected once at the end of winter in 2014. Soil samples were dried for about 48 hours at 60 °C, and then ground to pass through a 2 mm sieve and stored in plastic bags at room temperature pending for chemical analysis. Samples were then sent to the Department of Agriculture Western Cape for analysis of N, Ca, Mg, K, P, Fe, Cu, Zn and Mn. Soil pH was determined using a pH meter and Potassium Chloride (KCL) (ALASA, 1998). Soil P was determined on a continuous flow analyser. The total N was determined following the standard Kjeldahl method using a block digester method (Bremner and Breitenbeck, 1983). Soil Mg, Ca and K was determined by using Inductively Coupled Plasma (ICP) analysis of extracts of soil with 1 % citric acid (ALASA, 1998). Soil Fe, Zn, Mn and Cu were determined using the ICP in 0.02 M Di-ammonium EDTA soil extracts (ALASA, 1998).

5.2.4. Statistical analyses

By necessity, rangeland studies are often unstructured, and it is difficult to control the effects of spatial heterogeneity. In controlled field experiments, proper replication can be performed to reduce experimental errors and make meaningful comparison between treatment effects. In this study, 3 x 2 factorial field experiment in a completely randomized block design (Gwelo *et al.*, 2015) was used with distances from the homesteads (three levels), and seasons (two levels) being the main factors and the two fixed transects being the blocking factor. The HVUs which served as replicates were nested within the transects and the transects were nested within the main factors. Repeated measures were done for the vegetation in each plot over the two seasons. Both grass and soil data were analysed using General Linear Model (GLM) procedure of SAS (2010). Analysis of soil and grass minerals was done separately for the two study areas because they have significant difference in terms of landscapes, altitudes and vegetation types. The PDIFF option of SAS (2010) was employed for mean separation. Forage data analysis did not show significant interaction between site and seasons in both study areas.

The following statistical model was used:

$$Y_{ijk} = \mu + S_i + F_j + (S \times F)_{ij} + E_{ijk}$$

Where Y_{ijk} = the dependent variable

μ = overall mean

S_i = the effect of the i^{th} season

F_j = the effects of the j^{th} site (near, middle and far for Dyamdyam and bottom, slope and top for Machibi)

E_{ijk} = the random error

5.3. Results

5.3.1. Soil macro-elements

Results on macro-mineral status of soil collected from Dyamdyam and Machibi are presented in Table 5.1. At Dyamdyam soil N was highest ($P < 0.05$) in near site, whereas the middle and far sites did not show marked ($P > 0.05$) variations. Soil P and K levels were highest ($P < 0.05$) in near and middle sites. Soil Ca and Mg levels were higher ($P < 0.05$) in near and middle sites than the far site. At Machibi soil N was highest ($P < 0.05$) in bottom site followed by sloping and top sites. Soil P levels were highest ($P < 0.05$) in bottom site followed by the sloping site. Soil Mg, K and Ca levels were not significantly ($P > 0.05$) different among the study sites.

Table 5.1: Macro-nutrients of soil sampled from study areas in winter (n=12 per site per communal area)

Areas/Sites					
Dyamdyam	**N (%)**	**P (ppm)**	**K(cmol/kg)**	**Ca (cmol(+)/kg)**	**Mg (cmol(+)/kg)**
Near	0.06^{a}	24.0^{a}	0.21^{a}	1.12^{a}	0.91^{a}
Middle	0.03^{b}	22.0^{b}	0.10^{a}	1.02^{a}	0.91^{a}
Far	0.04^{b}	18.0^{c}	0.09^{b}	0.63^{b}	0.43^{b}
S.E	0.01	1.00	0.87	0.39	0.22
Machibi					
Bottom	0.90^{a}	30.5^{a}	0.17^{a}	2.56^{a}	1.81^{a}
Slope	0.63^{b}	27.0^{b}	0.16^{a}	2.11	1.59^{a}
Top	0.31^{c}	19.0^{c}	0.15^{a}	1.33	1.37^{a}
S.E	0.07	0.87	1.0	0.25	0.03

[abc]Means with different superscript within the same column are significantly different (P< 0.05)

5.3.2. Soil micro-elements

Results on micro-mineral levels of soil collected from Dyamdyam and Machibi are presented in Table 5.2. At Dyamdyam soil Fe and Mn were highest (P <0.05) in near site followed by the middle and far sites. Soil Cu and Zn were highest (P <0.05) in near site, whereas middle and far sites did not differ (P>0.05). At Machibi grazing land all micro-elements showed the highest value at the bottom site followed by the middle and top sites.

Table 5.2: Micro-nutrients (ppm) of soil sampled from study areas in winter (N= 12 per site per communal area)

Areas/Sites				
Dyamdyam	**Fe**	**Cu**	**Zn**	**Mn**
Near	181.5^a	0.55^a	0.46^a	21.16^a
Middle	173.9^b	0.39^b	0.34^b	6.11^b
Far	117.5^c	0.22^b	0.26^b	8.89^c
SE	1.12	0.02	0.03	0.71
Machibi				
Bottom	221.4^a	1.39^a	0.87^a	93.5^a
Slop	217.5^b	0.91^b	0.70^b	87.2^b
Top	208.5^c	0.76^c	0.55^c	81.3^c
SE	1.08	0.04	0.02	0.89

[abc]Means with different superscript within the same column are significantly different ($P < 0.05$).

5.3.3. Soil pH

Figure 5.1 and 5.2 presents the results on pH levels of soils collected from Dyamdyam and Machibi grazing areas respectively. The results showed that at Dyamdyam near site had significantly higher pH value than far and middle sites. Similarly, soil pH level at Machibi was higher in bottom site followed by the slope and top sites. Overall values indicated that pH in all study sites ranged from 4–4.5.

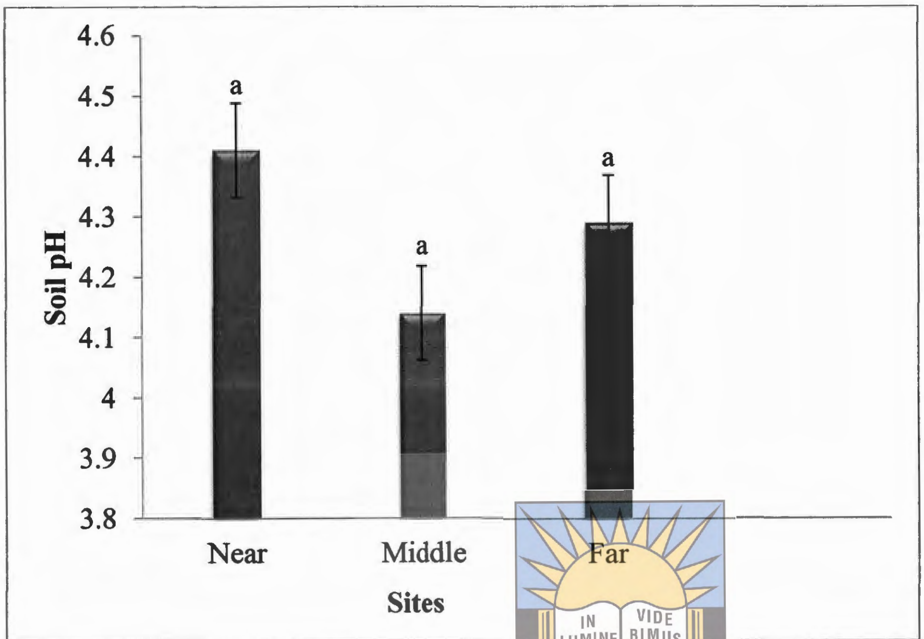

Figure 5.1: Soil pH levels of soil samples collected from Dyamdyam grazing areas

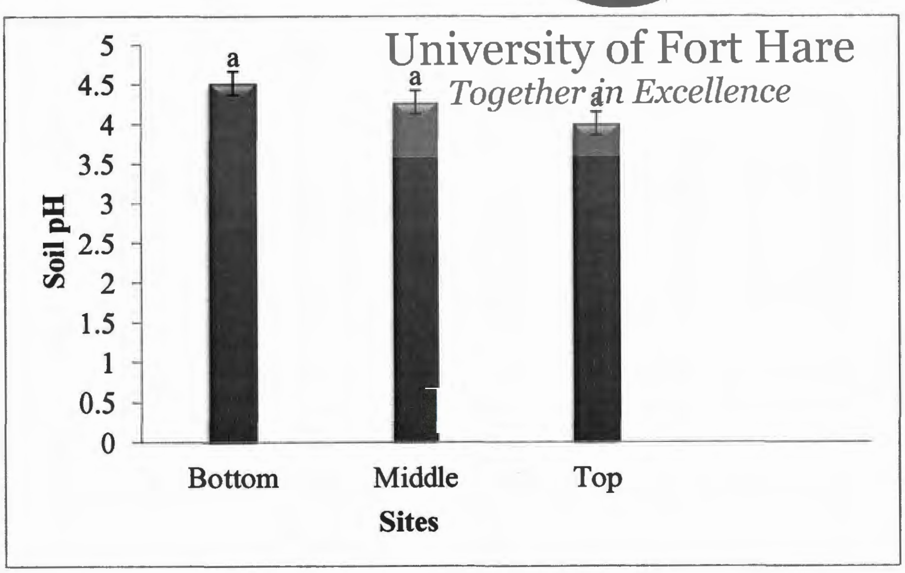

Figure 5.2: Soil pH levels of soil samples collected from Machibi grazing areas.

5.3.4. Forage macro-mineral contents

Table 5.3 presents the macro-mineral status of forage sampled at Dyamdyam and Machibi rangelands over the two main seasons (winter and summer). Results at Dyamdyam grazing distances showed that, forage P, Ca, K and Mg did not show a significant difference (P >0.05) between three distance positions. For forage N, this depends on season in that (though this interaction was not reflected in the analysis outcomes) forage samples collected during winter did not show significant difference between distances from homesteads, whereas for summer, the far site had the greatest N content. As for seasonal effect, forages collected in summer had greater concentrations of P and N, whereas the concentrations of other macro-elements were not significantly affected by the season. Results at Machibi grazing landscape showed that, forage N, P, Ca and Mg did not show significant difference (P >0.05) between three landscape positions. The seasonal variations were found on the slope and top sites where forage P, K and N levels were higher (P <0.05) in summer than in winter.

Table 5.3: Macro-nutrient (%) of forage harvested from Dyamdyam and Machibi in winter and summer (N= 12 per site per communal area)

as/Sites	N		P		K		Ca		Mg	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
mdyam										
r	0.49^{bA}	0.71^{aB}	0.05^{bA}	0.08^{aA}	0.51^{aA}	0.49^{aA}	0.29^{aA}	0.30^{aA}	0.17^{aA}	0.14^{aA}
dle	0.49^{bA}	0.68^{aB}	0.05^{bA}	0.08^{aA}	0.47^{aA}	0.50^{aA}	0.31^{aA}	0.27^{aA}	0.14^{aA}	0.14^{aA}
	0.54^{bA}	0.91^{aA}	0.05^{bA}	0.09^{aA}	0.52^{aA}	0.61^{aA}	0.31^{aA}	0.31^{aA}	0.17^{aA}	0.16^{aA}
	0.11		0.01		0.08		0.04		0.01	
hibi										
om	0.57^{bA}	0.82^{aA}	0.06^{aA}	0.07^{aA}	0.53^{aA}	0.66^{aB}	0.41^{aA}	0.47^{aA}	0.14^{aA}	0.15^{aA}
e	0.51^{bA}	0.74^{aA}	0.05^{bA}	0.08^{aA}	0.42[illegible]	0.70^{aAB}	0.36^{aA}	0.32^{aA}	0.14^{aA}	0.13^{aA}
	0.53^{bA}	0.85^{aA}	0.05^{bA}	0.11^{aA}	0.49[illegible]	0.83^{aA}	0.33[illegible]	0.34^{aA}	0.13^{aA}	0.14^{aA}
	0.14		0.02		0.18		0.08		0.02	

[ab]Lowercase superscripts are used to compare means between seasons within each site. [ABC]Uppercase superscripts are used to compare sites averages within each season. Means with different superscript within the columns and rows are significantly different (P <0.05). S.E= Standard Error.

5.3.5. Forage micro-mineral content

Micro-mineral levels of forage sampled from Dyamdyan and Machibi are presented in Table 5.4. At Dyamdyam the season interacts strongly with the site to influence most forage micro-element concentrations. The forage Fe levels were highest (P <0.05) in the near and middle sites during winter and summer, respectively. Forage collected from the near and far sites had the highest (P <0.05) Zn level during winter and summer, respectively. Forage Mn level did not show significant variations (P >0.05) between sites in winter, whereas forage harvested from the farthest site showed highest levels ($P < 0.05$) during summer compared to the other sites. Forage Cu levels did not exhibit seasonal nor spatial variations ($P > 0.05$) across the study sites. .

At Machibi season interacts strongly with three different landscapes to influence most forage micro-element concentrations. The forage Fe levels were highest ($P < 0.05$) in the slope and bottom sites during winter and summer, respectively. Forage collected from the slope and top sites had the highest ($P < 0.05$) Zn levels during winter and summer, respectively. Forage collected from the bottom and slope sites had the highest ($P < 0.05$) forage Mn levels during winter and summer, respectively. Forage Cu levels did not exhibit seasonal nor spatial variations ($P > 0.05$) across the study sites.

Table 5.4: Micro-nutrient (ppm) of forge harvested from Dyamdyam and Machibi in winter and summer (N= 12 per site per communal area)

Areas/Sites	Fe		Cu		Zn		Mn	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Dyamdyam								
Near	266.4^{bA}	306.6^{aB}	2.20^{aA}	2.25^{aA}	22.6^{aA}	19.9^{bB}	141.7^{bA}	193.0^{aB}
Middle	137.6^{bB}	413.5^{aA}	2.63^{aA}	1.75^{aA}	17.9^{aB}	16.3^{aC}	167.9^{aA}	162.4^{aB}
Far	136.4^{bB}	298.4^{aC}	2.49^{aA}	2.54^{aA}	15.4^{bC}	21.4^{aA}	140.6^{bA}	232.2^{aA}
S.E	77.0		0.4		1.8		20.2	
Machibi								
Bottom	271.5^{bB}	799.8^{aA}	2.61^{aA}	3.07^{aA}	19.3^{aB}	20.1^{aB}	349.5^{aA}	194.6^{aB}
Slope	441.0^{bA}	685.6^{aA}	2.59^{aA}	2.56^{aA}	23.7^{aA}	21.6^{bB}	272.2^{aB}	239.8^{aA}
Top	279.5^{bB}	796.5^{aA}	2.73^{aA}	2.73^{aA}	17.2^{bC}	24.9^{aA}	248.2^{aB}	178.9^{bB}
S.E	140.8		0.4		3.5		35.9	

^{ab}Lowercase superscripts are used to compare means between seasons within each site. ^{ABC}Uppercase superscripts are used to compare sites averages within each season. Means with different superscript within the columns and rows are significantly different (P <0.05). SE= Standard Error.

5.3.6. Forage crude protein content

Crude protein content of forages harvested from Dyamdyam and Machibi is presented in Figure 5.3 and 5.4 respectively. In both grazing areas, sites and seasons seemed to interact strongly to influence the forage CP contents. At Dyamdyam forage samples harvested from the far sites had the highest CP in summer, whereas in winter, all forages harvested from three sites had similar

CP contents. At Machibi forage CP levels harvested in three grazing sites in summer were significantly higher (P <0.05) than forage CP harvested in winter.

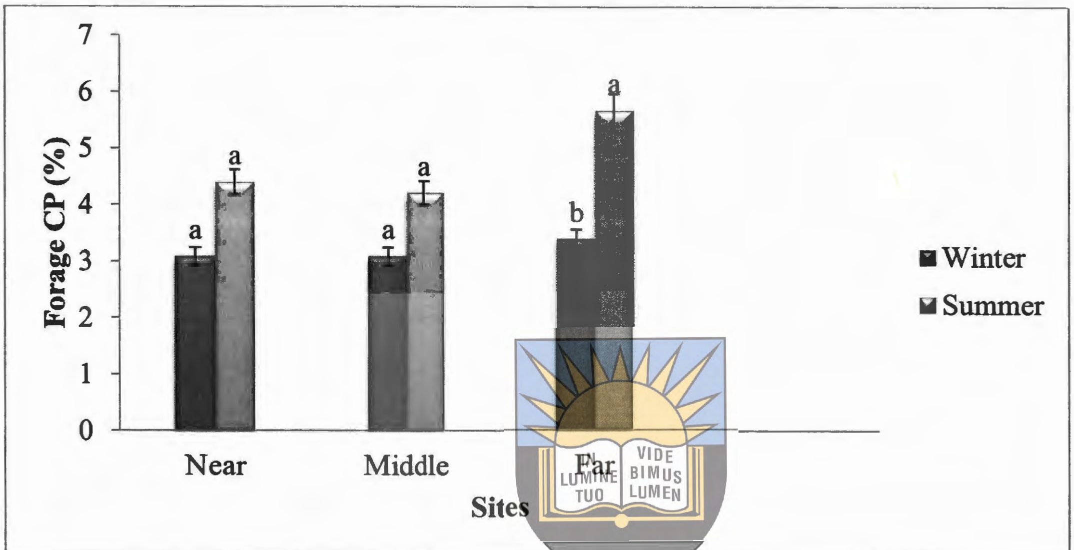

Figure 5.3: Spatial and seasonal differences in forage crude protein content of harvested samples at Dyamdyam

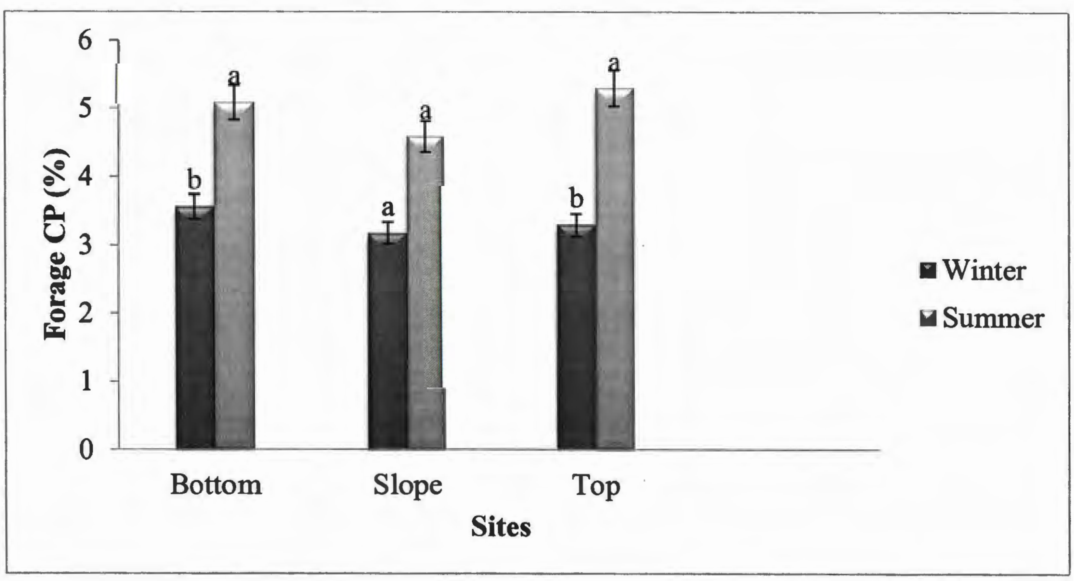

Figure 5.4: Spatial and seasonal differences in forage crude protein content of harvested samples at Machibi.

5.4. Discussion

5.4.1. Soil macro-and micro minerals on study sites

Soil analysis results revealed that the concentration of all macro and micro elements were significantly influenced by distance from homesteads. The result showed that in both study areas the levels of soil N, P, K, Fe, Cu, Zn, Mg, Ca and Mn were higher in the near site than the middle and far sites from homesteads. The higher amount of these elements close to the homestead in both grazing lands may be attributed to greater herbivore concentration per unit area of land (Nsinamwa *et al.,* 2005; Gwelo *et al.,* 2015). During most of the grazing periods, ruminants spend their time close to the homestead because there is plenty of forage supply and drinking waters per unit area of land that are readily accessible by the animals. Herbivore grazing, trampling, defecation and urination therefore increase the soil concentration of these elements (McNaughton *et al.,* 1997; Drewes, 1999; Yates *et al.*, 2000; Gao *et al.*, 2009; Sigua *et al.*, 2011).

In addition, at Machibi, which is characterized by sloping terrain, the higher concentrations of these elements in the near (bottomlands) sites might result from the gradual movement of topsoil particles and litter from the surrounding sloping areas. Similar results were reported by Gizachew *et al.* (2002) in Ethiopia and Lesolo (2008) in South Africa. The current study was however not in agreement with study of Gwelo *et al.* (2015) in South Africa who did not find any significant effect of landscape on soil macro-and micro element concentration.

The present study indicated that at Machibi soil N concentration levels were above the required levels of <0.1 % (McDowell, 1985; Tefere *et al.,* 2010) for plant growth in all the study sites.

Similar results were reported by Gwelo *et al.* (2015) in semi-arid savannas of South Africa. Nevertheless, soil N levels at Dyamdyam were below the recommended levels required for plant growth in all the study sites. Soil P contents in this study were above the optimum plant requirement level of 14.53 ppm (McDowell, 1985). Similar results were reported by Gizachew *et al.* (2002) in Ethiopia however, contrary to the results of Gwelo *et al.* (2015) in semi-arid savannas of South Africa. In many study sites, soil K levels were within the optimum plants requirement level of <0.15 cmol/kg (McDowell, 1985) except only in the middle and far sites at Dyamdyam were below the suggested levels. Soil Mg and Ca levels reported in the present research were lower than critical values of 30 ppm and 3.5 cmol/kg (Rhue and Kidder, 1983) respectively for plant growth.

The soil concentration levels of Zn reported in this study were below the suggested soil Zn level for normal plant growth (1 ppm) (Rhue and Kidder, 1983). The recommended critical levels of soil Cu concentration for normal plant growth is 0.3 ppm (Rhue and Kidder, 1983) and therefore, soil Cu concentration level in all the study sites were above the critical level except in the far site at Dyamdaym where the values are below the recommended levels. Soil concentration levels of Mn found in this study were above the recommended levels for normal plant growth (5 ppm) in all the study sites (Rhue and Kidder, 1983). Similar results were reported by Tisdale *et al.* (1985) in New York. In addition, soil Fe concentration levels reported in the present research were above acceptable value of 2.5 ppm for growth of plants species (Viets and Lindsay, 1973). High concentration levels of soil Fe presented in this study concur to the view reported by Cox (1973) that Fe insufficiency cannot be anticipated due to enough levels of Fe in soil and grass species.

5.4.2. Soil pH

The present study indicated that soil in study sites was acidic with pH values ranging between 4 and 4.5, which is consistent with results of previous studies in Botswana (Wang *et al.,* 2007). However, these results contradict the report of Gwelo *et al.* (2015), who documented higher soil pH in South Africa. The acidic soil in the study sites might be caused by a high amount of rainfall in coastal areas (Zhao *et al.*, 2007). Soil pH reported in the present study was below the normal range of 6–7 for the availability of macro-minerals (Matlhoahela *et al.*, 2006).

5.4.3. Seasonal and spatial differences of forage macro-and micro elements

Despite spatial differences in the macro-nutrients of the soil, most forages harvested from the three distance areas around the homesteads did not show significant difference in macro-elements concentration. This suggests that differences in soil contents are not strong enough to cause variation in the macro-mineral levels of the forage. Forage N and K levels at Dyamdyam and Machibi respectively were higher on farthest grazing sites from homesteads and this is similar to the report of Xin *et al.* (2001) in China. However, these results contradict with the findings of Gwelo *et al.* (2015) who reported high levels of forage N on middle area surrounding homestead. In addition, these macro-elements were expected to be higher on near and bottom sites due to higher soil N and K concentration levels reported on near and bottom sites in the present study. Forage Fe, Zn and Mn levels in this study were higher on near and slope grazing areas and these results concur with the findings of Drewes (1999) in South Africa and Gizachew *et al.* (2000) in Ethiopia. However, it disagrees with the report of Gwelo *et al.* (2015) in semi-arid savannas of South Africa. Higher forage levels of the above elements may be attributed to high soil concentration levels of these micro-elements on near and slope grazing sites reported in the present study and by the high accumulation of minerals in bottom and slope lands.

In the present study, forage N, P and K levels showed seasonal variations with significantly higher concentration of the elements in forage harvested in summer than in winter. The decline in the concentration of K, P and N with advancing growing season is similar to the report by other researchers from eastern Africa (Gizachew *et al.,* 2002), Pakistan (Khan, 2003), Greece (Mountousis *et al.*, 2008) and southern Africa (Gwelo *et al.*, 2015). Low forage contents of the above macro-elements in winter may be associated to the maturation of grass species with advancing the growing season. Additionally, in winter forage species become dead due to climatic conditions and therefore, the concentration levels of P, K and N in dead tissues is relatively low (Greene *et al.,* 1987). On the other hand, high levels of N, K, Fe Zn, Mn and P in forage in summer may be attributed to a high ambient temperature that will result in an increase in metabolic rates which in turn increases the absorption of nutrients from soil by roots (McKaffe, 2008).

Of the micro-elements, forage Fe and Mn concentration levels showed seasonal variation with higher levels recorded in summer than winter. Similar results were reported by Khan *et al.* (2006) and Fardous *et al.* (2011) in Pakistan, but contradict with the earlier findings of Ahmad *et al.* (2012) in semi-arid rangelands of Pakistan and Gwelo *et al.* (2015) in South Africa.

The present study indicated that forage N and P levels were below the optimum range of 1–5 % and 0.17–0.59 % (NRC, 1996) respectively required by ruminants for growth. Similar results were reported by Drewes *et al.* (1999) and Gwelo *et al.* (2015) in the Eastern Cape Province of South Africa. Phosphorus and N are the most limited mineral in forage from rangelands because of its low availability to rangeland plants and loss through veld degradation (Hussain and Durani, 2008). It is therefore expected that livestock grazing on these rangelands may encounter problems related to P and N deficiency (Beyene and Mlambo, 2012). Forage harvested from most grazing sites at Dyamdyam had K levels below the recommended critical range (0.60–0.70 %) for beef cattle production (NRC, 1996). At Machibi forage K levels on bottomlands and midslope in summer fell within the recommended range for beef cattle production (NRC, 1996), while on uplands it was above the recommended critical levels. Forage Ca and Mg levels in both seasons and study areas were within the suggested critical range of 0.17–1.53 % and 0.10–0.20 % respectively for beef cattle (NRC, 1996). Many studies worldwide reported similar results (Espinazo *at el.*, 1991; Islam *at al.*, 2003; Beyene and Mlambo, 2012). However, these results contradict with findings of Drewes *et al.* (1999) who reported insufficient Mg levels of the forage harvested from the communal rangelands of the Eastern Cape Province.

In the current study in both seasons and study areas forage Fe and Mn concentration levels were above the recommended critical levels of 50 ppm and 20 ppm (McDowell, 1985; Fardous *et al.*, 2011) respectively for growth of livestock. Similar results were reported by Valasquez-Pereira *et al.* (1997) in Nicaragua, Khan *et al.* (2006) in Pakistan, Beyene and Mlambo (2012) in Swaziland and Gwelo *et al.* (2015) in South Africa. Forage Cu concentration levels reported in this study were below the recommended critical levels of 4 ppm for beef cattle (NRC, 1996). The values of forage Cu levels reported in this study were slightly similar to the values reported by Espinoza *et al.* (1991) in central Florida. In addition, low concentration levels of Cu in forage may be due to its interaction with other soil minerals and plant maturity. It has been reported that Cu in soil strongly interacts with other micro-and macro-elements for absorption by the plant roots (McDowell *et al.*, 1993). For instance, Fe and Mn concentration levels in both soil and plants were very high in the present study and these high levels could inhibit the absorption of Cu by plant roots. The forage Zn levels found at Dyamdyam in summer and winter on far and near sites, respectively, fell within a recommended range of 20–30 ppm for cattle production (NRC, 1996). However, on other sites forage Zn levels were below the recommended range required by ruminants for growth and production. Forage Zn levels in summer in all study sites at Machibi were at a recommended range of 20–30 ppm for cattle, while the recommended level in winter was found only on midslope site. Forage Zn levels found in summer in the present study contradict with the results of Khan *et al.* (2006) in Pakistan, but similar to the findings of Gwelo *et al.* (2015) in South Africa. Low levels of forage Zn on other study sites in winter could be partly attributed to many factors comprising of climatic condition, maturity of plants and interaction with other elements (Cox, 1973). In addition, Cox (1973) reported that the deficiency of Zn in forage is due to climatic conditions and stage of plant maturity. Furthermore, Kabata-Pendias and Pendias (1992) suggested that forage Zn concentration levels can be affected by maturity because when plant is matured Zn levels decrease and it also depends upon the tissue type of plants. According to Tisdale *et al.* (1985), high concentration levels of Mn and Fe inhibit the absorption of Zn by plant roots.

5.4.4. Forage crude protein

In both study areas and seasons forage crude protein levels were below the recommended range of 6–8 % (Humphreys, 1991) for grazing livestock. Crude protein levels reported in this study were similar to the levels reported by Beyene and Mlambo (2012) in Swaziland. However, other researchers reported higher (Roukos *et al.,* 2011) and lower (El-Beheiry and El-Kady, 1998) CP levels than present study.

5.5. Conclusion

Based on the results of this study it can be concluded that, mineral levels in the soil were influenced by distance and landscape from homestead. The levels of many nutrients in soil were higher in near and bottom sites than the farthest site from homesteads. Soil sampled from both study areas contained sufficient levels of Mn, Fe, P, N and Cu needed for plants growth except for N at Dyamdyam. However, the concentration levels of Mg, Ca and Zn in soil sampled from both study areas were below the recommended values for plant growth. Although soil has sufficient N concentration levels required by plants for growth at Machibi, all forages collected from both study areas in both seasons had low N content. Forage K levels collected in winter from study areas contained insufficient levels required by beef cattle for production. Therefore, K must be added for winter feeding supplements. Forage sampled from study areas contained low levels of P, CP and Cu than the suggested levels required by grazing livestock for growth in both seasons. Therefore, supplementation with feed sources high in these elements throughout the year is highly recommended. Most of the forage analyzed from both study areas contained adequate levels of Ca, Fe, Zn, Mn and Mg required by grazing livestock for growth in both seasons.

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Chapter 6. Summary

6.1. General discussion

This study consists of three experimental chapters. The first study (Chapter 3) was conducted to determine famer's perceptions and practices of livestock and rangeland management in two communal coastal areas. A total of 100 farmers from both Dyamdyam and Machibi were interviewed using structured questionnaire to determine the indigenous knowledge on rangelands and livestock management. The majority of communal farmers reported that, the main challenges faced to raise their livestock are feed shortage, stock theft and animal health problems. All household respondents reported that they use continuous grazing due to the absence of fence on their rangelands. Similar results were reported by Shackleton (1993) in the eastern Transvaal Lowveld. The majority of communal farmers do not provide supplemental feed to their livestock and they depend on natural rangeland in order to feed their animals throughout the year. These findings agree with the study of Solomon *et al.* (2007) in Ethiopia who reported that most of the feed that the communal animals depend on is derived from natural rangelands.

The second study (Chapter 4) determined the species composition and biomass production surrounding homestead areas. A total of 20 herbaceous species were identified in the study areas. Highly palatable species such as *T. triandra* had low frequency of occurrence in near grazing site than middle and far sites. This suggests that high grazing pressure and selective grazing are the source of observe this variation. Biomass production was significantly higher during the wet season and lower during the dry season. This suggests that seasonal variations are main causes of variation in biomass production in communal rangelands (Noellemeyer *et al.*, 2006; Angassa and Oba, 2010).

The third study (Chapter 5) was conducted to determine the mineral dynamics in soil and forage. Soil and forage samples were analysed for N, Mg, Fe, Zn, CP, Ca, Mn, P, K, Cu. Soil sampled from study areas contained insufficient levels of Mg, Ca and Zn needed for plant growth. Forage K levels collected in winter contained insufficient levels than the levels required by ruminants for production. Therefore, K must be added for winter feeding supplement. Forage sampled from both study areas contained inadequate levels of P, N and Cu required by grazing livestock for growth in both seasons. It is therefore expected that livestock grazing on these rangelands may encounter deficiency problems related with P, N, CP and Cu mineral deficiency throughout the year.

6.2. Conclusion

The present study revealed that livestock play a vital role in the livelihood of poor resource farmers at Dyamdyam and Machibi by generating income and provision of food. This study also showed that communal rangelands are continuously grazed due to the absence of fences and camping system. The study also showed that the most important factors that influence vegetation changes, biomass production and soil and forage nutrients availability are abiotic factors (distance from homestead, topography and season) and biotic factor (livestock). Hence, these factors should be considered in planning rangeland management and rehabilitation programs in communal grazing areas.

6.3. Recommendations

It is advisable to help the communal farmers at Dyamdyam and Machibi by fencing and educating them about their rangeland management to improve rangeland condition and fodder production for livestock. There is a need for intervention to identify other sources of fodder that can be used by resource limited farmers during the dry seasons. Supplementation with sources of feed high in P, N and Cu is recommended. Rangeland rehabilitation program on communal rangelands is also recommended to reduce rangeland degradation.

6.4. Further research

1. Further studies should be access the indigenous knowledge of communal farmers on grass identification, palatability to the livestock, grazing value, characteristics and habitat of individual grass species.
2. Due to limited technical support and logistical challenges, water and blood samples were not included in study therefore there is gap to determine mineral levels of water and blood and relate to minerals levels of soil and forage in coastal areas.
3. In this study woody species was also excluded therefore further studies should be determining the effects of season, distance gradient and landscape from homesteads on woody species composition in coastal areas.

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Soil and forage mineral status and farmers' perceptions of livestock husbandry and rangeland management practices in two communal coastal areas of the Eastern Cape Province, South Africa

Appendix 1: Questionnaire

Enumerator's name .... Questionnaire reference number...........................
Name of the village.......................... Date...

All information provided by interviewee will be treated as strictly confidential for mutual benefit of both the research and the farmers.

A. HOUSEHOLD DEMOGRAPHY

A 1

Gender of household	Male	Female
Mark with X		

A 2

Head of household	Father	mother	other
Mark with X			

A 3

Marital status	Married	divorced or separate	Single
Mark with X			

A 4

Education	Preschool	Primary	Secondary	Tertiary	None
Mark with X					

A 5

Age of household	5-15	15-30	30-40	40-50	Above 50
Mark with X					

A 6

Occupation	Farming	household wife	employee	pensioner	business	No occupation	student
Mark with X							

A 7 Household size…………… Adults …………… Children (less than 15 years)……………..

B. LIVESTOCK

B 1 How long does the livestock spend on grazing?

……

……

B 2 Which cattle breeds have you keeping?

Cattle Breeds	Nguni	Angus	Brahman	Hereford	Other
Mark X					

B 3 What type of livestock do you keep and how many per each species?

Cattle		Goats		Sheep	
Number		Number		Number	

B 4 How many cattle species do you have in each of the following gender?

	Bull	Heifer	Cow	Calf	oxen
Number					

B 5 How many sheep species do you have in each of the following gender?

	Ram	Ewes	Castrated ram	Lambs
Number				

B 6 How many goats species do you have in each of the following gender?

	Doe	Buck	Kids	Castrated buck
Number				

B 7 How do you perceive the livestock population change in over the past 10-20 years?

	Decrease	Increase	Remain the same	Other
Mark with X				

B 8 From your own opinion what do you think can cause the above trend? (in order of importance 1-most importance and 5- least importance)

Causes	Mark with X	Rank
Diseases		
Shortage of feed		
Increase motility rate		
Decrease conception rate		

B 9 How does the animals perform in terms of production and reproduction?

	Good	Fair	Moderate	Poor	Other specify
Mark with X					

B 10 From your own opinion what do you think can cause the above performance?

....

....

B 11 Do you use supplements for your livestock?

Yes	
No	

B 12 If yes, which supplements do you use?

Supplements	**Mark with X**
Licks	
Lucerne	
Maize stalk	

B 13 At what time of the year do you supplement your animals?

Seasons	Autumn	Winter	Spring	Summer
Mark X				

B 14 What are your purposes of keeping livestock? (in order of importance 1-most importance and 5- least importance)

Purposes	**Mark with X**	**Rank**
Milk and meat production		
Lobola		
Sale		
Traditional purposes		
Traction		

B 15 Where does your livestock obtain water?

	Rivers	Dams	Other (specify)
Mark with X			

B 16 Does the drinking areas allocated near, middle and far from homestead on grazing lands?..

B 17 Where does your livestock start grazing? (in order of importance 1-most importance and 5-least importance).

Near from homestead	Middle form homestead	Far from homestead	Other (specify)

Justify the above answer..

B 18 Where does your livestock spend most of time on the rangeland (in order of importance 1-most importance and 5- least importance).

Near from homestead	Middle from homestead	Far from homestead	Other (specify)

Justify the above answer..

B 19 What challenges do you face in raising livestock? (in order of importance 1-most important and 5- least important)

Challenges	**Mark X**	**Rank**
Feed Shortage		
Water scarcity		
Drought		
Predators		
Animal diseases		
Stock theft		

(C) RANGELANDS

C 1 At what time of the year would you experience a shortage in grazing?

	Autumn	Winter	Spring	Summer
Mark with X				

C 2 What could be the cause of such a shortage? (in order of importance 1- most and 5- least importance)

Causes of shortage	Mark with X	Rank
Low rainfall		
Human activities		

Overgrazing		
Rangelands degradation		

C 3 Do you practice any rangeland management?

Yes	
No	

C 4 If yes, which management system did you practice?

Grazing management system	Rotation	Continuous
Mark X		

C 5 Explain why did you choose this grazing system...

C 6 What is the current state of your rangeland?

	Description
Deteriorating- Very Poor	
Deteriorating -Poor	
Fair	
Good	
Very Good	
I don't know	

C 7 What has led to the current state of rangelands? (in order of importance 1- most and 5- least importance)

	Mark with X	Rank
Grazing (overgrazing or under-grazing or optimum grazing)		
Burning (presence or absence)		
Rainfall (constant, variable or recurrent drought)		
Human population (increase, decrease or unchanged)		

C 8 Your rangeland is most used for? (In order of importance: 1-most important 5-least important)

	Mark with X	Rank	Season of access(summer, winter, year round)
Grazing/browsing of animals			
Collecting fire wood			
Collecting wood and grass for building and Fencing			
Collecting plants for medicinal purposes			

C 9. Do you mix livestock of different species mainly grazers and browsers during grazing time?

Yes	
No	

Appendix 2: Plant and soil mineral Anova tables

Dyamdyam forage Anova tables

Dependent Variable: N

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.04905000	0.02452500	1.02	0.4165
Seasons	1	0.19000833	0.19000833	7.88	0.0309
Site*seasons	2	0.01971667	0.00985833	0.41	0.6816

Dependent Variable: P

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.00021667	0.00010833	0.68	0.5399
Seasons	1	0.00300833	0.00300833	19.00	0.0048
Site*seasons	2	0.00011667	0.00005833	0.37	0.7065

Dependent Variable: K

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.01326667	0.00663333	0.56	0.5979
Seasons	1	0.00300833	0.00300833	0.25	0.6320
Site*seasons	2	0.00506667	0.00253333	0.21	0.8131

Dependent Variable: Ca

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.00046667	0.00023333	0.09	0.9116
Seasons	1	0.00030000	0.00030000	0.12	0.7400

Site*seasons	2	0.00140000	0.00070000	0.28	0.7638

Dependent Variable: Mg

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.00095000	0.00047500	1.12	0.3867
Seasons	1	0.00040833	0.00040833	0.96	0.3648
Site*seasons	2	0.00031667	0.00015833	0.37	0.7039

Dependent Variable: Fe

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	11026.36500	5513.18250	0.46	0.6495
Seasons	1	76193.20333	76193.20333	6.41	0.0445
Site*seasons	2	27811.22167	13905.61083	1.17	0.3722

Dependent Variable: Cu

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.24885000	0.12442500	0.35	0.7161
Seasons	1	0.20020833	0.20020833	0.57	0.4795
Site*seasons	2	0.57041667	0.28520833	0.81	0.4884

Dependent Variable: Zn

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	35.85020000	17.92510000	2.68	0.1472
Seasons	1	0.91853333	0.91853333	0.14	0.7236

Site*seasons	2	44.60446667	22.30223333	3.34	0.1061

Dependent Variable: Mn

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	1091.285000	545.642500	0.66	0.5486
Seasons	1	6288.340833	6288.340833	7.66	0.0325
Site*seasons	2	4759.031667	2379.515833	2.90	0.1316

Dependent Variable: CP

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	1.92211667	0.96105833	1.02	0.4153
Seasons	1	7.42613333	7.42613333	7.89	0.0308
Site*seasons	2	0.76711667	0.38355833	0.41	0.6824

Machibi forage Anova tables

Dependent Variable: N

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.01261667	0.00630833	0.16	0.8518
Seasons	1	0.20803333	0.20803333	5.43	0.0586
Site*seasons	2	0.00501667	0.00250833	0.07	0.9372

Dependent Variable: P

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.00071667	0.00035833	0.49	0.6359

Seasons	1	0.00270000	0.00270000	3.68	0.1034
Site*seasons	2	0.00105000	0.00052500	0.72	0.5262

Dependent Variable: K

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.02361667	0.01180833	0.18	0.8390
Seasons	1	0.18750000	0.18750000	2.87	0.1412
Site*seasons	2	0.02495000	0.01247500	0.19	0.8310

Dependent Variable: Ca

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.02821667	0.01410833	1.15	0.3775
Seasons	1	0.00040833	0.00040833	0.03	0.8612
Site*seasons	2	0.00551667	0.00275833	0.23	0.8049

Dependent Variable: Mg

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.00035000	0.00017500	0.18	0.8388
Seasons	1	0.00003333	0.00003333	0.03	0.8588
Site*seasons	2	0.00011667	0.00005833	0.06	0.9420

Dependent Variable: Fe

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	1875.6050	937.8025	0.02	0.9767

Seasons	1	554528.0133	554528.0133	13.97	0.0097
Site*seasons	2	51616.0217	25808.0108	0.65	0.5552

Dependent Variable: Cu

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.20871667	0.10435833	0.28	0.7668
Seasons	1	0.20280000	0.20280000	0.54	0.4903
Site*seasons	2	0.13505000	0.06752500	0.18	0.8399

Dependent Variable: Zn

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	17.85571667	8.92785833	0.35	0.7205
Seasons	1	13.39853333	13.39853333	0.52	0.4980
Site*seasons	2	50.68161667	25.34080833	0.98	0.4273

Dependent Variable: Mn

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	7309.14000	3654.57000	1.41	0.3138
Seasons	1	21947.85333	21947.85333	8.50	0.0268
Site*seasons	2	7898.40667	3949.20333	1.53	0.2907

Dependent Variable: CP

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.49386667	0.24693333	0.17	0.8513

Seasons	1	8.13453333	8.13453333	5.45	0.0583
Site*seasons	2	0.19446667	0.09723333	0.07	0.9376

Dyamdyam soil Anova tables

Dependent Variable: N

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.00130000	0.00065000	6.50	0.0812

Dependent Variable: P

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	37.33333333	18.66666667	9.33	0.0515

Dependent Variable: K

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	2400.333333	1200.166667	800.11	<.0001

Dependent Variable: Ca

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.26230000	0.13115000	0.68	0.5694

Dependent Variable: Mg

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.30403333	0.15201667	1.61	0.3350

Dependent Variable: Fe

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	4889.813333	2444.906667	978.62	<.0001

Dependent Variable: Cu

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.10570000	0.05285000	109.34	0.0016

Dependent Variable: Zn

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.04270000	0.02135000	14.23	0.0294

Dependent Variable: Mn

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	256.3404333	128.1702167	128.93	0.0012

Machib soil Anova tables

Dependent Variable: N

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.33083333	0.16541667	18.18	0.0210

Dependent Variable: P

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	65.33333333	69.5000000	46.33	0.0056

Dependent Variable: K

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	139.0000000	32.66666667	16.33	0.0244

Dependent Variable: Ca

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	1.54703333	0.77351667	6.13	0.0872

Dependent Variable: Mg

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.19363333	0.09681667	61.80	0.0036

Dependent Variable: Fe

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	175.4233333	87.71166667	37.35	0.0076

Dependent Variable: Cu

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.43843333	0.21921667	61.75	0.0037

Dependent Variable: Zn

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.10253333	0.05126667	69.91	0.0030

Dependent Variable: Mn

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	147.1754333	73.5877167	46.40	0.0055

Appendix 3: Biomass and density Anova tables

Dyamdyam biomass Anova table

Dependent Variable: Biomass

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	144726.9926	72363.4963	7.94	0.0206
Seasons	1	51109.0216	51109.0216	5.60	0.0557
Site*seasons	2	45918.7393	22959.3696	2.52	0.1607

Machibi biomass Anova table

Dependent Variable: Biomass

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	216225.1135	108112.5568	8.52	0.0177
Seasons	1	32423.6686	32423.6686	2.55	0.1611
Site*seasons	2	44395.0218	22197.5109	1.75	0.2522

Dyamdyam density Anova table

Dependent Variable: Density

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	2341.621667	1170.810833	154.21	<.0001
Seasons	1	342.400833	342.400833	45.10	0.0005
Site*seasons	2	29.051667	14.525833	1.91	0.2277

Machibi density Anova table

Dependent Variable: Density

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	1652.221667	826.110833	84.15	<.0001
Seasons	1	331.800833	331.800833	33.80	0.0011
Site*seasons	2	78.601667	39.300833	4.00	0.0786

Soil and forage mineral status and farmers' perceptions of livestock husbandry and rangeland management practices in two communal coastal areas of the Eastern Cape Province, South Africa

By

Matshawule Sinethemba

A dissertation submitted in partial fulfillment of the requirements for the degree

Of

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University of Fort Hare

P/Bag X1314

Alice

South Africa

Supervisor: Prof. S.T Beyene

Co-Supervisor: Prof. V. Muchenje

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