VEGETATION AND SOIL STATUS, AND HUMAN PERCEPTIONS ON THE CONDITION OF COMMUNAL RANGELANDS OF THE EASTERN CAPE, SOUTH AFRICA

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'Mota Samuel Lesoli January 2008

ABBREVIATIONS

ANOVA	Analysis of variance
CEC	cation exchange capacity
EC	electrical conductivity
GLM	Generalized linear model
SOC	soil organic carbon
LSD	least significant difference
PRA	participatory rural appraisal
SPSS	statistical package for social sciences
SAS	statistical analysis system

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DEDICATION

This thesis is dedicated to my wife **Makobeli Aciliah Lesoli**.

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ABSTRACT

Communal areas in South Africa consist of the former self-governing territories that are predominantly inhabited by black South Africans. In the Eastern Cape, out of the 2.6 million ha that is degraded the larger portion is found in communal rangelands. The main ecological factor limiting livestock production in the communal areas is rangeland degradation. The general hypothesis of this study was that the identical grazing strategies between Magwiji, Upper Mnxe and Mnyameni would lead to variation on vegetation and soil properties due to different rainfall and landforms and identical rangeland ownership in the communal areas leads to common human opinion on rangeland resource condition and management due to different in vegetation types. This study evaluated the vegetation condition and soil variation; and human perceptions on communal rangeland resource condition and management. A 100 m line transect was laid, 1m^2 quadrat was systematically located five times along the transect for herbaceous vegetation and soil sampling, and a 400m^2 belt transect was used to measure woody vegetation. The PRA and questionnaire surveys were conducted at 11 communities to investigate human perceptions on rangeland resource condition and management. ANOVA with GLM procedure of SAS was used to assess the variation of vegetation condition and soil properties between vegetation types and landscapes. Descriptive statistics using SPSS software was used to describe categorical variables. Species composition, biomass, and soil cover were significantly different ($p < 0.05$) between vegetation types and landscapes. The sand, clay, and silt content, fast wetting, and mechanical disaggregation, CEC varied ($p < 0.05$) between the vegetation types. Fast wetting, slow wetting, and mechanical disaggregation varied ($p < 0.05$) between the landscapes. Farmers appreciate that there are resources such as medicinal plants, grass

for grazing, thatching and crafting, firewood, fencing poles, water for animal drinking and wild foods. Farmers (49%) believe that the rangeland condition is good. Identical communal grazing strategies at Magwiji lead to greater variation on vegetation parameters than in Upper Mnxe and Mnyameni because of low rainfall and spatially heterogeneous landforms in Magwiji than Upper Mnxe and Mnyameni. Different soil chemical properties, soil organic carbon, and soil microbial activity are not affected by identical communal grazing strategies, however, soil physical properties are affected because of soil erosion and leaching potential due to slopes. The identical communal rangeland ownership leads to similar human opinion on communal rangeland resources condition and management.

1. INTRODUCTION

1.1. Problem statement

[1]In South Africa, communal areas (formerly called "homelands") were established under the Natives Land Acts of 1913 and 1936; indigenous African people were involuntarily resettled and confined to these areas (Wessels *et al.* 2007). Communal rangelands are the main source of livestock feed for poor resource communal farmers. Grazing is considered the economic way of utilizing rangeland vegetation. These communal homelands are characterized by high human and livestock populations, overgrazing, soil erosion, and the loss of more palatable grazing species (Hoffman and Todd 2000). Overgrazing reduces plant biomass, which provide nutrients to animals and soil cover, (Oztas *et al.* 2003). Communal rangelands in the Eastern Cape have low biomass and biodiversity (Fabricius 1997 and Palmer *et al.* 1998). Poor grass productivity reduces animal production and management options (Zacharias 1994).

Palmer *et al.* (1997) reported that in the Eastern Cape, out of the 2.6 million ha that are degraded the larger portion is found in communal areas. Rangeland degradation is a problem because it reduces rangeland primary productivity and soil protection. Trollope and Coetzee (1975) indicated that the main ecological factor limiting livestock production in the communal areas is rangeland degradation. Soil erosion removes tons of productive soil and large amounts of plant nutrients. Overgrazing result in replacement of preferred species by less preferred species, which gain a competitive ability and become

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[1] Written according to the style of African Journal of Range and Forage Science

dominant (Keya 1997).

The communal rangelands are utilized and managed under a communal land tenure system. In this land ownership system, rangeland resources are accessed and managed by the community (Hahn *et al.* 2005). This necessitates the engagement of rangeland users on the identification of problems and development of solutions. Lack of engagement of resource users is a problem because it leads to underestimation of the benefits of communal area production and strength of production strategies and measures required to change them if necessary. The problem of lack of involvement leads to poor adoption and implementation of scientific recommendations by communal famers.

There is a need for integration of modern scientific knowledge and indigenous knowledge on resource management for sustainable livestock productivity, and soil conservation (Kavana *et al.* 2005). Information on communal rangeland vegetation and soil condition, and human perceptions on rangeland condition will provide a scientific basis for utilization, management, conservation and intervention to specific communal farming areas. The aim of this study was to assess vegetation condition and soil properties; and investigate human perceptions on communal rangelands of Eastern Cape.

1.2. General objective

To compare the ecological status and human perceptions on communal rangeland condition between the vegetation types in the Eastern Cape.

1.2.1. Specific objectives

1. To assess variation on distribution of vegetation species composition, basal cover, aerial cover, bush density, basal area and canopy area along the landscape gradient and between vegetation types on communal rangelands.

2. To examine soil pH, electrical conductivity, cation exchange capacity, available Phosphorus, soil organic Carbon, particle size analysis, soil moisture, fast wetting, slow wetting and mechanical disaggregation along the landscape gradient and between vegetation types on communal rangeland.

3. To investigate and compare human perceptions on communal rangeland resources, condition and management between the vegetation types.

1.3. Hypotheses

1. Vegetation species composition, basal cover, aerial cover, biomass production, bush density, basal area and canopy area vary between vegetation types and between landforms in communal rangelands of the Eastern Cape.

(a) Identical communal grazing strategies at Magwiji are expected to lead to greater variation on species composition than in Upper Mnxe and Mnyameni because of low rainfall and spatial heterogeneous landforms in Magwiji than Upper Mnxe and Mnyameni.

(b) Identical communal grazing strategies at Magwiji are expected to lead to lower soil cover than in Upper Mnxe and Mnyameni because slopes in Magwiji are greater than in Upper Mnxe and Mnyameni and, soil erosion is positively correlated with slope.

(c) Identical communal grazing strategies at Magwiji are expected to lead to lower forage yield than in Upper Mnxe and Mnyameni because rainfall in Magwiji is more erratic than Upper Mnxe and Mnyameni.

2. Soil pH, electrical conductivity, cation exchange capacity, available Phosphorus, soil organic Carbon, particle size distribution, soil moisture, microbial activity, fast wetting, slow wetting and mechanical disaggregation differ between vegetation types and between landscapes in communal rangelands of Eastern Cape.

(a) Identical communal grazing strategies in Magwiji are expected to lead to different soil chemical characteristics compared to Upper Mnxe and Mnyameni because low rainfall and varied topography at Magwiji than Upper Mnxe and Mnyameni.

(b) Identical communal grazing strategies at Magwiji are expected to lead to different physical soil property distribution compared to Upper Mnxe and Mnyameni because of alluviation and leaching accelerated by slopes than at Upper Mnxe and Mnyameni.

(c) Identical communal grazing strategies at Magwiji are expected to lead to lower soil organic carbon and microbial activity than at Upper Mnxe and Mnyameni because of lower biomass production.

3. Communal farmers in the Eastern Cape vary in opinion about rangeland resources condition and management across vegetation types.

(a) Identical communal rangeland ownership is expected to lead to variation in human opinion on rangeland resource availability, access and utilisation between the vegetation types because of the climate variation.

(b) Identical communal rangeland ownership is expected to lead to variation in human opinion on rangeland condition between the vegetation types because of the climate variation.

(c) Identical communal rangeland ownership is expected to lead to variation in human opinion on rangeland management between the vegetation types because of the climate variation.

2. LITERATURE REVIEW

2.1. Vegetation status

2.1.1. Botanical composition

Plant species differ in the tolerance of and requirements from the environment so that distribution varies along environmental gradient (Swaine 1996). Botanical composition is one of the means of studying ecological changes in the development of a rangeland (Malan and Van Niekerk 2005). This is a reflection of many factors, including past management (Whalley and Hardy 2000). Any change in grazing practice will cause a change in species composition (Abel 1997; Hayes and Holl 2003). Grazing pressure causes changes in vegetation structure, composition and productivity (Moleele and Perkins 1998; Oztas *et al.* 2003; Maki *et al.* 2007). Meanwhile, Sisay and Baars (2002) indicated that a long-term increase or relaxation of grazing pressure changes a plant community. Under heavy grazing pressure, decreaser species disappear and are replaced by increaser or invader species (Sisay and Baars 2002). Coronato and Bertiller (1986), and Svejcar *et al.* (1999) Laughlin and Abella (2007), however, indicated that the composition change is determined more by rainfall than by grazing pressure. Structural characteristics of the community such as greater cover can affect efficiencies of water use and offset or complement physiological response to defoliation (Milchunas *et al.* 1989). Species composition is an indicator of rangeland condition because species vary significantly in their acceptability and response to grazing herbivores (Abule *et al.* 2007 I).

The impacts of herbivores are intensified directly around rangeland resources such as grass and bush. Uncontrolled grazing may result in rangeland degradation (Smet and Ward 2005). Abel (1997), Illius and O'Connor (1999), Hayes and Holl (2003), and Smet and Ward (2005) highlighted that herbivores have effect on vegetation dynamics. The vegetation changes from being dominated by perennial grasses to being dominated by annual grasses. The individual plant species, which make up the grassland communities, vary in their adaptive mechanisms and tolerance to grazing. The composition of the plant communities will shift over time in response to different grazing intensities (Tainton 1999).

Certain species characterize different succession stages during grassland retrogression and they can be used as indicators of rangeland condition (Malan and Van Niekerk 2005). High intensity grazing leads to excessive removal of the most palatable species, which are usually perennial grasses (Todd and Hoffman 1999; Anderson and Hoffman 2006). This opens the way for less palatable and faster establishing annual grasses and forbs to take hold (Nsinamwa *et al*. 2005). Constant diminishing of the highly desirable species (Malan and Van Niekerk 2005) can result in rangeland deterioration. On the other hand, heavy grazing depletes foliage of the palatable species, which results in reduced plant vigor (Morris and Kotze 2006). Single species grazing systems can have dramatic negative effects on vegetation composition due to selective grazing (Smet and Ward 2005). This, and invasion by unpalatable plant species, are other indicators of range overuse.

Grazing stimulates aboveground production, increases tillering and rhizome production, and root respiration and exudation rates. Livestock defecation and urination also significantly affect nutrient cycling and relocation in grazing systems (Schuman *et al.* 2002). Vegetation functional composition, cover and height vary in different vegetation types (O'Farrell *et al.* 2007). Species composition can be strongly filtered by abiotic factors such as total nitrogen in the soil (Laughlin and Abella 2007).

The nutrient value of range forage is dependent among other factors on botanical composition. Annual grasses and forbs are seldom considered as favourably as their perennial counterparts (Arzani *et al.* 2006). Botanical and chemical composition and season of growth affect the digestibility of grasses, and the nature and quantities of products of digestion (Dohme *et al.* 2006). The composition of the dry matter of the rangeland is very variable depending on the physiological stage of the grass, species dominating and soil nutritional status (McDonald *et al.* 1987).

Rangeland forage quality has spatial and temporal variation (Arzani *et al.* 2006; Laughlin and Abella 2007). Rangelands that are properly managed normally have more of acceptable species and higher biomass production (Sisay and Baars 2002). These rangelands usually supply livestock with high food quality during spring and early summer (Laughlin and Abella 2007).

2.1.2. Biomass production

Forage yield or biomass refers to above ground herbaceous material commonly and it is expressed as dry matter weight (Abule *et al.* 2007 I). Biomass production is used to determine the amount of available forage for animals, to measure the effects of management on vegetation and to assess the rangeland condition (Abule *et al.* 2007 I).

Forage yield in the rangeland may be described in terms of quality and biomass production of the dominant grass species (Peden 2005). Quality is influenced by factors such as type and amount of nutrients, fibre content, unpalatable chemical substances and percentage moisture and varies with species. Palatable species occur naturally in rangeland that is well managed, and decrease with poor management such as overgrazing (Morris and Kotze 2006). The biomass production of natural grassland systems varies considerably according to the available moisture (Noellemeyer *et al.* 2006). Biomass production is lower in the sand dominated rangelands than in silt and clay dominated rangeland soil and is related to soil organic matter (O'Farrell *et al.* 2007).

Acceptable grasses lose their vigour because of repeated removal of leaves and the constant draining on their nutrient reserves (Malan and Van Niekerk 2005). When the plant is unable to replenish the stored resources, it will fail to produce new leaves and will eventually reduced photosynthetic power (Morris and Kotze 2006). As the desirable plants become weaker and die off, the number of roots in the upper layer of the soil decrease, and this reduces the competitive ability of grasses (Sisay and Baars 2002). Defoliation removes plant biomass, which changes the light regime in a plant stand (Tomlinson and O'Connor 2005).

The bare areas between grasses also become larger as the grasses species are exhausted. This causes a decline in the effective use of rainfall in the area and the conditions become ideal for woody plants to establish (Stuart-Hill and Tainton 1989). According to Tainton (1996), environmental conditions play a role in changes in grass species composition. Many grasses are adapted to a wide range of temperatures but grow more luxuriantly within the optimal range, for example *Paspalum notatum* grows well at temperature range of 25°C to 30°C. Perennial grasses produce more foliage than annual grasses and thus provide more of forage yield (Peden 2005).

2.1.3. Soil protection

Many arid and semi-arid rangelands are characterized by patchy vegetation patterns (Schuman *et al.* 2002). In some areas, the patches are most apparent at the space between the plants, while in other areas the bare space is visible between the clusters of plants. Rapid degradation of the original plant communities and reduction in productive and soil protective species indicate the first phase of grassland retrogression (Morris and Kotze 2006).

Perennial grasses have extensive root systems and protect the soil from erosion more effectively than annual species. Annual species replaces perennial species as the grazing intensity rises (Maki *et al.* 2007). The dominance of perennial grass species locally indicates that the veld has a good protection against soil erosion (Morris and Kotze 2006). When annual grasses die, the ground remains bare for a long time and becomes susceptible to erosion (Malan and Van Niekerk 2005). The excessive removal of perennial grass species reduces ground cover (Eccard *et al.* 2000; Nsinamwa *et al.* 2005). Annual grasses can germinate in the bare patches during limited periods when water is available. Their seeds can survive in the soil during long periods of drought (Malan and Van Niekerk 2005).

The stage of rangeland retrogression in the grassland is characterized by increased rates of run-off (Svejcar *et al.* 1999). Water inputs may either be intercepted by plants, infiltrate in soil or run off the surface depending on, among other factors, soil characteristics, topography and vegetation cover (Morris and Kotze 2006). The most important single factor affecting water run-off is the amount and type of vegetative cover (Malan and Van Niekerk 2005).

Herbaceous plants provide more protection than non-herbaceous (Tainton 1999). Grasses provide a complex network of roots immediately below the ground surface. Stands of perennial species are more stable than stands of annual species and provide stable soil cover. The influence of basal cover and bare ground on grass yield was reported to be higher on forage biomass production, higher proportion of basal cover leads to the higher forage yield (Fahnestock and Detling 2000). Baars *et al.* (1997) indicated that under normal management the basal cover of excellent vegetation is expected to be greater than 12%. The basal cover increases as the condition of the rangeland declines, due to the replacement of tall, erect species with low growing, spreading species (Sisay and Baars 2002). Bare ground is a good indication of over utilization and degree of degradation of the vegetation (Abule *et al.* 2007 I).

Varnamkhasti *et al.* (1995) indicated that long term grazing can select for genotypes that are more tolerant to current year defoliations and basal cover of plants can increase with grazing. Potential for compensatory regrowth of plants after defoliation are often centred on resource conservation or utilization efficiency mechanisms. Rain use efficiency of plant communities may be at least as much a function of grazing management influence on vegetation condition and aridity (Varnamkhasti *et al*. 1995). At low rainfall, relatively more water is lost through evaporation, leaving less water available to plants, so the rain use efficiency is reduced, however, at high rainfall levels rain use efficiency decreases because ecosystem productivity becomes limited by nutrients rather than water (Hein 2006). In arid areas, herbaceous plant production is linearly related to rainfall, amounts, sequences, and season of rainfall as well as drought affect plant production by influencing soil moisture and, therefore, water efficiency (Oba *et al.* 2000).

2.2. Rangeland soil quality

2.2.1. Soil aggregate stability

Soil forms the basis for all vegetation growth and plays a key role in the hydrological, carbon and nutrient cycles of ecosystems (Li *et al.* 2007). Soil organic matter has been adapted as an indicator of soil fertility based on the rationale that it contributes significantly to soil physical, chemical, and biological properties that affect vital ecosystem processes of rangelands (Hopmans *et al.* 2005).

Soil aggregate stability is widely recognized as a key indicator of soil and rangeland health (Herrick *et al.* 2001). It is related to a number of ecosystem properties, processes, and functions, included are the quantity and composition of organic matter, soil biotic activity, infiltration capacity, and resistance to erosion. Soil aggregation has potential benefits on soil moisture status, nutrient dynamics, tilth maintenance, and erosion reduction (Sainju 2006).

Soil aggregate stability is a good indicator of organic matter content (Li *et al.* 2007), biological activity, and nutrient cycling in the soil (Amezketa 1999). The amount of organic matter increases after the decomposition of litter and dead roots. Stable aggregates result from this process because soil biota produces material that binds particles together (Shrestha *et al.* 2007). Changes in aggregate stability may serve as early indicators of recovery or degradation of ecosystems (Amezketa 1999).

The stability of aggregates is affected by soil texture, the predominant type of clay, extractable iron, and extractable cations (Li *et al.* 2007), the amount and types of organic matter present, and type and size of the microbial population (Caravaca *et al.* 2002). Calcium ions associated with clay generally promote aggregation, whereas sodium promotes dispersion. Soils that have a high content of organic matter have greater aggregate stability, primarily after decomposition begins and microorganisms have produced chemical breakdown products (Shrestha *et al.* 2007). Any practice that leads to a decrease in soil organic matter tends to decrease the water stability of aggregates (Lu *et al.* 1998).

Disturbance of the soil surface by grazing animals has both beneficial and detrimental effects on aggregate stability. It incorporates litter and standing dead vegetation into the soil, increasing the content of organic matter. It also breaks the soil apart, exposing the organic matter glues to degradation and loss by erosion (Caravaca *et al.* 2002). Heavy grazing that significantly reduces plant production disrupts the formation of aggregates by reducing the inputs of organic matter. Grazing is more likely to increase aggregate stability in areas where an unusually large amount of standing dead material is on the soil surface and the risk of erosion is not increased by removal of plant material and disturbance of the soil surface (Shrestha *et al*. 2007).

2.2.2. Soil pH and Electrical conductivity

Soil quality is defined as the capacity of a soil to function, within ecosystem and land use boundaries, to sustain biological productivity, maintain environmental quality, and promote plant and animal health (Corwin *et al*. 2003). Salinity and especially alkalinity can cause major impacts on plant production. Extreme values of soil pH, which affect the solubility of most of the elements necessary for plant growth, is an insidious problem in some regions. Soil pH affects the solubility of nutrients and uptake by plants (Rezaei and Gilkes 2005). Soil pH often affects plant community composition because plants differ in nutrient requirements and soil acidity or basicity tolerance. Soil pH is influenced by elevation because soil parent materials of higher pH occur at the lower elevation (Laughlin and Abella 2007).

Electrical conductivity (EC) is influenced by salinity, water content, bulk density and texture, which are all important properties related to the quality of soils (Corwin *et al.* 2003). Salinity, especially alkalinity, causes major impacts on plant production including yield production of rangelands (Rezaei and Gilkes 2005). Soil electrical conductivity is influenced among other factors by salinity, water content, clay content, and organic matter. The predominant mechanism causing the accumulation of salt is loss of water through evapotranspiration, leaving ever-increasing concentrations of salts in the remaining water (Corwin and Lesch 2005).

Salinity is a dynamic soil property; it varies temporally and spatially with depth and across the landscape. Salinity varies primarily due to the process of leaching with topographic effects contributing to this variation (Corwin *et al.* 2003). Surface topography plays a significant role in influencing spatial EC variation. The difference in CEC of the soils is influenced by organic carbon and clay content. The CEC values indicate the capacity of soil to retain nutrient cations against leaching (Ludwig *et al.* 2001).

2.2.3. Soil organic carbon

There is a positive relationship between soil organic carbon and the capacity of the soil to supply essential plant nutrients including nitrogen, phosphorus, and potassium (Rezaei and Gilkes 2005). Soil nitrogen (N) content follows soil carbon content in grassland soils (Conant and Paustial 1998). The relationship between organic carbon and landscape attributes, as well as positive relationship between organic carbon and nutrient elements, indicates the usefulness of organic carbon as a reliable and sensitive indicator for rangeland health (Rezaei and Gilkes 2005).

The soil under rangeland management contains the high level of organic carbon and almost all organic constituents (Lu *et al* 1998). Li *et al.* (2007) indicated that soil organic carbon plays an important role in improving soil physical, chemical, and biological properties for sustained plant growth. The soil carbon balance is maintained by plant litter inputs, which enter the soil as particulate organic carbon. Rangeland sustainability is related to soil carbon and nutrient balance and the capability to maintain adequate soil conditions for water availability and root development (Noellemeyer *et al.*

2006).

The soil under shade such as tree coverage community accumulates more soil organic carbon due to the influence of tree canopy on the soil temperature regime. The different carbon dynamics are the result of a high proportion of woody debris under shade and different removal rates of aboveground biomass by grazing in the open communities (Simion *et al.* 2003).

Changes in soil carbon can occur in response to a wide range of management and environmental factors (Schuman *et al.* 2002). Grazing management provides enough time between occupation periods and in turn stimulates growth of herbaceous species and improves nutrient cycling in grassland ecosystems (Schuman *et al.* 2002). Disturbance of rangelands has a negative impact on soil structural properties and water holding capacity, which are related to losses of soil organic carbon pools (Li *et al.* 2007). Deterioration in soil structural properties decreases soil infiltration and water retention and accelerates soil erosion.

2.2.4. Soil particle density

Soil texture is a fundamental property which determines largely the water balance and the potential biomass carbon production and in turn carbon input and stabilization. Soil moisture availability is determined by soil texture, which can influence the composition of the plant community (Laughlin and Abella 2007). Soil texture also has a strong effect on biomass production and soil organic carbon in rangeland soils (Scholes and Archer 1997). There is a positive relation between texture and soil organic carbon. This could be attributed to the stabilization of organic compounds by clay particles and the influence of texture on the water availability for biological activities (Noellemeyer *et al*. 2006).

Standing biomass is lower in soils dominated with sand and not significantly different in silt and clay dominated soils (Laughlin and Abella 2007). Plant cover change and off-site removal of biomass could decrease organic matter is soil, deteriorate important soil physical parameters and consequently increase soil erosion (Li *et al*. 2007). The soils that are dominated by sand class are highly limited in nutrient and water retention. Soil productivity is reduced also by the large proportion of gravel and stones in the soil due to the limited root growth (Salako *et al*. 2006).

2.3. Interaction of topography, moisture, and grazing on rangeland dynamics

Rangelands consist of a mixture of uplands and lowlands, the lowlands are generally 5 to 30m lower and are grazed approximately three times more intensely, than associated uplands due to easy access by the animals (Senft *et al.* 1985). Because the rangelands occur at heterogeneous topography any activity on rangelands require a spatial knowledge of soil physico-chemical properties (Corwin and Lesch 2005). Grazing reduces litter cover and increases bare ground and plant basal cover (Milchunas *et al.* 1989).

Long term grazing can have effects on soil water and nutrient cycling dynamics (McNaughton *et at.* 1988). Long term grazing intensity can alter litter, plant basal and canopy cover characteristics, which can also affect soil water dynamics by altering microclimate and soil temperature (Day and Detling 1994). Soil moisture, soil temperature, and soil organic matter are believed to be among the most important soil physiochemical properties influencing population dynamics, activity, and ecology of the soil microbiota (Varnamkhasti *et al*. 1995).

2.4. Perceptions of communal farmers

2.4.1. Communal rangeland resources

Hardin (1968) on his classic work on "the tragedy of commons" describes the degradation of scarce resources that are open to all appropriators in society. A "commons" is any resource used as though it belongs to all. In other words, when anyone can use a shared resource simply because one wants or needs to use it, then one is using a commons. Since all appropriators have equal access to the commons, they can enjoy the value of the average product from the commons. As long as this average value is greater than the marginal value, new appropriators aiming at the difference come into the commons with the result that resources are dissipated.

The communal rangelands are predominant in Africa and managed by pastoralists. The policy implications of the new ecological theories have been raised but only tentatively explored (Ellis and Swift 1988). The basic biological research which should inform policy making often is not readily accessible to the other stakeholders interested in applied rangeland management, (Behnke and Scoones 1993) this include administrators, extension officers and famers.

To provide sustainable solution to communal rangelands degradation, there is a need for balancing modern scientific knowledge and traditional natural resource management (Kavana *et al.* 2005). There is indigenous knowledge concerning the beneficial and harmful plant resources in communal rangelands. Communal farmers know poisonous plants affect their livestock production (O'Farrell *et al.* 2007). Pastoralists can classify the grass species as highly desirable, intermediate and least desirable based on their acceptability to livestock (Gemedo-Dalle *et al.* 2006).

Farmers in communal areas use different species of grasses for livestock feeding and thatching of houses (Abule *et al.* 2005). Some people in these areas believe that because of the high number of livestock there is not enough grass to be harvested for thatching. Communal farmers use plants for a wide range of purposes, the primary being grazing, and as a source of medicine and cosmetics, vegetation composition and productivity are believed to have implications on number of animals to graze, in turn affect animal production (Homewood 2004).

The plants used as a source of medication include the roots of *Euphorbia* species for treating wounds and the fruit of *Acacia nilotica* for treating wounds during circumcision of boys (Abule *et al.* 2005). Most farmers still prefer a communal land ownership. In semi-arid rangelands, goods and services required for livestock production are linked to the ecological functions that sustain production including the provision of water, nutritious grazing, shade, and shelter and seasonal regeneration of vegetation (O'Farrell *et al.* 2007). Feed resources available in communal areas are natural pasture, woody plants, crop residues, and weeds (Reed and Dougill 2002). Farmers admit that there is a critical feed shortage during the dry season (Solomon *et al.* 2006).

The first measure taken to solve feed shortage problem is migration (Ward *et al.*

2000). Animals' sale is not considered as the first and best measure to mitigate feed shortages. Mainly the households close to the towns practice feed purchases as a solution to shortage. The pastoralists far out in the rangelands do not buy feeds (Abule *et al.* 2005). Farmers perceive that natural vegetation provides a diverse and varied diet for livestock, supplying them with different ranges of nutrients and chemicals (O'Farrell *et al.* 2007).

Few farmers provide supplements to their animals during the dry season. The supplements from the most frequent to the least frequent are crop residues, browse, harvested grasses, and by-products of wheat meal (Solomon *et al.* 2007). The main animal categories given the supplements are calves, small ruminants, milking cows and oxen. The reasons for offering the supplements are milk production, alleviation of weakness in calves, strengthening of oxen and sick animals (Abule *et al.* 2005).

2.4.2. Communal rangeland condition

The interpretation of rangeland condition assessment requires a multiplicity of perspectives and cannot be judged in isolation from those who faces its consequences (Abule *et al.* 2007 I).

Most of the farmers still believe that communal management of rangelands is good. The possibility of increasing the size of land to be grazed by animals of an individual household and the decrease in land size if owned individually, are the main reasons for wanting to continue with communal land ownership (Abule *et al.* 2005). Some farmers prefer individual ownership of land for two reasons; to block the usage of the rangeland by immigrants and to control the use of grazing land by members of the community (Ward *et al.* 2000).

The communal farmers have knowledge of their rangeland ecosystem and, therefore, acquisition of information with regard to studying rangeland condition should consider them (Abule *et al.* 2007 I). Farmers acknowledge that compared to the past, there is a decrease in the abundance of grasses and legumes (Lemaire *et al.* 2005). They believe that it is because of decline in the amount of rainfall and drought (Retzer 2006). Other reasons include population pressure, increase in livestock numbers, expansion of farming and bush encroachment (Gemedo-Dalle *et al.* 2006; Solomon *et al.* 2007).

The rangeland users believe that compared to the past, most of their grazing areas are covered with bush and shrubs, and that this causes a decline in rangeland condition (Ward *et al.* 2000; Reed and Dougill 2002). Most of the communal areas have bush encroachment problem and farmers are aware of the problem. Farmers believe that grazing animals, birds and floodwater serve as a dispersal mechanism of those woody species associated with bush encroachment (Solomon *et al.* 2006).

Farmers also believe that a decrease in grass production is the first problem associated with bush encroachment (Ward *et al.* 2000). The second problem is difficulty in herding animals (Abule *et al.* 2005). Farmers consider bush encroachment to have an immense contribution in decreasing the size and productivity of their rangelands (Reed and Dougill 2002).

They also ascribe to the shortage of land and to the traditional communal type of ownership (Reed and Dougill 2002; Abule *et al.* 2005). Some communal farmers have positive perception on bush encroachment and they believe that it is not a constraint because the bushes provide forage for their goats (Reed and Dougill 2002). The rationale behind this choice is that different resources pose different problems and possibilities of exploitation.

Some of the communal farmers believe that the condition of their rangeland is poor (Ward *et al.* 2000), while others rate the rangelands to be in moderate condition (Abule *et al.* 2005). The most important determinants are overgrazing followed by drought (Solomon *et al.* 2006). The other major problems are increases in human population and immigrants from other areas. Farmers also identify bush encroachment as their major problem (Reed and Dougill 2002). Some of the farmers do not suggest any solution to improve the condition of the rangelands, but some suggest a wide range of possible solutions such as rotational grazing, veld resting, stock reduction, sharing of the grazing land stopping migration (Abule *et al.* 2005).

2.4.3. Communal rangeland management

Communal rangelands are owned and managed by the community where by every member has access to resources without restriction to time and quantities. It is not easy to adopt the commercial rangeland management practices in a communal set up because of the variation in the nature of land tenure (Behnke and Scoones, 1993). The communal rangelands are faced with the problem of land shortage, land tenure and rapidly expanding population (Shackleton, 1993). The rangelands in these areas are communally owned but free hold tenure system does occur, however it is an exception rather than the rule. There is a need for a synthetic approach that combines traditional and modern techniques (Wasonga *et al.* 2003).

There is a considerable uncertainty about the best practice for the management of livestock and rangelands in the arid and semi-arid areas (O'Farrell *et al.* 2007). A fundamental understanding of the perceptions and traditional livestock-rangeland management practices in communal rangeland is lacking (Solomon *et al.* 2007). The objectives of communal farmers differ markedly from those of commercial farmers, and higher stocking rates make economic sense (Peden 2005). Communal rangelands support multiple livelihood strategies. The animals are kept for milk, traction, bride-wealth, manure, ceremonial slaughter, and transport (Peden 2005). Meanwhile, communal rangelands provide thatch, firewood, medicinal plants, and wild foods.

Most of the feed that the communal livestock depend on is derived from native grassland and comprises indigenous grasses as well as browse from woody plants (Solomon *et al.* 2007). The communities employ various resource management practices. During average rainfall years, the households often engage in practices such as rotating herds between high-quality rangeland sites in order to increase productivity of their herds (Solomon *et al.* 2007).

Movement of livestock is an important management strategy for drought survival in African pastoral systems (Peden 2005). In drought situations, the pastoralists become more mobile, and often move outside the core of their territory. Such mobility minimizes livestock pressure on natural resources, as it tends to distribute the animals over a wide area, thereby reducing the concentration of animals in one particular area. It also enables the exploitation of heterogeneous environments in space and time (Solomon *et al.* 2007).

Communal grazing systems, weakened traditional local institutions controlling land tenure and land use are blamed for high stocking numbers, concomitant overgrazing, and environmental destruction (Rohde *et al.* 2006). In the case of Lesotho and some areas in South Africa, traditionally natural resource management is the responsibility of the chiefs (Rohde *et al.* 2006). The chiefs execute all aspects of natural resource management including the allocation of grazing areas, granting of grazing permits, protection of certain areas from grazing, and the prosecution of violators of regulations (Rohde *et al.* 2006). There are no measures taken by farmers to control bush encroachment, except discussing the problem among themselves (Abule *et al.* 2005). In the communal system, the rangelands are considered as common property, and land is owned communally where decisions regarding usage and management of resources are made concerns everyone (Abel 1997).

Grazing areas in some communal rangelands are not sub-divided into grazing units for efficient utilization of the rangeland (Ward *et al.* 2000). This does not allow for recovery of vegetation after grazing because the control of animals is not easy (Ward *et al.* 2000; Arnalds and Backarson 2003). The main reasons for this are the shortage of land for proper allocation, tradition, lack of common agreement, lack of knowledge, increased livestock numbers and the expansion of crop farming (Reed and Dougill 2002; Solomon *et al.* 2007).

Other communities such as Magwiji sub-divided their grazing land into mountainous, lowlands and swampy areas (Arnalds and Backarson 2003). The landscape variations are used as grazing units. Mountainous are used during summer when there is a lot of grass on top of the mountains. The lowland areas are used during winter because they are next to croplands that are used for grazing after harvest. Swampy areas are usually located along riverbanks and are used during the dry season (Abule *et al.* 2005).

3. VEGETATION STATUS

3.1 Introduction

Grazing is the dominant use of rangeland resources in the in the communal areas of Eastern Cape, this is because climatic, topographic, and geological factors limit crop production (de Wet and van Averbeke 1995). According to Palmer *et al.* (1997), the larger portion of the Eastern Cape is found in communal areas. The biodiversity is reduced and the biomass production is lowest on communal areas compared to commercial farming areas (Fabricius 1997). The main ecological factor limiting livestock production in the communal areas of Eastern Cape is rangeland degradation Trollope and Coetzee (1975).

Eastern Cape environment is characterized by large-scale spatial variability, (Scogings and Goqwana 1996). Spatial patterns of landscape are fundamental to understanding the rangeland vegetation dynamics (Derner and Wu 2001). The rangeland vegetation structure and function varies with the landscape (Thurow *et al.* 1986; Jones *et al.* 1989). Vegetation characteristics can change over time under different land uses, management systems, and soil erosion (Oztas *et al.* (2003).

Land degradation is the main problem in communal rangelands. It is a problem because it threatens the economic and ecological potential of rangeland ecosystems to which farmers depend for livestock grazing. Oztas *et al.* (2003) indicated that grazing is generally considered the most economical way of utilizing rangeland vegetation. Vegetation condition in terms of species composition, soil cover, and standing biomass production is indicative of the potential primary productivity and soil protection of the rangeland (Oztas *et al.* 2003). Grazing effects are inherently variable, depending on the nature of environment and production systems and the spatial and temporal scale of measurement (Landsberg *et al.* 2003). Biological complexity and diversity, essential components for sustainable production of a rangeland ecosystem, require the maintenance of a wide range of vegetation and various habitats within a production system (Snyman 1998).

Sustainability in communal rangeland resource utilization, management, and conservation requires the responsibility of all the stakeholders. This can be attained if sufficient information about the rangeland vegetation variation and distribution between vegetation types and between local landscape characteristics is available. The objective of this study was to assess the variation of the herbaceous vegetation species composition, basal cover, aerial cover, biomass production, bush density, basal area, and canopy area between the vegetation types and between the landscape formations. The hypothesis is that, the species composition, basal cover, aerial cover, biomass, bush density, basal area, and canopy area do not vary in distribution between vegetation types and between landforms.

3.2 Methods

3.2.1. Study areas

Three communities were selected at different vegetation types using the veld types as described by Acocks (1988). Magwiji (*Themeda-Festuca* Alpine) is located at 30°37′S, 27°22′E, and 1507m asl. The average summer rainfall (November to April) is 500 mm while winter rainfall (May to October) is 200 mm. The mean temperature in

January is 22°C and 10°C in July. The landscape at Magwiji is distinctively heterogeneous with high summit mountainous, steep slopes (20%) and valleys. The types of livestock kept include sheep, goats, cattle, and smaller numbers of horses and donkeys used for animal traction. The animals spent most of the time at the stock posts; they are not kraaled except for inspection and dipping.

Upper Mnxe (Highland sourveld) is located at 31°33′S, 27°36′E and 1441m asl. The average summer rainfall (November to April) is 600 mm while in winter (May to October) the rainfall is 200 mm. The mean temperature in January is 22°C and July is 12°C. Upper Mnxe is generally flat with some hills, gentle to steep slopes (12%) and wide valleys. The livestock types kept include cattle, sheep, and goats. The animals are not kraaled except during animal inspection and supplementary feeding.

Mnyameni (Coastal forest and thornveld) located at 32°28′S, 28°13′E, and 504m asl. The average summer (November to April) rainfall is 700mm and winter rainfall (May to October) is 300mm. The mean temperature in January was 22°C and July was 14°C. The grassland constituent is rarely a pure, uniform grassland, but rather scrubby, full of tall herbs, shrubs and tall coarse grasses. At Mnyameni, the topography is generally flat (3%) with gently rolling valleys. The main livestock type kept in this community is cattle. The animals are not herded but they are kraaled at night.

Domestic livestock under a nomadic and semi-nomadic pattern of land use have grazed the three study areas. Although grazing practices vary depending on local geography, the basic pattern of seasonal use is similar in all the three ecological zones.

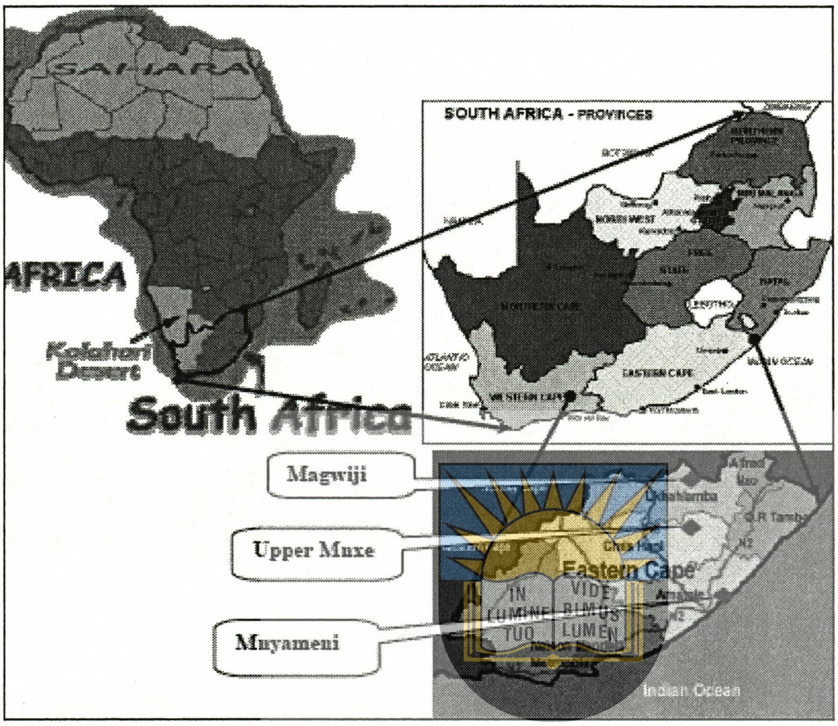

Figure 3.1: Map of Africa locating South Africa and Eastern Cape Map depicting location of the communities under study.

3.2.2. Sampling methods

The landscape, topographic gradients were used to assess rangeland vegetation dynamics at Magwiji and Upper Mnxe communities. Each site was divided into three experimental units, the valley, slope, and top based on the topography and altitude. In this study, the village proximity to the rangelands was regarded as the base for selection of the experimental units. The top unit is the area at the higher altitude relative to the homesteads, the slope was selected at the sides of the hills and mountains, and the valley unit was composed of the areas that are at the same level with or lower than the level of homesteads in altitude or topography. The geographic cardinal gradient were used at Mnyameni community, this area was divided into south, central, and north experimental units relative to the position of the homesteads. Each of the experimental units at each community was further sub-divided into four permanent treatment plots of 100m x 4m transect area established from a fixed centre point in each plot (recorded by global positioning system, GPS), resulting in a sum of 36 plots for three communities.

Systematically 1m^2 quadrats were located at 0, 20, 40, 60, and 80m along 100m line transect. In each quadrat, aerial cover was visual assessed in terms of percentage coverage of green vegetation, dead plants, litter material, rocks, and bare ground to the size of the quadrat. Herbaceous species were identified and clipped in categories: a dominant group, 3 sub-dominant groups, dicotyledons, legumes and other species within each quadrat based on visible occurrence. The samples of the similar species were mixed and composite samples were extracted for each transect and oven dried for 48 hours at 60^{o}C. The dry mass of the dominant category groups were calculated as dry matter weight per hectare (kgDM-ha^{-1}).

Species were further grouped into their ecological status determined by their perceived acceptability to animals and response to grazing: (i) highly desirable species: those, which occur in rangeland in good condition and decrease with over grazing (decreaser species) (Sisay and Baars 2002; van Oudtshoon 1992), (ii) undesirable species: those which occur in rangeland in good condition and increase with under utilization (increaser I species) and (iii) undesirable species: those which, occur in rangeland in poor condition and increase with overgrazing (increaser II species). In addition, species were grouped into annuals and perennial species based on their life cycle.

The basal cover was measured using step point technique along the line transect. Hundred points were taken at the interval of two meters. The presence of herbaceous plants was recorded as the strikes on the base of the plants, the absence of plants were recorded as bare and rock hits; the relative abundance of plants out of the total hits was used as percentage basal cover. Grass species were identified according to van Oudtshoon (1992). Woody vegetation was measured within the same plots along the 400 m^2 belt transects. All the rooted life woody plants were counted and used for an estimate of woody vegetation density per hectare. Furthermore, the spatial canopy areas of all rooted life woody plants encountered in the belt transects were recorded by; species names (van Wyk and van Wyk 1997), canopy diameter, and height, number of stems and diameter of major stems. For height and diameter of woody plants, two calibrated aluminum rods of 2 m long were used perpendicular to 100m tape measure on both sides. The data were collected in four seasons; early growing season (December), mid-growing season (February), late growing season (April) and dry season (June).

3.2.3. Data analysis

Descriptive statistics were used to describe the species composition for herbaceous and woody vegetation using SPSS (1999). The analysis of variance (ANOVA) with GLM procedure of SAS system (SAS Institute, 1999) was used to compute the variation of vegetation variables between the vegetation types and between the experimental units. The means of each vegetation variable for each classifying factor were classified using the Duncan multiple range procedure. The Pearson correlation coefficients were estimated for all possible paired combinations of the response variables to generate a correlation coefficient matrix. Statistical tests were considered significant at $p < 0.05$.

3.3. Results

3.3.1 Species composition

Decreaser species dominate in good rangeland but decrease when the rangeland is mismanaged. Increaser I species dominate in poor rangeland and increase with under stocking of selective grazing. Increaser II species dominate in poor rangeland and increase with overstocking. The decreaser, increaser I, increaser II, annual species and forbs percentages were significantly different ($p < 0.01$) between the communities (Table 3.1).

Upper Mnxe had the highest proportion of decreaser species such as *Themeda triandra*, *Heteropogon contotus* (Table 3.2), followed by Magwiji and Mnyameni was the lowest with (Table 3.1). The percentages of the decreaser, increaser I and increaser II species were significantly different ($p < 0.05$) between the sites at Upper Mnxe and Magwiji. The percentage of the perennial and annual species were significantly different ($p < 0.01$) diffeent between the sites at Magwiji and Upper Mnxe (Figure 3.2).

Table 3.1: The percentage occurance of species within ecological status and life cycle categories (mean) between the the communities.

Location	Ecological Status				Life cycle	
	Decreaser	Increaser I	Increaser II	Forb	Perennial	Annuals
Magwiji	22.7^{b}	1.0^{b}	60.2^{a}	16.3^{b}	79.8^{a}	3.98^{a}
Mnyameni	11.4^{c}	7.2^{a}	60.1^{a}	21.4^{a}	80.6^{a}	-
Upper Mnxe	34.3^{a}	6.9^{a}	34.9^{b}	23.9^{a}	76.7^{a}	-

$^{a, b, c}$ means with different superscripts within the same colomn are significantly different ($p < 0.05$)

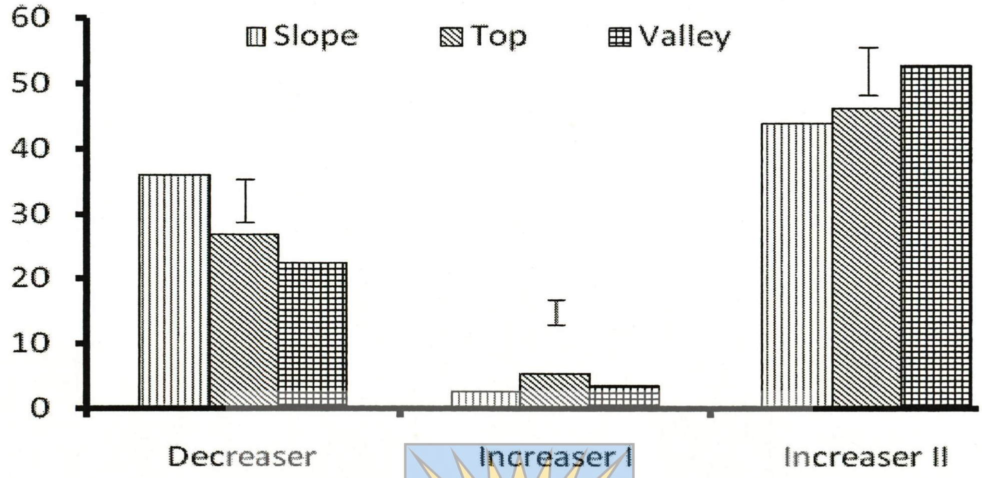

Figure 3.2: The species composition (means) between sites at Magwiji and Upper Mnxe (bars on each species group represent LSD at $p < 0.05$ and compares the mean within the group)

The decreaser and increaser II species were significantly different ($p < 0.05$) between the slope, top and valley (Figure 3.2). The perennial species were significantly different ($p < 0.05$) between the top (83%), slope (79%) and valley (77%). The percentages of increaser I species, perennial, annual and forbs were not significantly different ($p < 0.05$) between the sites at Mnyameni. The decreaser species were negatively related to the increaser II species ($r = -0.72$; $p < 0.0001$). The proportion of perennial herbaceous vegetation species was negatively related to the proportion of forbs ($r = -0.77$; $p < 0.0001$).

The dominant grass species as identified at each community are presented in their occurrence percentages on table 3.2. The total of 27 grass species was identified at the three communities within the study period. Other grass species, which were not identified within the four dominant groups, were classified as "other species" while the non-grass species were identified as dicotyledons and leguminous plants.

Table 3.2: Grass species composition (%) within the dominant groups at different communities.

Community	Magwiji		Mnyameni		Upper Mnxe	
	Species	**%**	**Species**	**%**	**Species**	**%**
Dominant	*Eragrostis chloromelas*	30	*Sporobolas africana*	38	*Themeda triandra*	38
	Elionuras muticus	25			*Heteropogon contortus*	38
Subdominant 1	*Heteropogon contortus*	33	*Paspalum dilatatum*	40	*Heropogon contortus*	23
Subdominant 2	*Eragrostis capensis*	23	*Eragrostis plana*	23	*Themeda triandra*	14
					Sporobolas africana	14
Subdominant 3	*Eragrostis capensis*	23	*Paspalum dilatatum*	10	*Microchloa caffra*	25
			Eragrostis plana	10		

3.3.2. Basal cover

The basal cover was significantly different ($p < 0.01$) between Magwiji, Mnyameni, and Upper Mnxe (Table 3.6). The basal cover between the valley (75%), top (73%), and slope (64%). Plant density was significantly different ($p < 0.01$) between the sites at Magwiji and Upper Mnxe (Table 3.3).

The basal cover of the herbaceous vegetation at Mnyameni was significantly different ($p < 0.01$) between north (86.5%), central (75%) and south (59%). The bush density was significantly different ($p < 0.05$) between Magwiji, Mnyameni, and Upper Mnxe (Table 3.3).

Table 3.3: Bush density, basal area, and canopy area at the locations and during different seasons.

Location	Plant density (P.ha^{-1})	Basal area (m^{2}.ha^{-1})
Magwiji	1935^{a}	12^{a}
Upper Mnxe	905^{b}	11^{a}
Mnyameni	604^{b}	7^{a}

$^{a, b,}$ the means with different superscript within the same column for the location and season are significantly different ($p < 0.05$).

The bush density was significantly different ($p < 0.01$) between the sites at Mnyameni. The bush basal area was significantly different ($p < 0.05$) between the north, central and south (Table 3.4). The bush density, basal area and canopy area were significantly different ($p < 0.01$) between the top, slope, and valley for both Magwiji and Upper Mnxe (Table 3.5). The bush density was positively related to bush basal areas (r = 0.69; $p < 0.01$).

Table 3.4: Bush density and basal area at different sites, during the different seasons at Mnyameni.

Site	Plant density (P.ha^{-1})	Basal area (m^{2}.ha^{-1})
South	3106.8^{a}	17.4^{a}
Central	356.3^{b}	3.5^{b}
North	-	-

$^{a, b}$ means with different superscript for the site and season within the same column are significantly different.

Table 3.5: Bush density, basal area, and canopy area at the sites for Magwiji and Upper Mnxe.

Site	Plant density ($P.ha^{-1}$)	Basal area ($m^2.ha^{-1}$)
Valley	1237.9^b	11.9^a
Slope	2383.6^a	19.2^a
Top	164.1^c	2.8^b

a, b, c Means with different superscript within the same column are significantly different ($p < 0.05$)

3.3.3. Aerial cover

The proportion of green cover, dead plant material, litter material, and bare ground were significantly different ($p < 0.01$) between Magwiji, Mnyameni, and Upper Mnxe. The canopy area for bushy vegetation was significantly different ($p < 0.05$) between the communities as well (Table 3.6).

Table 3.6: The herbaceous vegetation basal and aerial cover (%) for three communities.

Variable	Magwiji	Mnyameni	Upper Mnxe
Basal Cover	65^b	74^a	76^a
Green Cover	42^b	63^a	43^b
Dry Material	26^a	16^c	23^b
Litter Material	12^a	8^b	9^b
Bare Ground	17^a	12^b	19^a

a, b, c means with different super script within the same row for community and season are significantly different ($p < 0.05$).

The green cover was significantly different ($p < 0.05$) between the top (50%), slope (34%) and valley (45%). The proportion of green cover, litter, and dead material of the herbaceous vegetation was not significantly different ($p < 0.05$) between the sites at Mnyameni community (Table 3.8). Green plant cover proportion was negatively related to dead material proportion ($r = -0.84$; $p < 0.0001$) and bare ground proportion ($r = -0.66$; $p < 0.0001$).

Table 3.7: The basal and aerial cover (percentage) at sites Mnyameni community.

Variable	South	Central	North
Green Cover	57.9^{b}	65.8^{ab}	68.8^{a}
Dead Material	15.4^{a}	15.1^{a}	15.0^{a}
Litter Material	9.1^{a}	7.8^{ab}	6.3^{b}
Bare Ground	17.7^{a}	11.2^{ab}	7.3^{b}

a, b, c means with different superscript within the same row for community and season are significantly different ($p < 0.05$).

3.3.4. Biomass production

The biomass production was significantly different ($p < 0.05$) among the communities. Mnyameni had highest biomass (Figure 3. 3). The biomass production was significantly different ($p < 0.05$) between the communities. The biomass was not significantly different between Magwiji (360.1 $kgDM.ha^{-1}$) and Upper Mnxe (388 $kgDM.ha^{-1}$) but different between both Magwiji and Upper Mnxe and Mnyameni (577 $kgDM.ha^{-1}$).

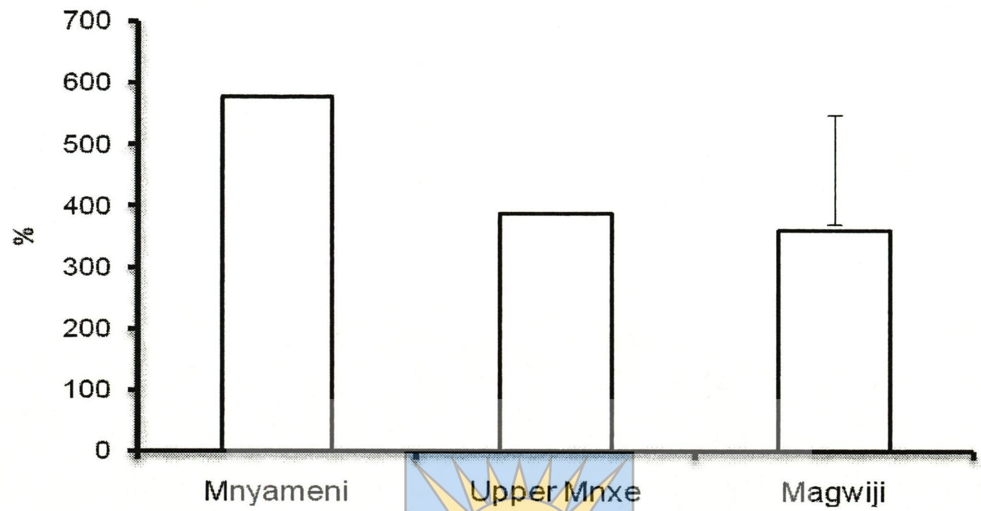

Figure 3.3: Biomass production between the communities (bar on the graph represent LSD at $p < 0.05$ and compares the mean biomass between the communities)

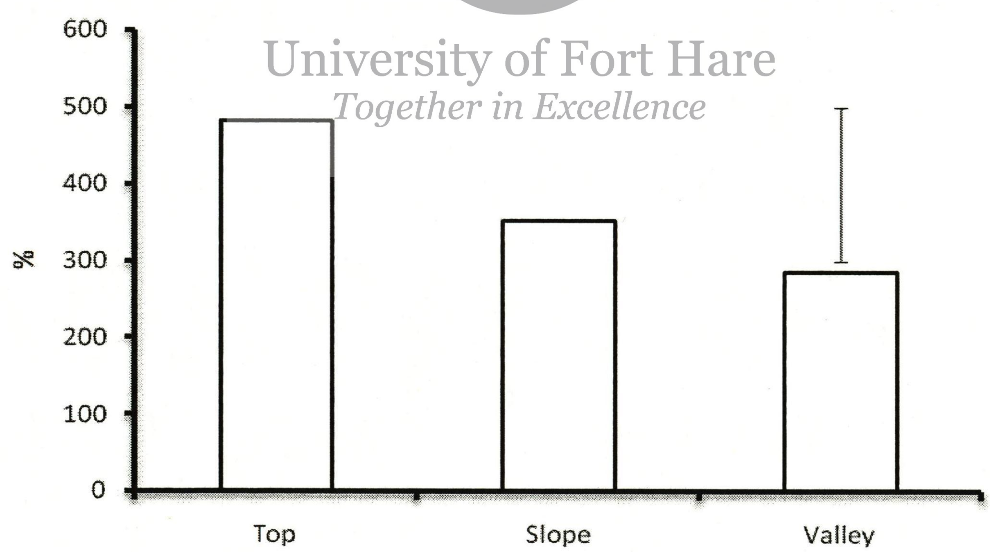

Figure 3.4: Biomass production between the sites at Magwiji and Upper Mnxe (Bar on the graph represent LSD at $P < 0.05$ and compares the mean biomass between the sites)

The biomass production between the top, slope, and valley for both Magwiji and Upper Mnxe were not significantly different ($p > 0.05$), neither was biomass production at the southern (528 kgDM.ha^{-1}), northern (411 kgDM.ha^{-1}), and central (615 kgDM.ha^{-1}) sites of Mnyameni community.

3.4. Discussion

3.4.1. Species composition and distribution

Species may vary significantly in their acceptability and response to grazing herbivores, due to differences in palatability (Abule *et al*. 2007 III). Upper Mnxe had the highest proportion of desirable species such as *Themeda triandra* and *Heteropogon contortus*, followed by Magwiji and the lowest were recorded at Mnyameni. Although the grazing practices are identical at these communal rangelands, such practices lead to the variation on species composition at the different vegetation types. This could be ascribed to the climatic variation between the vegetation types. The results corroborate the hypothesis that identical grazing practices at Magwiji are expected to lead to overgrazing because Magwiji has the erratic rainfall than Upper Mnxe and Mnyameni. In support of these results, Coronato and Bertiller (1986), and Svejcar *et al.* (1999) indicated that the species composition change is determined more by rainfall than by grazing pressure. However, Olff and Ritchie (1998) reported that livestock grazing decreases plant species composition in environments where water availability is limiting.

The hypothesis that identical grazing practices at Mnyameni are expected to lead to overgrazing because Mnyameni is generally flat which lead to easy access of animals throughout the grazing areas was also corroborated. This was affirmed by the fact that species composition was dominated by the increaser II species such as *Sporobolas africana* and *Paspalum dilatatum* (Table 3.2), that did not vary between the sites at

Mnyameni. In the meantime, the valleys at Magwiji and Upper Mnxe were dominated by increaser II species as well; such species include *Eragrostis chloromelas* and *Elionurus muticus*. This implies that although the grazing practices were identical in the communities, land formation altered the distribution and composition of the species and in turn leads to land degradation. Spatially complex environments that feature geometrically complex landscapes and patchy resource distribution affect animals' ability to search for and detect feed resources (Ritchie 1998). This in turn increases the grazing pressure at the areas which are easy to reach by animals. Rangeland theory predicts that the most desirable and least resistant species disappear due to preferential grazing in areas with high grazing pressure (Hein 2006). Del-Val and Crawley (2005) reported that the species categorized as herbivore decreasers are the most affected by defoliation. While according to Landsberg *et al.* (2003) decreasers and increasers together indicate consistent changes in plant composition that are likely to be related to the accumulated long-term impacts of grazing. Sisay and Baars (2002) reported that in the low laying areas the decreaser species were replaced by grazing resistant increaser species which are indicative of rangeland retrogression. Furthermore, in support of these results, Malan and Van Niekerk (2005) reported that constant diminishing of the highly desirable species could result in rangeland deterioration. Similar results have been reported in heavily grazed arid and semi arid areas of Africa (Abule *et al.* 2005; Gemedo-Dalle *et al.* 2006; Solomon *et al.* 2007).

The decreaser species were negatively related to the increaser II species while the perennial species were negatively related to forbs. This suggests that while other species are selected by grazing animals the species which are not preferred by animals keep growing undisturbed. The negative relationship between species groups could be due to intra-specific competition and preferential grazing (Hein 2006) but also from colonization effects (Sebastia 2004). This was further supported by Sasaki *et al*. (2005) and Maki *et al*. (2007) who reported that increaser II species replaces the decreaser species as the grazing pressure increases. Maki *et al*. (2007) highlighted that, species that respond negatively to livestock grazing decreases with grazing pressures, whereas grazing tolerant species increases. Meanwhile, Abule *et al.* (2005) reported that high grazing pressure reduces the growth rate and reproductive potential of individual grass plants and influences the competitive relationships amongst different species. The arrival of any plant in an area may be accidental and the continued presence of that plant in a community will be assured only if it is sufficiently well adapted to the conditions which are imposed to it to allow it to survive in competition with other plants which are present in that area (Tainton 1996).

The perennial species were negatively related to the forbs. This implies that as the perennial species disappear the forbs will occupy the space; this could be ascribed to the competition. Smet and Ward (2005). Abel (1997), Illius and O'Connor (1999), and Hayes and Holl (2003), reported that herbivores have negative effect on vegetation, the vegetation changes from being dominated by perennial grasses to being dominated by annual grasses with an increased grazing pressure.

Furthermore, based on the relative abundance (percentage) the woody vegetation at Magwiji was dominated by *Leucosidia sericea* and karroo bush such as *Passerina rigida* and *Chrysocoma ciliata*. *Leucosidia sericea* occurs naturally at this area while *Passerina rigida* and *Chrysocoma ciliata* are indicating the misuse of rangelands. Animals do not browse these bushes, but in the area, residents and herders use them as the source of firewood. Upper Mnxe had the highest density of *Euryops pyroides*. This species is regarded to be a problem in rangelands. The areas that were covered by dense *Euryops pyroides* have poor herbaceous layer. This could be attributed to the competition for soil nutrients, shading and alleleopathic chemicals exuded by the trees. Mnyameni dominated by *Coddia rudis*. This species occur naturally in this area. The south of the community could be classified as the grassy bush area, however, there are *Acacia karoo* species coming up especially at the areas, which were previously used as arable lands. This could be attributed to the over grazing especially at the open grasslands. It could further be attributed to the single species livestock grazing of cattle without goats to browse the bush.

3.4.2. Soil protection

The basal cover at Magwiji was lowest compared to Mnyameni and Upper Mnxe. This could be ascribed to the topography; Magwiji has greater landscape heterogeneity leading spatial preferential grazing and is more characterised by steeper slopes than the other communities which lead to acceleration of runoff. These results imply that the grazing and landform has effect on basal cover possibly due to increased plant interspaces' and run off rate. The hypothesis that identical communal grazing strategies in Magwiji is expected to lead to lower soil cover than in Upper Mnxe and Mnyameni because slopes in Magwiji are greater than in Upper Mnxe and Mnyameni corroborated. Ludwig *et al.* (2001) indicated that grazing affects grass species, leading to a decline in species vigour and increase plant mortality, which causes increase in the spaces between grasses, which in turn increases the rate of runoff. According to Svejcar *et al*. (1999), water inputs may be intercepted by plants, infiltrate to soil or run off the surface depending on, among other factors, soil characteristics, topography, and vegetation cover. The fact that basal cover was higher at the top and valley at Magwiji than on the slope implies that the herbaceous plants along the slope have higher proportion of plant inter-space which further supports the hypothesis. Parsons *et al.* (1997) reported that the bottomlands have higher tuft density, basal area, and abundance of poorly palatable species which implies that selective grazing leads to reduction on the basal cover. Svejcar *et al*. (1999); and Malan and Van Niekerk (2005) indicted that reduction in productive and soil protective species indicate the first phase of grassland retrogression.

The southern sites at Mnyameni, demonstrated lower herbaceous basal cover. This could be due to bush density on the southern sites. Hayes and Holl (2003) indicated that, mesic grasslands are prone to shrub and bush invasion with a consequent loss of herbaceous vegetation. An increase in woody plant abundance invariably results in the suppression of herbaceous plants (Richter *et al.* 2001). This implies that the southern site at Mnyameni have more plant-inter-space and are more prone to soil loss. This nullifies the hypothesis because it implies that while basal cover is affected by overgrazing and landform, the inter plant competition between bush and herbaceous vegetation affect the basal cover.

The part of hypothesis was nullified because the aerial cover was higher at Mnyameni which could be attributed to the high rainfall; the aerial cover is related to the biomass production which correlates with rainfall. This implies that the soil at Mnyameni is more protected against raindrop impact while the soil at Magwiji is more protected against runoff. Aerial cover protects the soil from the raindrop effect (Gutierrez and Hernandez 1996). Albertson *et al*. (2005) reported that grass cover is more responsive to annual rainfall fluctuations owing to grass's relatively rapid colonization of bare ground in wet conditions and swift dieback with water stress. Morris and Kotze (2006), demonstrated that the poor cover offered by leaves and litter provide less soil protection against the impact of the raindrops. This could be attributed to the hydrological and geomorphologic properties. The proportion of the green cover was inversely related to the proportion of the bare ground. This means, the higher the green plant proportion the lower is the proportion of the bare ground.

The balance between reception of rainwater, storage, and safe release may be different between the sites due to different landscape morphology. The slope gradient allows quicker release of water through run off, leaching and evaporation on the slopes that are more exposed to the sun for a longer time.

3.4.3. Biomass production

Magwiji had the lowest biomass production than Upper Mnxe and Mnyameni. This supports the hypothesis that identical communal grazing strategies in Magwiji is expected to lead to lower forage yield than in Upper Mnxe and Mnyameni because rainfall in Magwiji is more erratic than Upper Mnxe and Mnyameni. Mnyameni is located at mesic bush community vegetation type along the coast, it receives more rainfall in terms of both distribution and quantity; furthermore, the landscape allows storage and safe release of water, either to the streams and /or through evaporation.

Mesic grasslands are more productive than xeric grassland and thus accumulate higher levels of biomass (Hayes and Holl 2003). Noellemeyer *et al*. (2006) indicated that biomass production of natural grassland systems varies considerably according to the available moisture. Pineiro *et al*. (2006) indicated that aboveground net primary production of grasslands varies spatially. Pineiro *et al*. (2006) found that precipitation was the main control of aboveground biomass throughout the year whereas temperature played a secondary role. Grassland ecosystems are strongly responsive to climatic variability, and many fundamental aspects of their structure and function are tied to spatial properties (Fay *et al*. 2006).

4. RANGELAND SOIL PROPERTIES

4.1. Introduction

Communal rangelands form a larger part of Eastern Cape Agricultural productive areas, they support large number of people providing resources such as grazing, firewood, and natural foods (Noellemeyer *et al.* 2006). Assessment of communal rangeland capability and function is necessary to prevent resource degradation and to facilitate adaptive management practices (Rezaei *et al.* 2006). The soil property associations and their physical, hydrological, and biological characteristics that produce distinctive kinds and amounts of vegetation are an essential component of the ecological site description (Pyke *et al.* 2002).

There is little information available on soil properties in communal rangeland ecosystems (Snyman 1998). Ellis and Swift (1988) indicated that abiotic events have more crucial role to play in the vegetation dynamics of the communal rangelands than grazing. The provision of sufficient amounts of water, nutrients, resistance, and resilience to physical degradation, and sustenance of plant growth under appropriate management are the basic soil functions (Rezaei *et al.* 2006), therefore, to characterize the soil/plant system numerous soil analyses are required.

Understanding how nutrient resources vary across landscapes is fundamental on rangeland ecological research (Benning and Seastedt 1995). Characterization of spatial variability and distribution of nutrients in relation to site characteristics such as climate and landscape position is critical for predicting rates of ecosystem processes, understanding how ecosystem work and assessing the effects of the future land use change on nutrients (Wang *et al.* 2002). Study of soil property variations resulting from topographic aspect and vegetation changes will have implication on the proper management of marginal and environmentally sensitive areas (Yimer *et al.* 2006). Landscape positions influence runoff, drainage, soil temperature, and soil erosion and consequently soil formation. Variation in soil formation along a hillslope result in differences in soil properties (Brubaker *et al.* 1993), which can affect pattern of plant production, litter production and decomposition (Wang *et al.* 2002).

The communal rangelands of Eastern Cape Province of South Africa are degraded. Rangeland degradation leads to the loss of tons of productive soil. Soil losses affect the physical, chemical, and biological soil properties and consequently reduce soil productivity (Lobo *et al.* 2005). The reduction of primary productivity negatively affects the community economy due to decrease of animal production. Soil degradation is a major threat to sustainable use of soil ecosystem because it decreases actual and potential level of vegetation cover (Jia *et al.* 2005). An understanding of the variations and relationships between ecosystem variables is fundamental prerequisite to rangeland degradation solution. Soil is a substratum and medium of germination, survival, and growth of rangeland vegetation. It is significant to evaluate the soil quality, because soil quality properties relate to its contribution on nutrient cycling and potential for further ecosystem activity.

The objective of the study was to assess the variation of soil pH, electrical conductivity (EC), soil organic Carbon (SOS), available Phosphorus, cation exchange capacity (CEC), soil particle density, soil aggregate stability, and microbial respiration at three communal rangelands. The hypothesis is that communal rangeland soil dynamics are similar between the communities and along the landscape gradient.

4.2. Materials and methods

4.2.1. Description of the study area

Three communities (Figure 3.1) were selected at different vegetation types using the veld types of Acocks (1988). Magwiji (*Themeda-Festuca* Alpine) located at 30°37′S, 27°22′E, and 1507m asl. The average summer rainfall (November to April) is 500 mm while winter rainfall (May to October) is 200 mm. The mean temperature in January is 22°C and 10°C in July. The herbaceous vegetation at Magwiji is dominated by *Setaria flabellata, Themeda triandra, Heteropogon contortus, Microchloa caffra, Elionurus muticus, Eragrostis racemosa, Eragrostis chloromelas,* and *Eragrostis capensis.* The bush component is dominated by species such as *Leucocidea serecea, Rhamnus prinoides, Rhus erosa* and *Dyspiorose lyciodes* Acocks (1988).

Upper Mnxe (Highland sourveld) located at 31°33′S 27°36′E and 1441m asl. The average summer rainfall (November to April) is 600 mm while in winter (May to October) the rainfall is 200 mm. The mean temperature in January is 22°C and July is 12°C (Henning 2002). Upper Mnxe is generally sour grassland area with some invasive karroo bush species such as *Euryopes pyriodes* and *Chrysocoma ciliata.* The herbaceous vegetation at Upper Mnxe is dominated by species such as *Themeda triandra, Elionurus muticus, Heteropogon contortus,* and *Bracharia serata.*

Mnyameni (Coastal forest and thornveld) located at 32°28′S and 28°13′E 504m asl. The average summer (November to April) rainfall is 700mm and winter rainfall (May to October) is 300mm. The mean temperature in January is 22 °C and July is 14 °C (Henning 2002). The grassland constituent is rarely a pure, uniform grassland, but rather scrubby, full of tall herbs, shrubs and tall coarse grasses. The grass layer is dominated by species such as *Sporobolus africanus, Hyparrhenia Hirta, Paspalum dilatatum, Cymbopogon excavatus,* and *Festuca costata*. The bush component is composed of *Coddia rudis, Dyspioros villosa, Ptaerexilon obliqoum*, *Acacia karroo,* and *Pappia capensis*.

The landscape at Magwiji is distinctively mountainous with steep slopes (12 – 20%) and valleys. The types of livestock include sheep, goats, cattle, and smaller numbers of horses and donkeys used for animal traction. The animals spent most of the time at the stock posts; they are not kraaled except during the inspection and dipping. Upper Mnxe is generally flat with some hills, gentle to steep slopes (3- 8%) and wider valleys. The livestock types include cattle, sheep, and goats. The animals are not kraaled except during animal inspection and supplement feeding. Mnyameni is generally flat with some rolling valleys, slope (0 – 3%). The main livestock type in this community is cattle. The animals are not herded but they are kraaled at night. Domestic livestock under a nomadic and semi-nomadic pattern of land use have grazed the three study areas. (Extension officers and Farmers 2007, personal communication). Although grazing practices vary depending on local geography, but the basic pattern of seasonal use is similar in all the three ecological zones. More detailed description of historical grazing regimes was not available.

4.2.2. Experimental design

The assessment of communal rangeland soil dynamics at Magwiji and Upper Mnxe communities was based on landscape and altitude gradient. Each site was divided into three experimental units that were assigned valley, slope, and top. The cardinal gradient was used at Mnyameni community to examine rangeland soil properties, this site was divided into south, central, and north experimental units. Each of the experimental units, at each community, was sub-divided into four treatment plots of 100m x 4m transect area established from fixed centre point in each plot; recorded by global positioning system (GPS), resulting in a sum of 36 plots for the three communities.

Soil samples were collected within each plot at the 0, 20, 40, 60, and 80m points along the 100m line transect at the maximum depth of 20cm. The soil water at field capacity was determined using the open field method by Anderson and Ingram (1993). Soil samples were field into pots and saturated with water to field capacity and natural drainage was allowed (Anderson and Ingram 1993).

Top soil samples were carefully collected without breaking the aggregates, the samples were transported in a rigid box to prevent breakdown of aggregate. The samples were oven dried at 40°C for 24 hours to unify the samples moisture condition, thereafter, subsamples were subjected to (a) fast wetting, by immersion in water, (b) mechanical disaggregation, by shaking and (c) slow wetting, by capillary action. The aggregates were then oven dried after ethanol treatment and sieved through six mesh sizes viz., 2000 µm, 1000 µm, 500 µm 200 µm, 100 µm and 50µm. The mean weight diameter was calculated for each sampled site and interpreted based on classification table by Le Bissonnais (1996).

Soil pH was measured on 2.5:1 water to soil suspension as described by Okalebo *et al.* (2002) using an electrode pH-meter for a saturated soil paste using distilled water. The electrical conductivity (EC) was measured in the saturated paste extract to determine the level of salinity (Okalebo *et al.* 2002). After resting it for one hour, soil particle density was determined using the hydrometer method. Soil organic Carbon content was determined by the sulphuric acid and aqueous potassium dichromate ($K_2 Cr_2 O_7$) mixture. After complete oxidation from the heat of solution and external heating, the residual $K_2 Cr_2 O_7$ was titrated against ferrous ammonium sulphate (Anderson and Ingram 1993).

Available Phosphorus was extracted from the soil using Bray No 1 solutions as extractant. The extracted phosphorus was determined calorimetrically based on the reaction with ammonium molybdate and development of the 'Molybdenum Blue' color. The absorbance of the compound was measured at 882nm in a spectrophotometer and was directly proportional to the amount of phosphorus extracted from the soil. Cation exchange capacity (CEC) was measured by replacement of exchangeable cations by ammonium acetate. The Ammonia nitride (NH_4-N) was determined using spectrophotometer as described by Anderson and Ingram (1993). Microbial respiration was measured with the closed chamber method as described by Bekku *et al.* (1995). The CO_2 was absorbed by sodium Hydroxide (NaOH) solution during incubation in the closed chamber. The CO_2 concentration was measured by titration with Sulphuric acid. Soil respiration was calculated from the concentration increase in the chamber.

4.2.3. Data analysis

The analysis of variance (ANOVA) with GLM procedure of SAS system (SAS Institute, 2001) was used for statistical analysis. The means of each soil variable for each classifying factor were classified using the Duncan multiple range procedure. The Pearson correlation coefficients were estimated for all possible paired combinations of the response variables to generate a correlation coefficient matrix.

4.3 Results

4.3.1. Soil chemical characteristics

The mean pH for the communities under the study was 5.4. The electrical conductivity (EC) was significantly different ($p < 0.05$) between the sites at Mnyameni (Table 4.3). Cation exchange capacity (CEC) was significantly different ($p < 0.01$) between Magwiji, Upper Mnxe, and Mnyameni. The mean CEC for all the vegetation types was 40.5 $Cmol.kg^{-1}$. The mean available P was 0.052 $g.kg^{-1}$. At Mnyameni, available P was significantly different ($p < 0.01$) between the sites. Available P was significantly negatively related ($p < 0.001$; $r = -0.867$) to cation exchange capacity.

4.3.2. Soil physical properties

A soil particle analysis was significantly differences between Magwiji, Upper Mnxe, and Mnyameni, with sand ($p < 0.01$); Clay ($p < 0.05$) and Silt ($p < 0.01$) (Table 4.1). The mean sand, clay, and silt textural classes for the three communities under the study were 52%, 22%, and 26% respectively. The mean soil moisture at three communities was 20%.

Table 4.1: Soil physical, biological, and chemical properties at Magwiji, Upper Mnxe, and Mnyameni communities.

Community	**Magwiji**	**Upper Mnxe**	**Mnyameni**
Vegetation type	***Themeda-Festuca* Alpine**	**Highland sourveld**	**Coastal forest and thornveld**
pH	5.5^{a}	5.3^{a}	5.5^{a}
EC ($uS.cm^{-1}$)	17.8^{a}	11.3^{a}	15.7^{a}
Sand (%)	56.4^{a}	65.1^{a}	35.5^{b}
Clay (%)	20.6^{b}	19.0^{b}	26.8^{a}
Silt (%)	23.0^{b}	15.9^{b}	37.7^{a}
Soil moisture (%)	21.5^{a}	18.5^{a}	20.7^{a}
Soil organic C (%)	2.3^{a}	1.8^{a}	1.8^{a}
Fast wetting (g)	2.5^{a}	2.3^{ba}	1.9^{b}
Slow wetting (g)	3.1^{a}	3.1^{a}	2.9^{a}
Mechanical disaggregation (g)	3.2^{a}	2.9^{b}	3.1^{a}
Carbon Dioxide ($g.kg^{-1}$)	2.1^{a}	2.3^{a}	2.5^{a}
Available P ($g.kg^{-1}$)	0.054^{a}	0.059^{a}	0.042^{a}
CEC ($Cmol.kg^{-1}$)	45.8^{a}	40.4^{b}	36.3^{c}

[a, b, c] Mean values with different superscripts within the same row are significantly different ($p < 0.05$)

The response of soil aggregates to fast wetting treatment was significantly different ($p < 0.05$) between the communities. The response of soil aggregates to mechanical disaggregation was significantly different ($p < 0.05$) between the communities (Table 4.1).

Table 4.2: Soil properties between the top, slope and along the valley at Magwiji and Upper Mnxe communities.

Site	Top	Slope	Valley
pH	5.3[a]	5.4[a]	5.4[a]
EC (uS.cm^{-1})	13.3[a]	11.5[a]	17.8[a]
Sand (%)	59.8[a]	63.9[a]	59.4[a]
Clay (%)	21.2[a]	18.0[a]	20.4[a]
Silt (%)	19.0[a]	18.1[a]	20.3[a]
Soil moisture (%)	20.4[a]	19.8[a]	19.7[a]
Soil organic C (%)	2.4[a]	1.8[b]	1.8[b]
Fast wetting (g)	2.9[a]	2.1[b]	2.1[b]
Slow wetting (g)	3.3[a]	3.0[b]	2.9[b]
Mechanical disaggregation (g)	3.2[a]	2.9[b]	2.7[b]
Carbon Dioxide (g.kg^{-1})	2.5[a]	1.9[b]	2.1[a]
Available P (g.kg^{-1})	0.054[a]	0.045[a]	0.068[a]
CEC (Cmol.kg^{-1})	43.9[a]	25.7[b]	43.2[a]

[a, b] Mean values with different superscripts within the same row are significantly different ($p < 0.05$)

The proportion of the stable soil aggregates was significantly different ($p < 0.01$) between the sites in response to fast wetting, slow wetting and mechanical disaggregation. Soil aggregate stability in response to fast wetting and mechanical disaggregation at Mnyameni was significantly different ($p < 0.05$) between the sites (Table 4.3). Mechanical disaggregation was negatively related ($p < 0.001$; $r = -0.74$) to CEC, but significantly positively related to ($p < 0.001$; $r = 0.91$) available P.

Table 4.3: Soil properties between the southern, central, and northern sites at Mnyameni community.

Site	South	Central	North
pH	5.5[a]	5.5[a]	5.4[a]
EC ($uS.cm^{-1}$)	28.2[a]	9.3[a]	9.5[a]
Sand (%)	31.0[a]	42.0[a]	33.5[a]
Clay (%)	30.0[a]	24.3[a]	26.3[a]
Silt (%)	39.0[a]	33.8[a]	40.3[a]
Soil moisture (%)	21.9[a]	19.1[a]	21.2[a]
Soil organic C (%)	1.8[a]	1.6[a]	1.9[a]
Fast wetting (g)	1.4[b]	2.1[a]	2.3[a]
Slow wetting (g)	2.6[a]	2.9[a]	3.3[a]
Mechanical disaggregation (g)	2.9[b]	3.1[ab]	3.3[a]
Carbon Dioxide ($g.kg^{-1}$)	2.5[a]	2.6[a]	2.3[a]
Available P ($g.kg^{-1}$)	0.106[a]	0.007[b]	0.014[b]
CEC ($Cmol.kg^{-1}$)	36.1[a]	35.2[a]	37.7[a]

[a, b] Mean values with different superscripts within the same row are significantly different ($p < 0.05$)

4.3.3. Soil organic Carbon and microbial respiration

The mean soil organic carbon content for all the study areas was 2%. The mean carbon dioxide (CO_2) between the sites was 2.29 $g.kg^{-1}$. Soil organic Carbon was significantly related ($p < 0.001$; $r = 0.54$) to electrical conductivity. Soil microbial respiration was significantly ($p < 0.001$; $r = 0.60$) related to CEC. The available P was negatively ($p < 0.001$; $r = -0.65$) related to microbial respiration. Microbial respiration was negatively related ($p < 0.001$; $r = -0.53$) to mechanical disaggregation.

Table 4.4: The relationship between the soil properties at Magwiji, Upper Mnxe, and Mnyameni communities

	pH	Sand	Clay	Silt	Soil Moisture	Organic Carbon	Carbon dioxide	Availabble Phosphorus	Cation Exchange Capacity	Fast wetting
pH	1									
Sand	NS	1								
Clay	NS	-0.734***	1							
Silt	NS	-0.921***	0.412*	1						
Soil Moisture	NS	-0.395*	0.411*	NS	1					
Organic Carbon	NS	NS	NS	NS	0.338*	1				
Carbon dioxide	NS	NS	NS	NS	NS	NS	1			
Available Phosphorus	0.403	NS	NS	NS	NS	NS	-0.645***	1		
Cation exchange capacity	NS	NS	NS	NS	NS	0.537***	0.595***	-0.867***	1	
Fast wetting	NS	0.452**	NS	-0.416*	NS	0.337*	NS	NS	NS	1
Slow wetting	NS	NS	NS	-0.346*	NS	0.399*	NS	NS	NS	0.658***
Mechanical disaggregation	NS	NS	NS	NS	NS	NS	-0.532***	0.910***	-0.744***	0.335*

*Significant at $p < 0.05$; **Significant at $P < 0.01$; *** Significant at $P < 0.001$; NS: not significant

4.4. Discussion

4.4.1. Soil chemical characteristics and distribution

The analyzed chemical soil properties namely pH, electrical conductivity (EC) and available Phosphorus did not vary between Magwiji, Upper Mnxe and Mnyameni communities except for the cation exchange capacity (CEC). The hypothesis that identical communal grazing strategies in Magwiji are expected to lead to different soil chemical characteristics compared to Upper Mnxe and Mnyameni because of low rainfall and topographic variation in Magwiji than Upper Mnxe and Mnyameni was nullified.

The results suggest that the pH did not vary between the communities and between the sites. This implies that identical grazing practices at different vegetation types did not have effect on soil pH. This could be attributed to the similarities in terms of herbivore grazing intensity, trampling, defection and urination. These results were supported by Killham (1994) and Zhao *et al.* (2007) who reported that herbivore grazing, trampling, defecation, and urination could affect soil pH.

The electrical conductivity values did not vary between the communities and between the sites. This implies that identical grazing practices at different the vegetation types and the landscapes did not affect the concentration and distribution of the soil salinity at the communal rangelands. This could be attributed to soil physical properties than land and vegetation types. In support of these results, Corwin *et al.* (2003) indicated that EC is influenced by water content, bulk density, and texture.

The available Phosphorus was not different between the communities and between the top, slope and valleys. This implies that identical grazing practices at the different vegetation types did not affect availability of phosphorus in communal rangelands. Nevertheless, at Mnyameni, the available phosphorus was different between the sites. The southern site was significantly higher than both the central and northern sites. This could be attributed more to the land use history than the current land use practice which is grazing, the south were never used as arable lands before, while both the central and northern sites were previously arable lands. These results are consistent with the work of Congdon and Herbohn (1993) who reported that the available phosphorus concentrations of the surface soils were low at the disturbed sites. Available P was inversely related to cation exchange capacity which implied that the soils with higher CEC have lower available Phosphorus. This could be attributed to Phosphorus fixation as consistent with the work by Yimer *et al* (2006).

Meanwhile, the cation exchange capacity (CEC) varied between Magwiji, Upper Mnxe and Mnyameni. Magwiji had higher CEC than both Upper Mnxe, and Mnyameni. This implies that identical grazing practices at different vegetation types have effect on CEC of the soils. This could be attributed to the variation of rainfall. Mnyameni has the highest rainfall, followed by Upper Mnxe while Magwiji has the least of rainfall. This suggests that exchangeable cations were leached following the amount of rainfall for each community as supported by Chadwick *et al.* (1999), Ludwig *et al.* (2001) and Yimer *et al.* (2006) who reported that exchangeable cations are leached at high rainfall areas.

4.4.2. Physical soil properties and their distribution

Sand, silt, clay content, soil aggregate resistance to fast wetting and mechanical disaggregation were different between Magwiji, Upper Mnxe, and Mnyameni. This implies that the hypothesis that identical communal grazing strategies in Magwiji is expected to lead to different physical soil property distribution compared to Upper Mnxe and Mnyameni because of erosion and leaching accelerated by slopes than Upper Mnxe and Mnyameni was corroborated. Magwiji and Upper Mnxe had the highest sand percentage and lowest clay content compared to Mnyameni. This could be ascribed to the difference in landscape; Mnyameni is flat, with reduced soil erosion potential than the other two communities. This means clay particles at Magwiji and Upper Mnxe could have been lost through soil erosion. Oztas *et al.* (2003) indicated that the landscape positions vary with the impact of running water washing the clay particles from higher landscapes.

The highest soil aggregate stability in response to fast wetting was observed at Magwiji and the lowest at Mnyameni. This implies that the soils in three communities respond differently to heavy rainfall. This could be attributed to the percentage of clay particles on the soil. Mnyameni had the highest clay content when compared to other communities and that could cause to the lower resistance to fast wetting. These results are supported by Lado *et al.* (2004a; 2004b) who reported that aggregate slaking by fast wetting increased with an increase in clay content, thus an increase in clay content, leads to an increase in the slaking mechanisms that compensate for the increase in aggregate stability. Aggregate stability is one of the main factors controlling top soil hydrology, crustability, and erodibility (Caravaca *et al.* 2002). The stability of soil aggregates and the pores between them affects the movement and storage of water, aeration, and soil erosion (Amezketa 1999). Fast wetting stable aggregates was again negatively related to available Phosphorus. This implies that as the available P increases the resistance of the soil-to-soil erosion due to heavy rainfall decreases.

Mechanical disaggregation affected the stable soil aggregates differently amongst the communities. Magwiji and Upper Mnxe had the highest soil aggregate resistance to mechanical disaggregation. Furthermore, soil stable aggregates between the sites behaved differently to mechanical disaggregation. The top was more resistant to mechanical disaggregation than the valley and slope, indicating that the soils at the top are more stable to impact of raindrops, movement of animals and other physical impacts. This could be attributed to the silt percentage of the soil, and soil organic carbon, which are binding soil aggregates together. Caravaca *et al.* (2002) and Li *et al.* (2007) support these results; they reported that the stability of aggregates is affected by soil texture, extractable iron, and extractable cations, the amount and types of organic matter present, and type and size of the microbial population. Organic matter contributes on water holding capacity of the soil and cementing of soil aggregates. Soil aggregation has potential benefits on soil moisture status, nutrient dynamics, and erosion reduction (Sainju 2006). Soil aggregate stability is a good indicator of organic matter content (Li *et al.* 2007), biological activity, and nutrient cycling in the soil (Amezketa 1999). (Shrestha *et al.* 2007) reported that the increased resistance of aggregates to the action of rainwater considerably reduces the risk of soil erosion. The higher-level resistance of soil aggregates to the action of rainwater considerably reduces the risk of soil erosion (Caravaca *et al.* 2002).

Slow wetting stable aggregates were positively related to sand particles. That implies that the higher the proportion of sand particles the higher the resistance to soil erosion caused by the light rainfall. Meanwhile, slow wetting stable aggregates were negatively related to silt content implying that the higher the silt contents the lower the resistance of the soil aggregates to light rainfall. According to Ramos *et al.* (2003) the soil with low stable aggregate values when exposed to slow wetting had higher silt contents. Mechanical disaggregation was strongly related to available Phosphorus; this suggests that when the available phosphorus increases the resistance of the soil aggregates to mechanical disaggregation also increases.

4.4.3. Soil organic Carbon and Microbial respiration

The soil organic carbon and microbial activity (Carbon dioxide) were different between the communities. These results nullifies the hypothesis that identical communal grazing strategies in Magwiji is expected to lead to lower soil organic carbon and microbial activity than Upper Mnxe and Mnyameni because of lower grass biomass production. This implies that the organic matter contributed to the soil by vegetation through decomposition by microorganisms does not vary in quantities at these communities. These results are supported by Caravaca *et al.* (2002) who reported that the amount of organic matter increases after the decomposition of litter and dead roots into the soil. However, organic carbon and microbial activity were different between the top, slope and valley. The top sites had higher soil organic carbon than the slope and valley while, the microbial activity was higher at the top and valley.

The microbial respiration was negatively related to available Phosphorus. This implies that available Phosphorus negatively affects the microbial population in these areas. Microbial population was directly related to Cation exchange capacity. This implies that the higher the CEC the higher the microbial population whilst, the higher the CEC the lower is the available P. Organic carbon was weakly positively related to silt content of the soil. The microbial population was negatively related to the stable aggregates in response to mechanical disaggregation. This implies that the soil with lesser resistance of the soil aggregation to mechanical disaggregation had higher microbial population. The stability of aggregates is affected by soil texture, the predominant type of clay, extractable iron, and extractable cations (Li *et al.* 2007), the amount and types of organic matter present, and type and size of the microbial population (Caravaca *et al.* 2002).

5. PERCEPTIONS OF FARMERS ON COMMUNAL RANGELAND

5.1. Introduction

Communal areas can be defined as areas where rangelands are held under communal tenure, while individuals or households hold arable land (Abel 1997). The communal rangeland tenure system is such that all members of the community use the rangeland resources (Hahn *et al*. 2005). In South Africa, communal areas consist of the former self-governing territories or homelands, and are predominantly populated by black South Africans, engaged in the production of crops and livestock for consumption and for sale on local and informal markets (Wessels *et al.* 2004).

Communal rangelands in the Eastern Cape form a larger part of natural ecosystem and resource base for communal farmers. These areas support multiple livelihood strategies of poor resource rural people (Peden 2005). The use of rangeland resources provide services which can be classified as infrastructural, nutritional, health, production, and energy. Most of communal rangelands in Africa have been reported to be degraded (Ward *et al*. 2000; Solomon *et al*. 2007), and so are the Eastern Cape rangelands (Palmer *et al*. 1997 and Palmer et *al*. 1998).

Heitschmidt *et al.* (2004) indicated that economic sustainability and social acceptance of rangelands are both closely tied to social perceptions and beliefs, while ecological sustainability is dependent on the biological and physical laws of nature. Communal farmers, who have their opinions and perceptions of the condition and management, manage these rangelands. In an attempt to improve livestock productivity and achieve ecological stability in communal rangelands, an investigation of perceptions of communal farmers about their rangelands is important. This is because human activities and attitudes have been reported to have substantial direct and indirect effects on ecosystems and are recognized as primary drivers of biological changes in all environments (Brown and Havstad 2004).

There is a need for conciliation of scientific and indigenous knowledge to develop a compliant management program for communal rangelands (Kavana *et al.* 2005; Solomon *et al.* 2007). The main objective of this study was to investigate the perceptions of farmers on communal rangeland resources, condition, and management.

5.2. Materials and methods

5.2.1. Description of study areas and vegetation types

The study was conducted at 11 communities, which are located at nine vegetation types (Table 5.1). *Themeda-Festuca* Alpine veld is a short, dense grassveld, varying from sweet to mixed, dominated by *Themeda triandra* with admixture of species such as *Elionurus muticus, Heteropogon contortus* and some *Eragrostis* spp (Acocks 1988). *Cymbopogon Themeda* veld is found on the sandy parts of the wetter higher-lying portion of the highveld in the northern Eastern Cape, undulating to flat country. The rainfall comes in summer, the winters are severely frosty. The Coastal forest and thornveld is an open thornveld with numerous and extensive patches of forest. The grassland constituent is rarely pure and uniform but is rather scrubby with tall herbs, shrubs, and tall coarse grasses. Highland sourveld is found on the eastern slopes and foothills of the Drakensberg. It receives summer rainfall; frosts are severe in winter, and snowfalls at higher altitudes. Eastern Province Thornveld occupies broken country and the soil is generally poorer, on sandstone and quartzite. The rainfall comes throughout the year. Alexandria Forest is the southwestward extension of coastal tropical forest. These areas receive rainfall throughout the year and the soils are stable. The valley bushveld is found along the hot valleys that receive less rain. These valleys are dominated by *Euphorbia* species such as *Euphobia confinalis*. False thornveld of Eastern Province is found on the undulating country along the foot of the mountains from Debe Nek to Somerset East. The vegetation includes bush species such as *Acacia karroo, Scutia myrtina, Maytenus polyacantha, Ehretia rigida* and grass species such as *Sporobolus fimbriatus, Digitaria eriantha*. Dohne sourveld lies on the lower altitudes, is warmer and drier, no snow in winter except on top of the mountains (Table 5.1) (Acocks 1988).

Domestic livestock under communal management have grazed these areas. Although grazing practices vary somewhat depending on local geography, the basic pattern of seasonal use is similar in all the communities.

5.2.2. Data collection and analysis

The study involved 11 communities, which were selected based on the vegetation type. Data on perceptions of farmers on rangeland resources, condition, and management were obtained by combination of participatory rural appraisal (PRA) and questionnaires. The PRA sessions were conducted during October 2006. All the community members, extension officers, and local leadership were invited to participate. The participants were divided into three focus groups namely, youth, women and men. The data collection at this phase dealt with (1) assessment of general concerns of the farmers on rangelands; (2)

focus group discussion on communal rangeland resources; (3) condition of communal rangelands; (4) communal rangeland management and (5) mapping of communal rangeland resources.

Table 5.1: Location of the study sites, vegetation types, and climate.

Study site	Location		Vegetation type	Climate	
				Mean Rainfall (mm)	Mean Temp (°C)
Magwiji	30°37'S	27°22'E	*Themeda Festuca* Alpine	500	22
Entsimekweni	30°36'S	27°11'E	*Cymbopogon Themeda*	500	22
Mnyameni	32°28'S	28°13'E	Coastal forest and thornveld	700	22
Upper Mnxe	31°33'S	27°36'E	Highland sourveld	600	20
Tsaba	33°08'S	27°31'E	Eastern Province thornveld	900	24
Wesley	33°19'S	27°20'E	Alexandria Forest	900	24
Lashington	32°38'S	27°28'E	Valley bush veld	600	20
Kolomana	32°26'S	26°47'E	Highland sourveld	700	20
Nxamkwana	32°57'S	27°38'E	Eastern Province thornveld	500	22
Hekele	32°26'S	27°32'E	False thornveld of Eastern Province	500	20
Mgwali	32°24'S	27°29'E	Dohne sourveld	800	20

Climate figures from Henning A J 2002. Map production. Project No 008. Vegetation types by Acocks 1988.

Data on individual opinions of residents were obtained by individual questionnaires with residents in selected households. The systematic selection was used to select the households where by every third household was interviewed. The 50 questionnaires were administered per community coming to the total of 550 questionnaires.

Data were analyzed using the SPSS statistical software program SPSS-CP Version 15.0 (SPSS Inc., 1999). The means, standard deviations and cross tabulation were used to determine categorical data. The correlations were estimated and used to determine the relationship between variables.

5.3. Results and Discussion

5.3.1. Common constraints and Livelihoods survey in communal rangelands

The participants in most (55%) of the communities indicated that soil erosion, bush encroachment, change in grass species, lack of fencing and uncontrolled burning are the challenges on their rangelands. They further (64%) cited lack of skills in range management as a constraint. Participants (36%) observed that some problem woody plants in their areas include species such as *Acacia karroo (Umga)*, *Euryops pyroides* (*Lapez*) and *Acaccia meansii* (*Iwabase*). The words in parenthesis are species names in local language (Xhoza) as used by the respondents.

At the communities that are located at the Highland sourveld (Upper Mnxe and Kolomana) participants identified invasion of bush species as their main problem. They believe that these invasive trees compete with grass for the sun, moisture, and nutrients. At Lashington (Valley busveld), respondents indicated that the main problem is the presence of some grass species that are not eaten by animals such as *Eleunurus muticus* (*Silefu*). The respondents further articulated that this grass grows fast and dominate the rangeland vegetation. Participants were consistent that this grass is not palatable especially during late growing seasons.

The participants in most of the communities (54%), were consistent in opinion that the soils are shallow and rocky, therefore, unable to support vegetation growth. At

Mnyameni however, it was mentioned that the rangelands are good in summer and poor in winter. In all the communities respondents alluded that their rangelands are in good condition and large enough to support livestock (Figure 5.3 and 5.4). Farmers are aware of the changes that occur in the rangeland, bush encroachment was the most cited challenge. This finding concurs with the work of Reed and Dougill (2002) who reported that communal farmers are aware that there are some changes to natural resources.

Farmers in the communal areas (93%) are consistent opinion that they depend on communal rangeland resources for their multiple livelihoods strategies. Dovie *et al.* (2006) reported that the majority of households in communal areas depend on resources from the local woodlands and livestock production.

5.3.2. Household demographics

A communal area household is defined as a man, his wife, their children and any other who is dependent on that household for food. However, there are some single parented and female-headed households. At the study sites, the mean household size was seven people. Most of the household heads were males (65%) compared to female (35%). The average number of adults in a household was five and average number of children was two.

Gender distribution of the respondents was such that 44% were females while 56% were males. The marital statuses of the respondents were in the following proportions; single 31%, married 56%, divorced 1% and widows 12%. The educational levels of the respondents varied from none to tertiary; 22% never attended school, 2% ended at preschool, 27% up to standard five, 35% from standard six to nine, 11% standard 10 and

3% had a tertiary education. Age proportions of the respondents varied from 18 to 93 years (Figure 5.1).

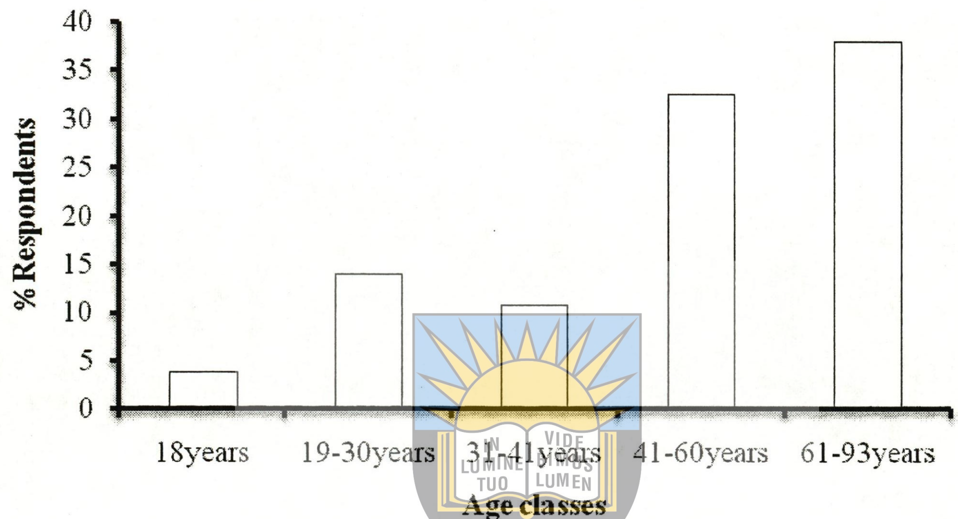

Figure 5.1: Age group distribution of the respondents during questionnaire survey.

5.3.3. Rangeland resources availability, access and utilization

The farmers during both PRA and questionnaire in the communal rangelands cited grazing, crafting, collection of firewood, medicinal plants, fencing poles and wild foods as the activities through which they utilize the rangeland resources (Figure 5.2). During the PRA discussion grazing was cited to be the major (n = 11communities, 81%) rangeland utilization activity by the farmers in the communal areas across the vegetation types, 54% (n = 11 communities) reported collection of medicinal plants and 63% (n = 11) indicated that they get water for livestock drinking in rangelands. In 63%, 27% and 18% (n = 11) of communities men, youth and women respectively cited grazing as the major use of the rangelands (Figure 5.2).

During questionnaire survey 84% (n = 553) of the household respondents were consistent with the opinion from the PRA discussion that the major resources from the rangelands include grass, firewood and medicinal plants. In terms of availability 49% (n = 553) indicated that grass for grazing is available during the rainy season and too little in winter. However, the response on availability of grass during summer were in the decreasing order that; the Valley bushveld (77%, n = 497) > False thornveld of Eastern Province (73%, n = 487) > Coastal forest and thornveld (70%, n = 510) > Dohne sourveld (59%, n = 484) > Alexandria Forest (58%, n = 260) > Highland sourveld (57%, n = 519) > Eastern Province thornveld (54%, n = 437) > *Cymbopogon-Themeda* veld (51%, n = 466) > *Themeda-Festuca* Alpine (35%, n = 488) >. The rangelands at *Themeda-Festca* Alpine were reported to have too much grass in summer (65%, n = 488). The grass was said to be too little during winter season (Figure 5.3).

On the question of access to rangeland resources 89% (n = 553) indicted that the right to access of rangeland resources is gained by virtue of being the resident in the community. Communal rangeland resource access is not (53%, n = 553) controlled both in terms of time of collection and amount collected or utilized. The rangelands are accessed throughout the year (66%, n = 553) without restriction to quantities (65%, n = 553) and time of collection (76%, n = 553). These results suggest that availability, access and utilization do not vary between the communities. This could be ascribed to the identical communal rangeland ownership between the communities at different vegetation types. This nullifies the hypothesis that identical communal rangeland ownership is expected to lead to variation in human opinion on rangeland resource availability, access and utilisation between the vegetation types because of the climate variation.

These results are consistent with the findings of the previous workers. Homewood (2004) and O'Farrell *et al.* (2007) who reported that communal farmers use rangelands for a wide range of purposes, the primary being grazing, and as source of medicine and cosmetics. Reed and Dougill (2002) reported that communal livestock farmers relied more on natural vegetation. Feed resources available in communal areas are natural pasture, woody plants, crop residues, and weeds (Solomon *et al.* 2007). Ward *et al.* (2000) in support of these results also reported that management of grazing areas and control thereof by the local headmen, or community groups did not occur in Otjimbingwe, in Namibia. This further concurs with the work that was done by Shackleton *et al.* (1998) and Dovie *et al.* (2007) who reported that communal area resources are mostly described as open access, they support, and supply diverse sources of biological resources from which people benefit. The results are also in agreement with Reed and Dougill's work (2002); who reported that the rangelands in communal areas are grazed continuously throughout the year. According to Meinzen-Dick *et al.* (2005) communal people possess use rights, this include right to access the resource such as to walk across a field; withdraw a resource such as to pick a wild plant and exploit a resource for economic benefits. de Oliveira *et al.* (2003) indicated that many rural households in developing countries rely heavily on producing their own food through pastoralism and sourcing additional food products from the wild. Dovie *et al.* (2007) have indicated that over 90% of resource poor rural households in the southern African region depend on the rangeland natural resources for food and other services. According to de Oliveira *et al.* (2003) communal rangeland ecosystem services include provision services such as human food, fiber, fuels, timber, pharmaceuticals, minerals and fresh water;

regulating services such as purification of air and water, hydrological regulation; cultural services such as aesthetic values, spiritual and social values; and supporting services such as primary production, nutririent cycling and provision of habitat. In semi-arid rangelands, goods and services required for livestock production are linked to the ecological functions that sustain production including the provision of water, nutritious grazing, shade, and shelter and seasonal regeneration of vegetation (O'Farrell *et al.* 2007).

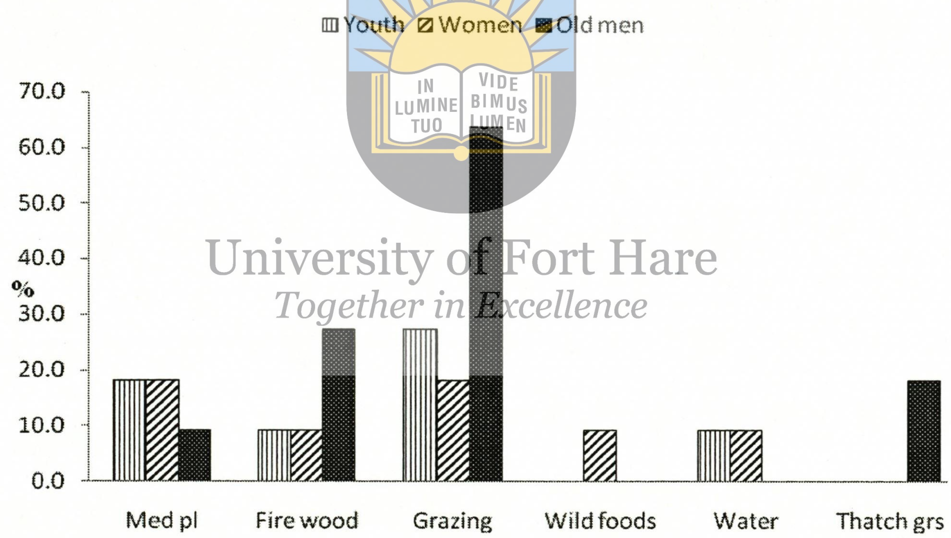

Figure 5.2: Focus group response on available rangeland resources
(Med Pl = Medicinal plants, Thatch grs = Thatch grass)

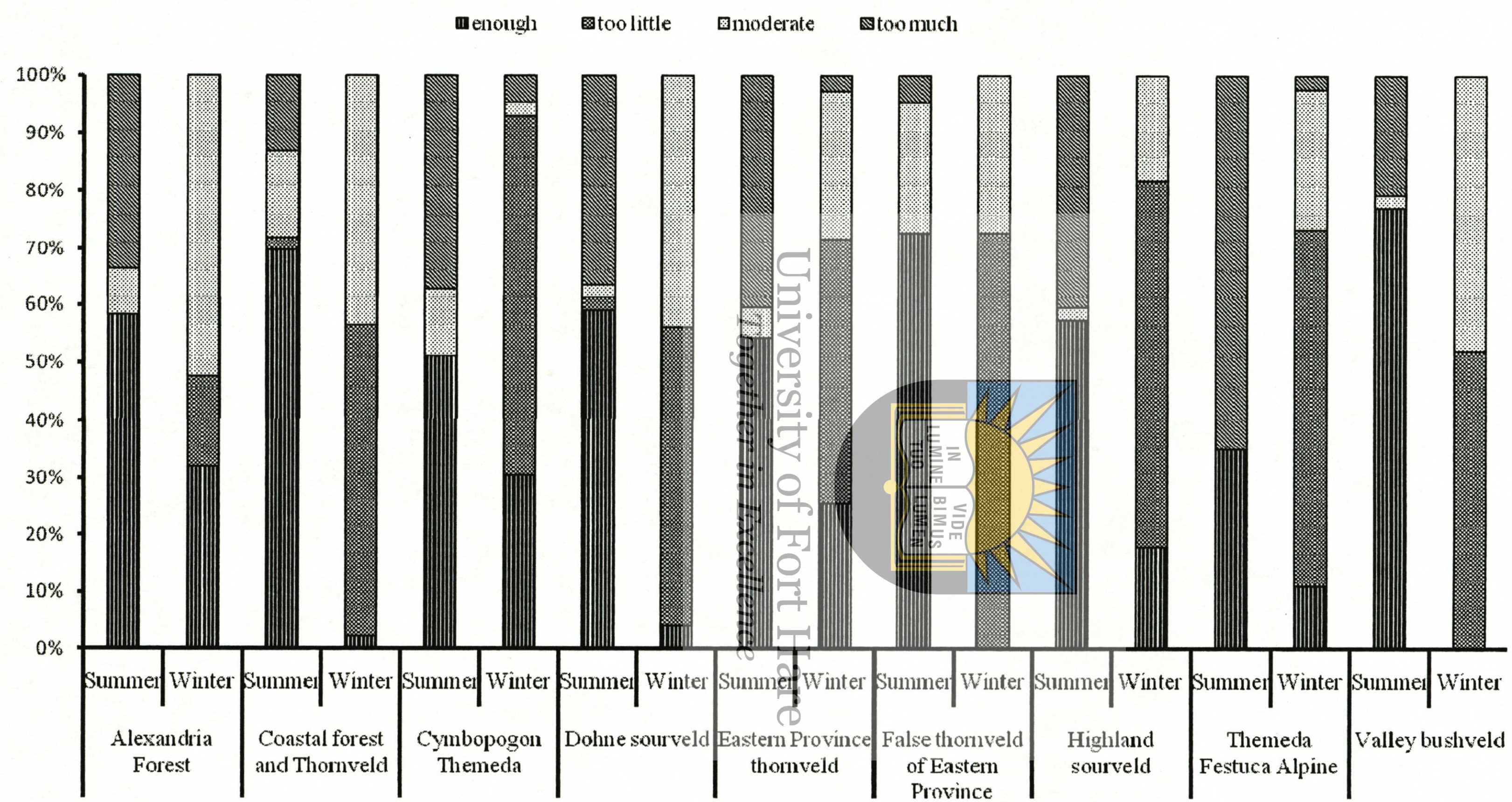

Figure 5.3: Response of the participants at the communities according to vegetation types on the seasonal availability of grass

5.3.4. Rangeland condition

The participants of the PRA session discussed the issue of the rangeland condition at all the communities. In response 90% (n = 11) of the communities believe that their rangelands are in good condition and large enough to support their livestock. The farmers were consistent in opinion that the grass becomes dry and unpalatable during winter, whilst in summer it is green and good. The farmers supported their perception about rangeland condition variation in winter by further indicating that the animals lose weight in winter which they associate with poor grass production. When the participants were divided into groups during PRA sessions, the out comes from the men, women and youth groups were consistently indicting that the rangeland condition is good with some minority say they are poor (Figure 5.4). Farmers believe that their main problem in the rangelands is lack of fencing, soil erosion and bush encroachment.

In the meantime, during the questionnaires farmers (49%, n = 553) indicted that their rangelands are in good condition. The response on the rangeland condition varied with vegetation types in the order that highland sourveld (67%, n = 553), *Themeda-Festuca* Alpine (59%, n = 553), Eastern Province thornveld (55%, n = 553) valley bushveld (53%, n = 553), Dohne sourveld (50%, n = 553), Alexandria Forest (41%, n = 553), Coastal Forest and thornveld (35%, n = 553), False thornveld (30%, n = 553) , *Cymbopogon-Themeda* (29%, n = 553) (Table 5.2).

The respondents (n = 553) believe that heavy grazing (82%), soil depth (97%), and bush encroachment (92%) do not cause change in rangeland condition. They also believe that heavy grazing (82%), burning (89%). The farmers in communal areas believe that soils in the grazing areas are good (57%). On the question of the use of supplementary feeding during the dry season, the respondents (48%, n = 553) from the highland sourveld type indicated that they use supplements during the dry season (Table 5.3). The respondents indicated that communal rangelands are not divided into camps (48%). Farmers acknowledged that there is high rate of soil erosion in their rangelands (26%). It was cited that rangelands are not fenced (68%) and therefore, need fencing (62%). The results suggest that farmers in the communal areas have the common opinion on rangeland condition regardless of the vegetation types at which they are located. This results nullifies the hypothesis that identical communal rangeland ownership is expected to lead to variation in human opinion on rangeland condition between the vegetation types because of the climate variation.

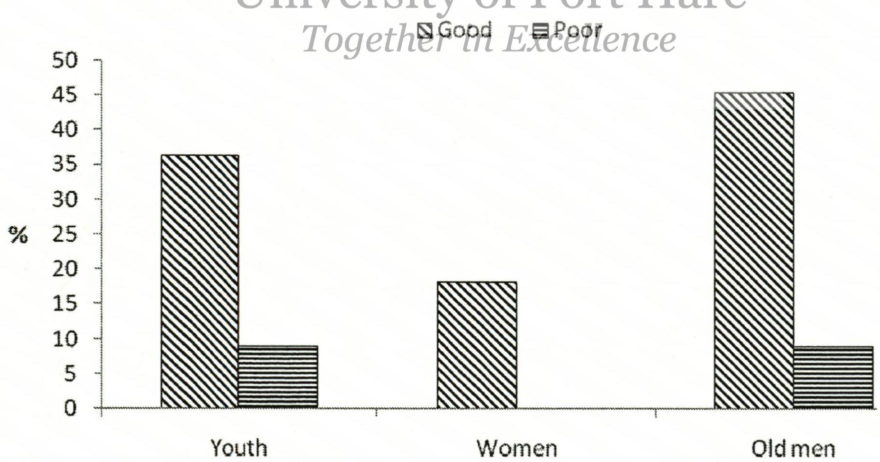

Figure 5.4: Community response by focus groups on rangeland condition

Table 5.2: The percentage response on rangeland condition at different vegetation types.

Vegetation type	**Condition of the grazing area**						
	very poor	**poor**	**fair**	**good**	**very good**	**don`t know**	**no response**
Alexandria Forest	0	2	14	41	2	2	39
Coastal Forest & thornveld	0	6	49	35	0	0	10
Cymbopogon-Themeda	8	8	22	29	18	0	16
Dohne sourveld	0	2	27	50	9	2	11
Eastern Province thornveld	2	4	14	55	9	1	15
False thornveld of Eastern Province	0	22	28	30	0	0	20
Highland sourveld	0	6	11	67	11	0	5
Themeda-Festuca Alpine	0	10	22	59	4	0	6
Valley bushveld	0	14	20	53	2	0	10
Total	1	8	21	49	7	1	14

Table 5.3: Relationship (percentage) between vegetation type and use supplementary feed given by farmers.

Vegetation type	Supplementary feed given		
	yes	no	no response
Alexandria Forest	4	37	59
Coastal Forest & thornveld	2	65	33
Cymbopogon Themeda	25	14	61
Dohne sourveld	25	38	38
Eastern Province thornveld	2	27	71
False thornveld of Eastern Province	16	50	34
Highland sourveld	48	33	18
Themeda Festuca Alpine	25	25	49
Valley bushveld	12	65	22
Total	19	38	43

5.3.5. Rangeland management

During the PRA session the farmers in all the communities indicated that their rangeland management is poor. The farmers believe that their rangeland management is poor because of lack of fencing and camps. The men (81%), youth (45%), and women (45%) said the rangeland management at their communities is poor. They believe that fencing is the solution to mismanagement of rangelands; however, some suggested that the government should provide rangers to look after the rangelands.

During the questionnaire survey, farmers indicated that there is no daily (45%, n = 553), monthly (36%, n = 553) and seasonal (38%, n = 553) management of rangelands. In most of the communal areas (65%, n = 553), drinking points for livestock are less than

1km from grazing areas. They (61%, n = 553) anticipate that division of rangelands into fenced camps will improve their rangelands. Communal farmers conceive that they do not have skills in rangeland management (27%, n = 553). Farmers articulate that there was never a community training on rangeland management (63%, n = 553) and there is a need for such (21%, n = 553).

There is neither short nor long-term management of communal rangeland resources in the communities. The poor management was attributed to the absence of fences in the rangelands and lack of necessary skills on rangeland management. With some farmers indicating, that daily grazing management is influenced by the distance of water source from grazing areas. The results indicate that farmers are on opinion that their rangeland management is poor and they ascribe that to the lack of fencing and poor level of skills in rangeland management. These results nullifies the hypothesis that identical communal rangeland ownership is expected to lead to variation in human opinion on rangeland management between the vegetation types because of the climatic variation.

6. CONCLUSION

Identical communal grazing strategies at Magwiji lead to greater variation on vegetation parameters than in Upper Mnxe and Mnyameni because of low rainfall and spatially heterogeneous landforms in Magwiji than Upper Mnxe and Mnyameni. Magwiji is more subject to overgrazing because of lower rainfall which affects the species composition and biomass production, and steeper slopes which affect soil cover compared to Upper Mnxe and Mnyameni. Mnyameni will be affected by overgrazing because the landscape is more homogeneous and animals have easy access to the whole grazing area, selective grazing lead to reduction of decreaser species, however, at Mnyameni, the basal cover is affected by bush density, while aerial cover is affected by lower rainfall at Magwiji. Different soil chemical properties, soil organic carbon, and soil microbial activity are not affected by identical communal grazing strategies, however, soil physical properties are affected because of soil erosion and leaching potential due to slopes. The identical communal rangeland ownership leads to similar human opinion on communal rangeland resources condition and management. Intra-vegetation type heterogeneity in landscape, vegetation dynamics and inherent soil properties should be recognized in designing utilization, management, conservation, and degradation intervention programs. This further suggests that communal rangeland policies, grazing programs and vegetation restoration activities have to pay specific attention to vegetation types and landscape morphology. Future studies should examine the effects of landscape morphology on communal rangeland hydrology, characterize communal rangeland degradation in the Eastern Cape and assess the potential of the rangelands restoration and possible strategies to combat further degradation. Guided by the farmers' perceptions, the recommendation is that further study on consultative and participatory biophysical assessment of communal rangelands should be conducted. The traditional or perceptive indicators of assessing range condition by farmers should be investigated with relevance to the production objectives. Such indicators should be aligned with the scientific indicators to harmonize the technicality of science to the farmers' comprehension.

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APPENDICES

Appendix 1

Survey questionnaire on management of communal rangelands

Enumerator's name………………………… Date…………….. Village…………………..

Name of respondent……………………….. Questionnaire reference number…………

A. Household demographic information

	Relation to head	Age	Gender	Marital status.	Education	Occupation	Involvement in rangelands
A1.1							
A1.2							
A1.3							
A1.4							
A1.5							
A1.6							
A1.7							
A1.8							
A1.9							

Codes:

Relation to head: **1** Head, 2 Spouse /husband, **3** Child, 4 Grandchild, **5** Father or mother, 6 other

Marital status: (**S**) single (**M**) married (**D**) divorced or separate (**W**) widow

Education: **1** Preschool **2** Up to std 5, **3** Std 6-9 **4** Std 10 **5** Tertiary **6** None

Status: (**F**) farming (**H**) household wife, (**E**) employee (**P**) pensioner (**B**) business (**N**) no occupation (**S**) student

A2. Household size………….. Adults ………….. Children (less than 13 years)…….

A3. Sex of head of household……………………………………………………………..

A4. Do you belong to any farmers' organisation? Yes ☐ No ☐

a) If yes, which one?............................
b) If no, what are your reasons?..

B. RANGELANDS/GRAZING

B1. Do you have access to rangeland? Yes ☐ no ☐

B2. How did you obtain access?

By virtue of being resident in this community	
Through an application to the Tribal Authority	
Through an application to the village committee	
Local Authority	
Other (specify)	

B3. What threat do the neighbouring communities put to your rangeland?

……………………………………………………………………………………………

B4. How do you minimise neighbouring communities from utilising your resource excessively?

B5. At what time of the year would you experience a shortage in grazing?

…………………………………………………………………………………………..

B6. What could be the cause of such a shortage?...

B7. How is access to the grazing land controlled? By whom? Tribal Authorities ☐ Farmers Association☐ Farmers Union☐ No one☐ Other (specify)…

B8. Who monitors that users of the grazing land adhere to the rules and regulations?……………………….

B9. Rangeland is accessed for?

Uses	Yes/ No	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		
Collecting dry dung for cooking		
Other (specify) ………………………………………………………		

B10. Are there times of restricted access to rangelands Yes ☐ No ☐

B11. If Yes, Which month/s……………………………………………………………………..

B12. Are there any restrictions to quantities of harvested resources ………………………

B13. Does your community have grazing camps? Yes ☐ No ☐

B14. If yes, what is the purpose of camps?

……………………………………………………………………………………………..

B15. Who is responsible for ensuring that the grazing rules are

followed?……………………………………………………………………………………..

B16. Do you manage livestock movement during grazing?

a) Permanently (daily) YES / NO if yes, who?…………………
b) Monthly YES / NO if yes, who?………………...
c) In Summer YES / NO if yes, who?………………...
d) In Winter YES / NO if yes, who? ………………...
e) When rain comes? YES / NO if yes, who? ………………...
f) Free ranging? YES / NO if yes, who? ………………...

B18. What are the sources of water for your animals? (Tick one or more)

Borehole ☐ Dam/pond ☐ River ☐ Water well ☐ Spring ☐ Others (specify)………………………..

B19. What is the distance to the farthest water point?

At household ☐ < I km ☐ 1 to 5 km ☐ 6 to 10 km ☐ > 10 km ☐

B20. Do you have a problem of water for livestock drinking? Yes☐ no☐

B21. How would you describe the condition of the grazing?

Deteriorating- Very Poor Condition Little Grass	
Deteriorating -Poor Condition, but Some Grass	
Fair - Reasonable Amount of Grass	
Good - Plenty Grass	
Very Good-Improving	
I don't know	

B22. What has led to the current state of rangelands (tick one or more)? Grazing☐ Burning☐ Soil depth☐ Climate variation (e.g. drought)☐ Bush encroachment☐

B23. What is the reason for your answer above?...

B24. Comment on the availability of grazing in the different seasons of a year

Rainy season: Enough☐ Too little☐ Moderate☐ Too much☐

Winter: Enough☐ Too little☐ Moderate☐ Too much☐

B25. Do you give any supplementary feed to your animals? Yes☐ No☐ If yes:

a) At which time of the year?..................................
b) How often do you feed animals with supplementary feed?...

B26. Do you plant any fodder crops (e.g. rye, oats etc.) for supplementary feeding? Yes ☐ no☐

B27. Do you consider your soil Good☐ Fair☐ Poor☐ Very poor☐

B28. What is the reason for your answer above?..

B29. What control measures need to be put in place to ensure a sustainable utilization of the grazing resource?..

....

B30. What problems or constraints do you face in management of grazing areas?

....

....

B31. Do you receive any advice from extension services? Describe the type of advice.

....

....

B32. How has this advice impacted on communal grazing in the community?

....

....

B33. Do you use arable land for grazing purposes? Yes☐ no☐

If yes when and why?

When.................................Why...

....

B34. Are your grazing lands fenced? Yes☐ No☐

B35. If **yes**, who did the fencing....................................

B36. If **no**, do you need fences? Yes☐ No☐

B37. How would you describe the state of fencing in your grazing lands? Good☐ Bad ☐. If bad why?...

……………………………………………………………………………………………

B38. Is the community doing any repairs on fencing? Yes☐ No☐

If yes what type of repairs?..

B39. Who provides resources for repair of fences?...

B40. What is the condition/ level of erosion in your grazing lands? High☐, Average ☐

Low ☐ None ☐

B41. If high, do you apply any erosion control measures on your grazing lands? Yes☐

No☐

B42. What methods of erosion control measures do you use (Describe)?

…………………………………………………………………………………………

…………………………………………………………………………………………

B43. Is the control measure effective? Yes☐ no☐

B44. Give reasons for your answer above (1.34)

…………………………………………………………………………………………

B45. Is there any commercial or game farm near your community? Yes☐ No☐

B46. Are there any benefits your community derives from the game farm?

…………………………………………………………………………………………..

B47. How would gauge your knowledge on veld management?

…………………………………………………………………………

B48. Where did you gain this knowledge from?

………………………………………………………………

B49. Have you or the community ever had any training on veld management? Yes ☐ No

☐

B50. What kind of training would you or the community like to receive?

……………………………………………………………………………………………

B51. Give five suggestions which in your opinion can improve communal grazing areas?

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………