Sustainable Options in Communal Beef Cattle Grazing Systems in the Matatiele Local Municipality of the Eastern Cape, South Africa

by

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DECLARATION

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ABSTRACT

This study explores three communal beef cattle grazing systems practiced in the Matatiele Local Municipality. Beef cattle production in communal areas remains a potential source to increase the beef supply in South Africa. However, communal beef production faces challenges such as uncertain land tenure, forage shortage and lack of proper management. This leads to systems that are functioning below the optimum possible production level and contributing to environmental degradation, and that are often not economically viable. The identified communal beef cattle grazing systems are, modified the holistic planned grazing (HPG), continuous grazing, and rotational rest grazing. The systems were investigated in terms of their contribution to financial and ecological sustainability.

A mixed methods approach was adopted, where the meta-analysis study was conducted to determine the effects of continuous and rotational grazing systems on cattle weight gain and profitability. A case study research was adopted to collect data and techniques included interviews, focus group interview, grazing site observations, telephonic follow-up interviews and artefact identification. The data that was collected include information on how grazing systems are implemented and managed on a daily basis, financial and environmental status. An Ecological index methodology was employed to measure the impact of each grazing system on the environment, by measuring variables such as biomass production, percentage of litter, bare ground, potential grazing capacity, and the veld condition score of the grazing area.

The outcomes of the study indicated that the modified HPG system had an initial R94 602.00 capital investment in infrastructure needed to operate the system. Furthermore, the daily management of this grazing system is systematic, and key grazing management records kept included rangeland condition score, stocking rate and livestock numbers. The financial analysis indicated that the payback period is three years, assuming that everything remains constant and the farmers reinvest the revenue generated through sales of livestock into the system.

The absence of state support to farmers, led to the implementation of the continuous grazing system, because it requires minimum or no investment in infrastructure. This system is skewed in that the cattle are managed and not the grazing area. The rotational rest grazing system ensures that 25% of the grazing area is rested for a full growing season, while 75% is grazed on, but less attention is paid to cattle-stocking rate. The cost of implementing and managing this type of system required a budget allocation of R126 500.00, and no fencing infrastructure is needed to divide grazing camps.

The financial and ecological sustainability contribution of these grazing systems in the short term is variable. The modified HPG and Rotational rest grazing systems depend on external funding to cover operational costs and cattle stocking rate that are above the grazing capacity also degrades the environment. However, hypothetical scenarios indicate that in the long run all these system have potential to be financially viable as a result of improved veld condition. The findings of the study agree with the literature review in that the outputs of both the continuous and the rotational grazing management systems are area-specific.

OPSOMMING

Hierdie studie ondersoek drie gemeenskap vleisbees weidingstelsels in die Matatiele Plaaslike Munisipaliteit. Vleisbees produksie in gemeenskap areas is steeds ‘n potensiale bron om beesvleis aanbod te verhoog in Suid-Afrika. Gemeenskap beesvleis produksie het egter spesifieke uitdagings naamlik; onseker grondgebruiksreg, weidingstekorte en ongewensde bestuur. Dit veroorsaak dat stelsels nie optimale produksie lewer nie en dra by tot omgewings agteruitgang en is dikwels nie finansieel haalbaar nie. Die geïdentifiseerde stelsels is; die aangepasde holistiese weidingstelsel, die aaneenlopende stelsel en geroteerde rus stelsels. Die stelsels is evalueer volgens bydra tot finansiële en ekologiese volhoubaarheid.

Verskeie metodes is geïmplementeer, ŉ meta-analise is gebruik om die effek van aaneenlopende weiding en wisselweiding te bepaal op gewigstoename en winsgewendheid. ŉ Gevallestudie navorsings benadering is gebruik om data in te samel en tegnieke soos onderhoude, fokusgroep-besprekings, veld observasies, telefoniese onderhoude en artefak identifisering is gebruik. Die data wat ingesamel is sluit in; die aard van die weidingstelsels, die bestuur van weidingstelsels, finansiële en omgewings status. ŉ Ekologiese indeks metode is gebruik om die impak van elke weidingstelsel te meet aan die hand van sekere ekologiese indikatore soos biomassa, persentasie strooi, kaal-grond persentasie, potensiële weidingskapasiteit en weidings-toestand telling. Die uitkoms van die studie dui aan dat die aangepaste holistiese stelsel ŉ aanvanklike kapitale invetsering benodig van R94 602.00 in infrastruktuur. Die daaglikse bestuur van die stelsel is sistemies van aard en sleutel rekords word gehou aangaande veld toestande tellings, veeladings en veegetalle. Die finansiële ontleding dui daarop dat die terugbetaal tydperk drie jaar is, met die aanname dat alle komponente gehandhaaf word en dat herinvestering deur die produsente wel plaasvind van fondse gegenereer uit die veestelsels uit.

Die afwesigheid van owerheid ondersteuning aan die produsente het gelei tot die aaneenlopende weiding stelsel aangesien dit geen ekstra investering verg nie. Die prestasie van die stelsel word skeefgetrek omdat die beeste bestuur word en nie die veld nie. Die rotasie weidingstelsel verseker dat 25percenmt van die area elke jaar vir die volle jaar gerus word en 75 persent word aangewend vir weiding, daar word egter nie baie aandag aan drakrag gegee nie. Die implementering van die stelsel benodig ŉ aanvanklike investerings behoefte van R126 500.00, omheinings is egter nie nodig in die geval nie.

Die finansiële en ekologiese bydra van die verskillende stelsels tot volhoubaarheid is wisselvallig oor die korter termyn. Die aangepaste holistiese weidingstelsel is afhanklik van eksterne finansiering bronne om investerings en bestuurkoste te dek. Die veegetalle wat tans in plek is, is bo

die natuurlike drakrag vir die omgewing. Die hipotetiese scenario wat veldtoestandverbetering simuleer dui egter daarop dat al die stelsels oor die langer termyn finansieel beter behoort te vaar. Die gevolgtrekkings dui egter daarop dat, in ooreenstemming met die literatuur, aaneenlopende weidingstelsels en rotasie weiding-stelsels se effektiwiteit area spesifiek is.

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ABBREVIATIONS

AU	Animal Unit
AIP	Alien Invasive Plant
DAFF	National Department of Agriculture, Forestry and Fisheries of South Africa
FAO	Food and Agriculture Organisation of the United Nations
FFMS	Farm Financial Modelling System
TED	Technology, Entertainment and Design
UCPP	uMzimvubu Catchment Partnership Programme
IDP	Integrated Development Plan
BML	Business Modelling Language
TGS	Tradition Grazing System
PLAAS	Programme for Land and Agrarian Studies
MLM	Matatiele Local Municipality
NGO	Non-governmental organisation
DPM	Disc Pasture Meter
SME	Subject Matter Expert
GVA	Rangeland Assessment
GC	Grazing Capacity
GDP	Gross Domestic Product
RCS	Rangeland Condition Score
LAU	Large Animal Unit
BFAP	Bureau for Food and Agricultural Policy

Chapter 1: Introduction

1.1 Background

The production of livestock in the world is expected to increase to more than twice its current proportion by 2050 (Steinfeld *et al.*, 2006; Ilea, 2009). The livestock sector contributes 40% of the global gross domestic product of global agriculture (Steinfeld *et al.*, 2006). Expansion in human population and workforce, decreasing land production capabilities due to ecological stress and climate change have significantly compromised food security (Rao, 2009). According Nhamo (2013), governments and organisations that are prepared for an economy aimed at reducing environmental degradation must invest sufficient resources to address the main pillars of sustainable development namely environment, society and economy. In South Africa (SA), cattle production increased by 2% from 2002 to 2012 (National Department of Agriculture, Forestry and Fisheries, 2013). However, the supply of meat is still below the national demand. An increase of 2% cattle production is ascribed to the availability and accessibility to the necessary facilities and technologies (National Department of Agriculture, Forestry and Fisheries, 2013).

An estimated 80% of the agricultural land in SA is suitable for extensive grazing (National Department of Agriculture, Forestry and Fisheries, 2013). Extensive grazing is characterised by each animal grazing on a large area, with low labour and capital requirement (Allen *et al.*, 2011). The estimated 80% of land suitable for extensive grazing may give the impression that an extensive beef cattle production system contributes significantly to the total supply of beef cattle in the country, since the agricultural land is conducive for this system to operate. However, 65% to 75% slaughtered cattle are rounded off in feedlots, i.e. within an intensive cattle production system. The extensive system supplies the feedlot (intensive) system with beef cattle as weaners that are calves aged six to eight months, tolly are year old calves, and steers are two years old. These animals are sold to the feedlot in order to bulk-feed them for weight gain as required by the market.

There is an obvious dependence on the feedlot sector in an extensive system, and this indicates that primary cattle production at farm level plays a crucial role in the beef supply chain. This extensive system does not exclude integrated approaches where crop residues and some supplemental feeds (e.g. protein licks, Lucerne bales, etc.) are used. It can be argued that other alternative ways exist, as it is the case that ‘crop residues are becoming more important elements in raising livestock and fattening penned livestock to be profitable’ (Tiffen, 2006).

The National Department of Agriculture, Forestry and Fisheries (2013), recognizes three sectors of cattle producers, namely: communal, commercial and emergent. Commercial farmers own an estimated 60% of cattle in SA and 40% are owned by emergent and communal farmers. Unlike commercial farmers who farm on private land, the communal and some of the emergent farmers share land for grazing their livestock. Despite owning almost half of the cattle in SA, off-take is much lower than its potential due to farming challenges experienced in communal areas. A study in SA, found that the top three limiting factors to cattle production for all communal farmers were feed shortage, diseases and parasites (Mapiye *et al.*, 2009). One of the challenges of the South African red meat industry is thus to overcome these limitations and create market conditions that are inclusive of communal farmers. This is important in the South African context in order to reduce dependency on beef imports from other countries, and also for improving the living standard of rural communities. To partially address these challenges that communal farmers face, the government committed R7 billion throughout the provinces in the form of conditional grants aimed at supporting 435 000 subsistence and 545 000 smallholder farmers (Gordhan, 2014). However, the question remains as to whether grants are sufficient without proper recommendations on improved livestock and rangeland management.

Besides livestock supplements, vaccinations and other medication, the quality of livestock from communal areas can be improved via improved forage and hence improved rangeland management. Another possibility is the improvement of livestock for market via a rounding off/finishing period, e.g. via a feedlot. This thesis will focus on the former, i.e. rangeland management. The most common grazing system on communal land tenure areas in SA is the open access, continuous or season long grazing system (Bennett & Barrett, 2007), the concept of 'open access' is explained in Chapter 2 see (section 2.2) (Adams *et al.*, 1999).

An NGO called Conservation SA is currently working with communal and private farmers within the uMzimvubu Catchment Partnership Programme (UCPP), a multi-stakeholder platform comprising practitioners, NGOs, government, industry, retailers and researchers. The NGO partners within the UCPP, represented by Conservation SA, are contractors to government and are implementing agents for government investment in natural resource management (NRM) in the area. Conservation SA has trained one community on Holistic Planned Grazing (HPG) based on formal community mobilization process, while another NGO, Lima, has guided another community back to the use of the traditional rotational rest system. As such, the NGO partners wish to supply farmers with the best possible advice concerning rangeland management for improved rangeland and livestock health, with the ultimate aim of improved and sustainable livelihoods. For this reason, the NGO has implemented a program of research around livestock management systems, of which this thesis forms a part. The larger research programme focuses on private and communal areas within the Matatiele Local Municipality in the Eastern Cape.

Different types of grazing management for cattle production have both advantages and disadvantages. Briske *et al.* (2008), argue that the rotational grazing system is still the most recommended and practiced grazing strategy. Grazing experiments, however, often show that rotational grazing results in similar production when compared to continuous grazing on rangelands (Heady, 1961). Within the rotational grazing systems, a particular approach called Holistic Management® (Savory 1983; Butterworth,1985; Butterfield *et al.*, 2006) has attracted controversy for the last 40 years. An important feature of Holistic Management® (HM) when applied to livestock farming is Holistic Planned Grazing (HPG). The HPG approach aims to increase forage utilisation by concentrating livestock into camps, generally with a short duration and, depending on the aim of the community, a high intensity (cattle density). Recently, the Savory Institute developed a community mobilization strategy, for engaging with poorly-resourced communal farmers regarding HPG (http://www.savoryinstitute.net/).

In this study we had the opportunity to assess the efficiency of a communal area that had been practising a form of modified HPG for one year. In this area, farmers used mobile electric fences and herders to form the camps, and beef cattle were rotated in short duration for seven days. Besides the HPG system, a community was assessed that had reinstituted the traditional 'rotational rest' beef cattle grazing system for the past year. Lastly, a community that continued to use a continuous grazing system that has been practised for more than two decades, using herders only, was also assessed.

This research study is part of the larger research project "Does Holistic Planned Grazing work in the Grasslands?". The wider study includes animal and rangeland production, biodiversity loss, erosion and runoff. The economic aspects, and environmental impacts of livestock farming (land degradation and methane production, Ilea, 2009), overgrazing, soil erosion, climate change and loss of biodiversity and ecosystem services) are needed to evaluate all costs (including externalities) and efficiency of the selected livestock grazing systems. However, the measurement of externalities is beyond the scope of this study and the costing was restrict to those available from agricultural inputs and outputs. The focus of this study is on the contribution of selected communal beef cattle grazing systems on ecological and financial sustainability. Factors that contribute to sustainability include the sphere of the ecological, social and economic aspects. For the purpose of this study, the focus was not on the sociological aspect since it forms part of the wider study for the Matatiele Local Municipality and is dealt with in other research studies conducted by other students who are part of the project. However, a mixed methods approach was adopted as a broad methodological framework for this study and this framework included sociological methodology (see Chapter 3).

1.2 Research question

Do the different management regimes of the selected communal beef cattle grazing systems (continuous, rotational rest and modified HPG) in the Matatiele Local Municipality contribute positively to financial and ecological sustainability?

1.3 Overall objective of the study

The main objective of this study is to determine if different communal beef cattle grazing systems can contribute positively to financial and ecological sustainability in the Matatiele Local Municipality area.

1.4 Specific objectives of the study

1. To determine financial costs for implementing each grazing system in the communal area.
2. To determine the operational costs for managing each grazing system as well as the returns realised.
3. To determine the ecological impact of each grazing system on the grazing area.

1.5 Division of thesis chapters

This thesis comprises five chapters as follows:

<u>Chapter One: Introduction</u>

<u>Chapter Two: Literature Review</u>

This chapter will cover the background of communal beef cattle farming, ecological impacts, the economic context, a meta-analyses study of the previous and current studies that compared the continuous and rotational grazing systems in terms of cattle weight gain and profit, social benefits, the role of institutions, and the sustainability of communal beef cattle grazing systems.

Chapter Three: Material and Methods

In this chapter, a meta-analysis method will be covered, followed by the description of the research study site, case study research method, rangeland condition assessment methods and mathematical equations used for computing the theoretical income value due to improved veld condition.

Chapter Four: Case study results and discussion

Three case study research reports inclusive of rangeland condition assessment data will be presented as well as an integrated analysis of the three case studies.

Chapter Five: Conclusion, summary and recommendations

In this chapter, the outcomes of the research study will be concluded, summarised and recommendations made.

Chapter 2: Literature review

2.1 Introduction

In order to understand firstly, the principles of various grazing systems, and secondly, the measurement instruments available for assessing them, an in-depth review of appropriate literature is required. The purpose of this chapter is to review the peer-reviewed literature on cattle grazing systems. This chapter provides a theoretical framework for the subsequent gathering of data in the field (Chapter 3). The topics covered in this chapter include some background on communal grazing systems and their application in SA, ecological impacts of grazing systems, the economic context of communal grazing systems, effects of the continuous and rotational grazing systems on cattle weight gain and profit. The background section explains the context of communal beef cattle grazing systems, the theoretical base for this research and clarifies concepts introduced in Chapter 1.

Each of the three grazing systems will be explained in terms of their goals and possible benefits. The environmental impacts associated with the grazing systems will be discussed. The social benefits and economic context under which communal grazing systems operate will also be discussed in order to expose the uniqueness of the rural context. A brief quantitative literature review will be conducted to determine the effects of the continuous and rotational grazing systems on cattle weight gain and profit. The role of institutions in supporting communal farmers will be discussed by looking at governance systems in place and key stakeholders influencing the functioning of communal beef cattle grazing systems.

2.2 Background to communal beef farming

Extensive livestock grazing is a common form of land use in Sub-Saharan Africa (Yayneshet *et al.*, 2009). According to the National Department of Agriculture, Forestry and Fisheries (2013), in SA 80% of cattle are used for beef and 20% for dairy production. Furthermore, an estimated 80% of agricultural land in SA is suitable for extensive grazing. The legacy of land dispossession in SA during the early 20th century resulted in land being unevenly distributed among races. According to Van Wyk (2013), this resulted in the minority population owning 87% of the land, whereas the majority population had only 13%. Furthermore, the latter group mostly find themselves in a communal type of land tenure (Van Wyk, 2013).

Lahiff (2007), argues that the process of equitable land redistribution is slow-paced in post-Apartheid SA. According to Cousins (1996), disagreements about livestock and rangeland resources partially have their origin in inequitable dissemination of land. Cousins (1996) explained that Apartheid and segregation policies were contributing factors to conflicts over livestock and rangeland. Additionally, the varied range of livestock uses within the dynamism of multi-faceted social diversity and livelihood systems also play a role in the complexity of challenges experienced in managing communal resources.

In rural areas of SA, livestock has multiple uses, of which the greatest component is own consumption. Other uses include payment of Lobola and slaughtering during funerals (Cousins, 1996). Lobola is an indigenous cultural practice in SA, where a bridegroom asks for the blessings of the bride's parents in exchange for a number of cattle requested by the bride's family. The practice of slaughtering for funerals, is done to ensure enough red meat for all the people attending the funeral.

Traditionally, cattle grazed near the homestead, but away from crop fields. This was done when there was sufficient grass and water available to feed the animals (Verlinden *et al*., 2007). The population growth in communities and an expansion in herd size increased the need for space, water and forage. The outcome was competing land use practices that included cattle feeding on field crops, produced for human consumption. Verlinden *et al*. (2007), stated that the frontier of the traditional land expansion was reached, meaning that the demarcation land by tribes or other methods limited movement of livestock to other areas that have ample grass for grazing. Other factors that have contributed to the reduction of the grazing land size include expanding human settlements, mining, cropping, forestry and conservation (National Department of Agriculture, Forestry and Fisheries 2013).

Most communal farmers are challenged to find alternative ways to best manage their available grazing land in ways that can also support that part of their livelihoods that is dependent on livestock production. Hardin (1998), explains the concept called 'tragedy of the commons' as follows;

'Picture a pasture open to all. It Is expected that each herdsman will try to keep as many cattle as possible on [this] commons....What is the utility...of adding one more animal?....Since the herdsman receives all the proceeds from the sale of the additional animal, the positive utility [to the herdsman] is nearly +1,.,,Since, however, the effects of overgrazing are shared by all the herdsmen, the negative utility for any particular decision-making herdsman is only a fraction of -1 . Adding together the... partial utilities, the rational herdsman concludes that the only sensible course for him to pursue is to add another animal to [the] herd. And another; and another.... Therein is the tragedy. Each man is locked into a system that [causes] him to increase his herd without limit-in a world that is limited....Freedom in a commons brings ruin to all.'–G. Hardin, "The Tragedy of the Commons," Science **162**,1234 (1968), p, 1244

Source: (Hardin, 1998)

The major constraint for continuously grazed systems is that the rangelands have finite natural resources to accommodate a limited number of livestock. The analogy given about a 'pasture open to all' to graze their herd is an accurate depiction of how communal farming areas operate. 'All' in this context would mean tribal members of that community. It is, however, acknowledged that Adams *et al.* (1999) describe the phrase 'The commons' as having two meanings, namely 'controlled access' and 'open access'. The distinction being that the former (controlled access) refers to a commons in which a group exercises control over the pool of resources and has power to exclude non-members. The latter term (open access), refers to the commons in which there is no access control exercised. It is the 'open access' type of commons that Hardin (1998) refers to. Even the 'controlled access', if control measures are not fully functional, it may be subject to the tragedy of the 'open access' commons. Not all "open access" systems are categorically accepted as scenarios that lead to the tragedy of the commons as depicted by Hardin (1968). In comparing different cases of tenure systems across the world, Ostrom (1998) found that "the commons" are usually governed by sets of rules, agreements and sanctions that ultimately lead to regulation of the natural resource, whether intentional or not. The argument is thus that there are means of governance around the management of commons, some of them often overlooked in tenure systems that do not fully recognise or subscribe to more traditional management regimes. For this reason, and for the contextualisation of this research, the role of institutions are also considered in more detail in Chapter 2 (section 2.7).

Many households in rural areas are reliant on natural resources for subsistence with little option for alternative livelihoods (Harrison & Shackleton, 1999). Hence, interventions have focused on improving the natural resource base within communal livestock farming areas, namely the rangeland, via improved grazing systems. Vallentine (1990) refers to a grazing system as a method used to decide how grazing and non-grazing periods are organised during a grazing season within a year or beyond.

2.3 Beef cattle grazing systems and their application in SA

A total of 61% of the land in Africa is used for grazing purposes (Næss, 2013). Bennett *et al.* (2007), identified three grazing management systems found in communal areas across Africa. These include; open access grazing, grazing controlled by the community, and grazing that takes place on private land controlled mainly by the land owner. These grazing systems may qualify to be regarded as extensive grazing systems, depending on whether each animal grazes on a large area, and low labour and capital are employed in the grazing management (Allen *et al.*, 2011). In describing these grazing management types, Bennett & Barrett (2007) emphasise land tenure systems, rather than the technical aspects of grazing management. Booysen (1967), gives a comprehensive breakdown of the types of grazing management that are in use in SA within the different land tenures. These include; (1) rotational grazing, (2) rotational resting, (3) rotational grazing and resting, and (4) zero grazing. An additional type of grazing management is continuous or seasonal long grazing (Howery *et al.*, 200). There are innumerable ways for implementing each of these grazing management types, and each specific manner of application is referred to as grazing system (Booysen, 1976).

Briske *et al.* (2008b), identified the following variations of a rotational grazing system; deferred, rest, high intensity and Holistic Planned Grazing systems. These grazing systems promote resting of grazed areas for a certain period so that the pastures may regrow. Other variables considered when planning a rotational grazing system include paddock size, rangeland type and season of the year (Gadzirayi *et al*., 2007) as well as stocking rate. The advantage of the rotational grazing system is that it allows areas to be rested while others are being grazed, and thus forms an effective management system for ensuring that there is forage during winter season.

In contrast to rotational grazing systems, a continuous grazing system requires less managerial skills and inputs for its operation because the livestock graze freely with no or little restriction. With rotational grazing system, management input is essential to ensure that the movement of the livestock is restricted to comply with the grazing plan. A grazing system in which managerial inputs are applied to a high degree, increases the chances of that system performing better in term of higher livestock production and management of the grazing area than the one in which less or no management is applied (Briske *et al*., 2008b).

A management system is the process of balancing the farming expectations of livestock owners in relation to the natural resources in that environment (Scogings, de Bruyn *et al*., 1999). Undersander *et al*. (2002), argue that the establishment of management goals is the first step for initiating a grazing system in a farm environment. The impacts of these grazing systems on the environment are variable. It depends on the vegetation type, number of animals on the land, the size of the grazing land, annual rainfall and rainfall distribution, and principles of management adopted. The comparison of these systems is usually with reference to a particular variable. Most studies focused on either one of the following aspects; economic, ecological or social implications (Briske *et al*., 2008a, Gillespie *et al*., 2008, Quiroga *et al*., 2009). There was a limited number of studies that focused on two or more of these aspects simultaneously in a more inter-disciplinary manner. An outline of the distinguishing characteristics and conditions favourable for implementing each grazing system are given (Table 2.1).

Table 2.1: The distinguishing features and applicable conditions in various grazing systems used in the Western USA and Canada

Types of grazing system	**Distinguishing features**	**Applicable (environmental) conditions**
Continuous or Season-long	Continuously graze an area the entire year (continuous), or the entire growing season (season-long);	Flat, well-watered rangeland, where most plants have similar grazing value, with a uniform precipitation pattern that encourages regrowth… also, may be applicable in some areas of the California annual grassland
Deferred-rotation	Periodically defers each pasture in the rotation. Animals are rotated through the other pastures on a seasonal basis.	Distribution problems where animals habitually overuse "convenience areas" (e.g. riparian areas), or where there are multiple use objectives.
Rest-rotation	Periodically tests each pasture in the rotation for 12-months. Animals are rotated through the other pastures on a seasonal basis	Generally, same criteria as deferred-rotation.
Santa Rita	Modification of the rest-rotation system where each pasture receives rest during both the early spring and "summer-monsoon" growing periods two out of every three years.	Semi-desert grassland where forage production is irregular and heavily influenced by " summer monsoons" and winter precipitation.
Seasonal suitability	Diverse vegetation types are partitioned and grazing rotation is managed based on seasonal changes in forage production.	Diverse vegetation types that can be partitioned and managed as separate units based on seasonal differences in plant phenology, forage quantity, and forage quality.

Best pasture	Matches cattle movements to vagaries of forage production due to irregular precipitation patterns or disparate ranges (ecological) sites.	…Irregular forage production due to spotty precipitation patterns, grazing areas that require special management due to species differences in forage production and/or resistance to grazing.
Holistic Planned Grazing (HPG), short duration, mob, cell or similar systems	Frequently rotates a single cattle herd through multiple pastures allowing for relatively brief periods rest in previously grazed pastures. Use levels are typically heavy due to increased stocking rates and stock densities.	Generally, the same criteria as the continuous and season-long (typically divided in several paddocks or cells, each of which may receive more than one period of non-use and grazing during a single growing season), This system typically requires more capital investment and labour than other grazing systems.

Modified from Howery *et al.* (2000)

Many researchers and practitioners have used the HPG system with some modification (Olsen & Malechek1988; McCollum *et al.*, 1999; Popp *et al.*, 1997). The HPG and modified HPG systems require more capital investment and higher labour inputs when compared to other systems. Sebina (1999), argue that putting a fence around a communal grazing area accompanied by precise management can reduce degradation of natural rangelands. Undersander *et al.*, (2002), stated that fencing is compulsory for a rotational grazing system, whether permanent or movable. A permanent fence is usually used to encircle the circumference of the farm, whereas, a mobile one is often used for single paddocks. However, practitioners, particularly in communal systems, use herders instead fencing (e.g. at Africa Centre for Holistic Management in Zimbabwe).

The descriptions of grazing systems (Table 2.1) refer to the United State of America, but they are also applicable to the SA context. According to Booysen (1967), different countries may use various terms to refer to the same grazing management types. In the communal areas of SA, continuous grazing is the most common type of grazing system. This is followed by rotational grazing in areas that receive support from the government or other civil society structures, because of the relatively high costs of implementation. The season long grazing system is known as rotational rest grazing system.

2.4 Ecological impacts of communal beef cattle grazing systems

The misuse of common-pool resources is a problem worldwide (Briske *et al.*, 2008b). The outcomes of some of the livestock activities, such as overgrazing, compaction and erosion, are commonly thought to be responsible for the degradation of 20% of the world's pastures and rangelands (Steinfeld *et al*., 2006). Degradation is poorly defined but generally refers to overall changes in landscape properties compared to some reference point (Abel & Blaikie, 1989). Hoffman & Todds (2000), described veld degradation by breaking it down to six main types, namely, loss of cover, alteration in species composition, bush encroachment, alien invasive plant invasion, deforestation and others not included in the fore mentioned types. Rangeland degradation is also referred to as a decline in palatable plant species and an increase in non-palatable plant species, and a decline in perennial grasses and an increase in annual grasses and shrub encroachment (Abel & Blaikie, 1989), erosion, and invasion by alien species, all of which have a negative impact on the quality and quantity of forage (Brooks, *et al*., 2004). Another definition state that rangeland degradation is a state in which the 'natural processes will not rehabilitate the land within a timescale relevant to humans (effectively)' because of the 'permanent decline in the rate at which the land yields livestock products under a given system of management' (Abel & Blaikie, 1989).

An understanding of the relationship between changes in vegetation cover and grazing is essential to finding more sustainable rangeland management strategies (Bradley & O'Sullivan, 2011). According to Steinfeld *et al.* (2006), the environmental impacts per unit of livestock production can be minimised by decreasing the livestock numbers to half in order to reverse the damage caused. According to Abel & Blaikie (1989), the management of the stocking rate is more important than choosing a particular grazing system to influence the productivity of animals and secondary productivity of the land.

Gillespie *et al.* (2008), found that the reasons for rotational grazing system to be preferred over a continuous grazing system are generally for conservation benefits that relate to soil and plant species, and subsequently, ecosystem goods and services. Moreover, the rotational grazing systems reduce the chance of overgrazing. Norton (1998), states that rotational grazing controls the rate of plant defoliation, whereas continuous grazing causes patches and destruction of grazing land. Undersander *et al.* (2002), argue that in either grazing system (continuous or rotational), selective grazing is possible as animals naturally select forage to meet their nutritional requirements. Again, stocking rate is seen as the variable that determines whether animals will graze less or more selectively, rather than this depending entirely on a particular grazing system (Abel *&* Blaikie 1989).

The results obtained from a meta-analysis study that investigated the impact of communal livestock grazing on the environment, specifically vegetation and soil, concluded that the effects of grazing systems are area specific. This is because of variation in terms of vegetation, soil, rainfall and elevation (Yayneshet *et al.,* 2015) are often more important in determining production than management systems (Vetter & Bond, 2012).

In SA, the type of rangeland (locally called 'veld') also determines the acceptable period for grazing, based on whether it is a sour-rangeland or sweet-rangeland (Booysen, 1967). Moreover sour-rangeland produces unpalatable vegetation upon reaching maturity, effectively excluding that area of the rangeland for a portion of each year. Sweet-rangeland remains palatable even upon maturity, allowing grazing at all times of the year. In a study investigating the seasonal dynamics of cattle production in the sweet and sour communal rangelands, it was found that cattle production declined in the sour rangeland during the cool-dry and wet seasons. The study further indicated that households located in sweet-rangeland areas had a greater production efficiency compared to those in sour rangeland areas (Mapiye *et al.,* 2009).

2.5 The economic context of communal beef cattle grazing systems

The livestock sector generates 1.3 billion jobs, and one billion poor people in the world are dependent on this sector for their livelihoods (Steinfeld *et al.,* 2006). The resource-poor land-users make up the majority of communal farmers, and make a significant contribution to local meat supply. On a global scale, the involvement of developing countries in markets is essential to agriculture and rural development (Ndoro & Hitayezum, 2014). In a communal context, it is important that an examination of the economic situation be inclusive of a variety of aspects that are considered valuable by poorly-resourced farmers (Scoones, 1992), e.g. cultural and ceremonial value of livestock; livestock for own use.

According to the National Department of Agriculture, Forestry and Fisheries (2013) report, livestock production is increasingly economically viable compared to other agricultural sectors due to the enhancement brought by new technology. Change in market structures such as new knowledge of production, and organized red meat industry structures such as the Red Meat Industry Forum (RMIF) further contribute positively. Despite these positive changes, challenges persist. Ndoro & Hitayezu (2014), define livestock as being a 'highly productive and prestigious asset' for smallholder farmers. Despite this, communal livestock farming systems are characterised by a lack of access to capital. This is mostly due to a lack of collateral (Ndoro & Hitayezu, 2014). Intervention to improve the overall well-being of communal farmers requires investment in education and training, and awareness about the latest technologies and best practices in breeding and veterinary services (Sikhweni *et al.*, 2014). Poorly resourced farmers depend on ecosystem services, e.g. forage, water, wood for fuel and building, medicine (Dembélé *et al.*, 2006; Archer & Predick, 2014; Kala, 2000). For this reason, it is also important that they manage their resource base well.

Usually by default communal farmers produce beef using free range (unrestricted movement of cattle to graze the rangeland) production methods and mostly without added fodder, licks or other agricultural inputs. Grassland is one type of rangeland and it is predominant in the Eastern Cape Province. Since there is a growing demand for grass-fed beef (Gillespie and Nhring, 2013) communal farmers could take advantage of this. However, a challenge of the beef cattle value chain is the absence of market conditions conducive for emerging producers to commercialize grass-fed beef (Labuschagne *et al.*, 2011).

Campbell *et al.* (2000), argue that rural (pastoral) systems are more economically rewarding than other non-rural systems (e.g. commercial systems where feed inputs are bought from external suppliers). This can be attributed to the fact that rangeland based livestock farming systems are minimally exposed to the dynamics of the market, such as fluctuations in (maize) feed prices (Bernués *et al.*, 2011). In the case of SA communal beef cattle grazing systems, very few agricultural inputs are used compared to alternative systems, such as private and commercial grazing systems, and in the extreme case, feedlot systems. The feedlot systems are affected by the price of grain (BFAP, 2013) and the numerous market forces that determine the price of animal feed.

The communal systems are more vulnerable to environmental, climatic and seasonal changes. This is so because of poorer nutritional base and/or lack of grazing reserve and supplemental fodder, and hence results in reduced resilience of cattle to climatic stress (Mapiye *et al.*, 2009). South African commercial farmers in summer rainfall areas have identified winter season to be a limiting factor on the availability of important livestock production resources. To manage this situation they depend on planted pastures and concentrates, in extensive conditions, such as licks (Scogings *et al.*,1999*)*.

The communal livestock farmers experience the same challenges of insufficient quantity and quality of rangelands during the dry season (Scogings *et al.,* 1999). Grazing areas which provide palatable plant species for a portion of the year consist of sour rangeland (Booysen, 1967). Thus dry season usually have detrimental effects on communal livestock farming systems (Milton *et al.,* 1994), because the depend on ecosystem goods and services provided by the grazing area, primarily forage.

Finally, inadequate control of stocking rate in the communal areas hampers the success of communal farmers to become consistent commercial producers (Tilburg *et al*, 2011). According to Quiroga *et al.* (2009), a positive economic result can be realised when a rotational grazing system has a moderate stocking rate. Stocking rate is therefore an important aspect of grazing systems that has to be controlled in order to maximise cattle production, which in return increases profitability.

The lack of consistency in meat quality further impedes emergent farmers to transition from trading in informal to formal markets (Labuschagne *et al.,* 2011). Beef cattle reared on natural grazing amass at a lower rate than those that produced by commercial farmers. This is because the commercial farmers provide a higher nutrition base from natural rangelands with some additional inputs such as licks and hay. In addition, livestock from better systems do not travel long distances in search for feed and water. Communal livestock farmers rely on natural rangelands as the main source of feed for their livestock.

Profitability is ‘function of a variable stocking rate, animal performance, income and expenses’ (Dunn *et al.*, 2010). Quiroga *et al* (2009), state that economic benefits of a beef cattle grazing system can be determined by calculating the difference between the production input costs (expenditure) and revenues generated from sales of livestock. However, this is not a straight forward process for communal livestock farmers, because of the lack of production records (Mapiye *et al.*, 2009).

The evaluations of the ecosystem services and goods such as those provided by the grazing land may be daunting to express in monetary terms. However, for the purpose of this study the ecosystems good and services refers to forage. The labour requirements for rotational grazing system are higher when compared to a continuous grazing system when they both have similar stocking densities (Gillespie *et al.*, 2008). In financial terms, this implies that a rotational grazing system may incur higher labour costs compared to a continuous grazing system.

2.6 A meta-analysis study comparing the cattle production and profitability from continuous and rotational grazing systems

A quantitative literature review was conducted to determine the effects of continuous and rotational grazing systems on cattle production in terms of weight gain and profitability in a global context. The meta-analysis was conducted to inform the current study in a quantitative manner. The results presented below were acquired by following the meta- analysis protocol that is presented in Chapter 3 (see section 3.1.1 to 3.1.3). Profitability in this case refers to revenues generated from the sale of livestock from either system. The effects of the continuous and rotational grazing systems to cattle production and profit is an essential evaluation for determining which system is production orientated and consequently profitable.

Three studies that compared continuous and rotational grazing systems with respect to profit generation were statistically analysed using meta-analysis (Figure 2.1). In addition, 22 other studies that compared continuous and rotational grazing systems with respect to cattle weight gain in kilograms per hectare and daily weight gain in kilograms per head at the same stocking rate were also analysed using meta-analysis (Figure 2.2 and 2.3). The outcomes of these studies are presented using Forest plots (Figure 2.1, 2.2 and 2.3). The overall effect size in the three Forest plots are only significant if the width (confidence interval) of the diamond crosses the line of no effect.

The dashed vertical line indicates the mean and the solid vertical line indicates the ‘line of no effect’, and its value is zero as indicated on the x-axis (Figure 2.1, 2.2 & 2.3). The P-value indicates the significance level of the heterogeneity index (Cochrans Q and I2). All the studies with negative treatment effect sizes are on the left side of the line of no effect, and those with positive effect sizes appear on the right side. The 95% confidence intervals (CI) are represented with solid horizontal lines and Weight indicates the weight in percentage that was computed using the quality score system see (Table 3.1) in Chapter 3. The overall effect size is significant at P = 0.05 when the width of the diamond (indicating 95% CI) does not cross the line of no effect.

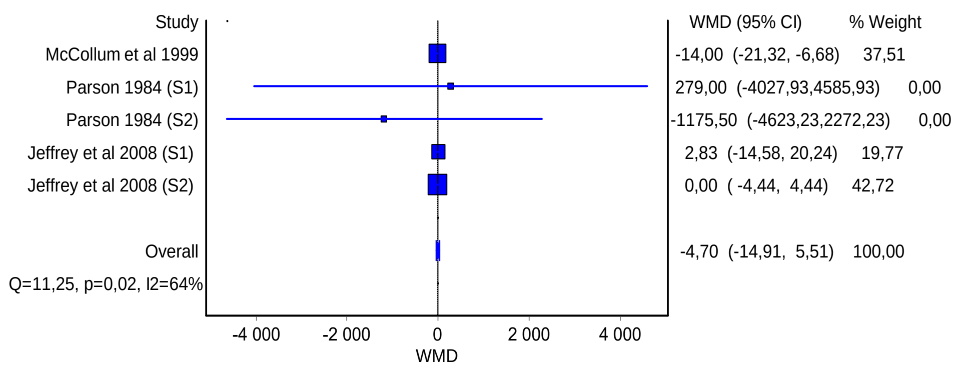

Figure 2.1: Forest plot indicating the comparison of the effects of continuous and rotational grazing systems on revenue generation.

As indicated in Figure 2.1, there was no difference between continuous and rotational grazing for profit/revenue generation, at a P-value of <0.05.

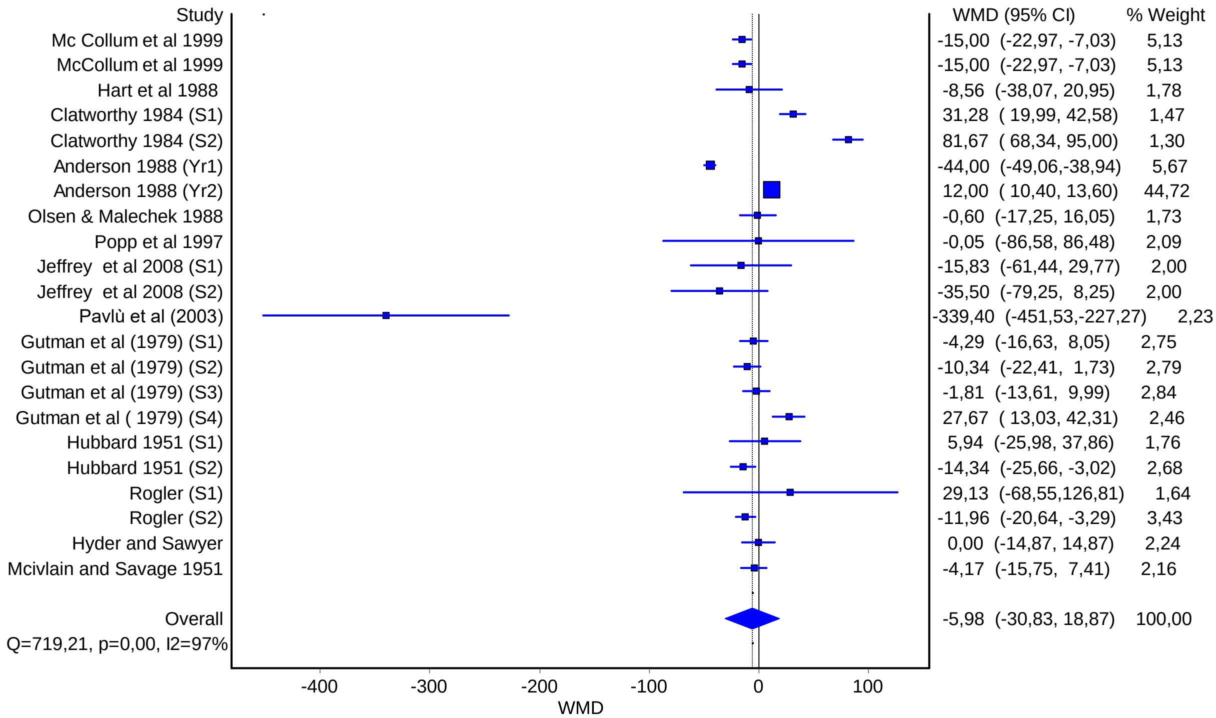

Figure 2.2: Forest plot indicating the weighted mean difference (WMD) in terms of cattle weight gain (kg ha^{-1}) between continuous and rotational grazing systems based on 11 studies presented on the left side of the y-axis.

Figure 2.2, indicates that there was no difference between continuous and rotational grazing for cattle average weight gain (kg ha^{-1}), at a P-value of < 0.05.

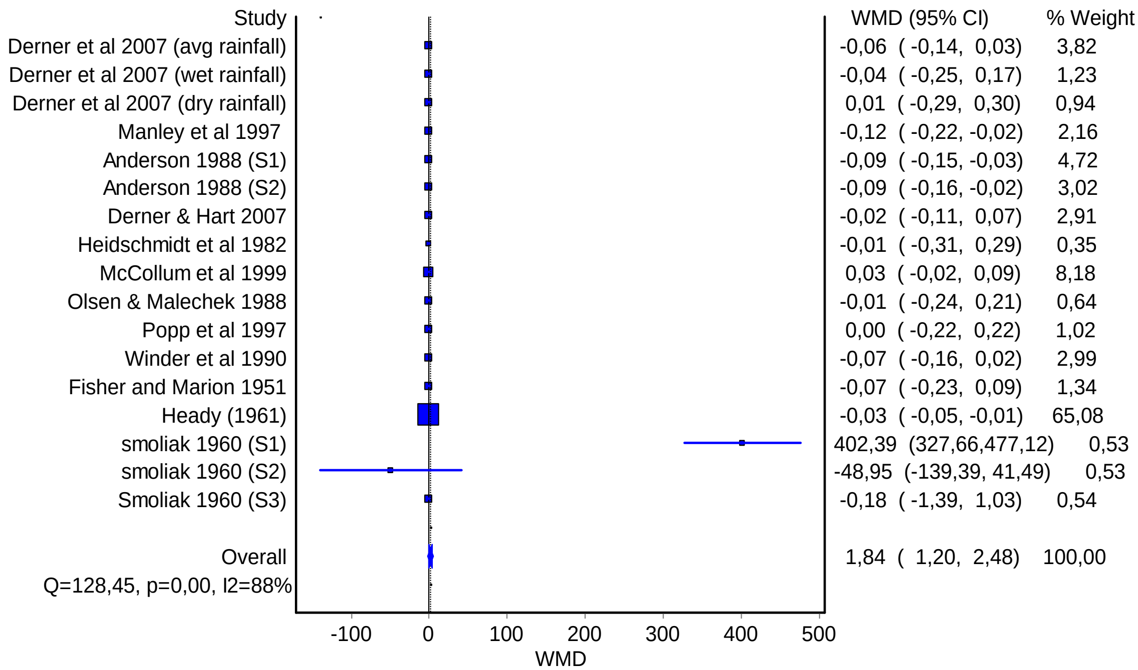

Figure 2.3: Forest plot indicating the weighted mean difference (WMD) of the effects of continuous and rotational grazing systems on cattle average daily weight gain (kg head^{-1}).

Figure 2.3. indicates that there was no difference between continuous and rotational grazing for cattle average daily weight gain (kg ha^{-1}), at a P-value of < 0.05.

A frequent criticism of meta-analysis is that there is publication bias toward studies reporting significant results over those reporting non-significance (Petitti, 2000). However, the shape of the funnel plots (effect size versus study size) in the present study indicated that there was little publication bias (data not shown). However, in the study of profit should not be used as an authority for decision making or recommendation since only few studies were available. The results for continuous and rotational grazing systems showed that there was no significant difference in terms of cattle weight gain (kg ha^{-1}) and average daily weight gain (kg head^{-1}). Therefore, since the continuous and rotational grazing systems have an insignificant effect on cattle weight gain, it is logical that they do not influence the profitability, even though few studies were found for profit directly. The narrative literature reviewed indicates that there is correlation between cattle weight gain and profitability. From this review there is a fair amount of consensus that there is no difference between continuous and rotational grazing systems in terms of production per hectare.

There is more variability between the studies of production per animal, indicating that more studies would be needed to lend credibility to the review. A broader review was outside the scope of this thesis. Nevertheless, the review here is in with agreement with other reviews in the literature. Regardless of the management system, it should be stated that management is key to the success of cattle production. (Bromley & Cernea, 1989).

The global literature also indicates that the stocking rate influences cattle weight gain and profit (revenue) rather than the type of grazing system adopted (Behnke, 1985; Quiroga *et al*., 2009; Jarvis, 1984; O'Reagain *et al*., 1992, and Campbell *et al*., 2000). Compliance to good farming practices, such as adherence to stocking rate recommendations, are difficult to apply in communal areas unless there is good leadership and a grazing plan in place. Since the land belongs to all the members of the community, in the absence of leadership some people will inevitably not want to, or not be able to, comply with stocking rates. It is necessary for communal farmers and tribal authority to realise that optimizing the number of cattle has potential to maximise economic benefits and ensure efficient utilization of the natural resource.

2.7 Social benefits of beef cattle grazing systems

Including a sociological review on beef cattle grazing systems may provide more insight about the manner in which cultural or other social norms inform and influence the types of beef cattle grazing systems used in South Africa. Norgaard (1984) argues that societal norms expressed through knowledge learned have co-evolved with environmental changes and with which societal structures have co-evolved.

Livestock farming is customary within rural systems of SA (Coetzee, 2005). The benefits of sustainable grassland-based livestock farming systems include meeting societal needs such as appreciation for the aesthetic landscapes and biodiversity. Animal ethical concerns about food production (Bernués *et al.*, 2011) are issues of less concern in rural areas because most farmers sell their livestock at informal markets, where food safety laws are not enforced due to the absence of stringent trade protocols.

The production of livestock in communal areas has multiple social benefits. These include creating social stability and job creation through labour participation in production activities. The by-products of beef cattle, such as hides, are used to manufacture traditional attires. The young and old people are often hired as herders. Beef and milk contribute significantly to the dietary requirements of people in the rural areas. Beef and milk produced in communal farming systems, presents people with the cheapest access to protein and calcium nutrients. Cattle are also important in the lives of rural communities because of the role they play in cultural ceremonies and ritual, such as the payments of Lobola, food provision at funerals and other cultural events. Money generated through livestock sales is used for payment of school fees for children and to address other family affairs that require financial input. Ndoro & Hitayezu. (2014), describe livestock as an asset for smallholder farmers, because they are kept as a store of wealth, and overtime they increase in number and value. Furthermore, communal beef cattle production systems compliment crop production systems because they produce manure used as fertilizers.

An estimated 43% of the agricultural labour force in developing countries is women, even though their output per unit of land is lower when compared to males (FAO, 2011; Croppenstedt *et al*., 2013), and consequently, the involvement of women in commercial farming is low. Flora (1985), argues that the limitations for women in progressive societies to participate in agricultural production are high labour demand, little chance for leisure and little control over resources for production. Livestock farming is dominated by males with male farmers having a relatively high socioeconomic status. Mixed gender labour forces are generally hired by farmers of a medium to low socioeconomic status (Varma (1992).

2.8 The role of institutions in supporting communal beef cattle farmers

Knowledge of the different grazing management systems practiced in communal areas, is important for facilitating the improvement of common property institutions in the communal areas of South Africa (Bennett *et al.*, 2007). The absence or lack of facilitation of knowledge transfer by agricultural institutions has contributed to a decline in cattle production (Jaffé *et al*., 2010). Critically, a factor that necessitates institutional intervention is the difficulty experienced when communal farmers have to make a collective decision about how to manage the communal grazing land.

Yami *et al.* (2011), describe the role institutions play in addressing problems of communal resource management to involve rules, norms and regulations. The institutions assist in creating an environment that allows economic actors to be productive, when incentives (e.g., benefits of complying with recommended stocking rate) are clearly defined (Coetzee, 2005) and constraints (e.g. lack of access to markets) removed (Jaffé *et al.*, 2010). Traditional leadership and even police can assist in enforcing by laws that farmers have agreed to follow (Gadzirayi, 2007). The NGOs are also playing an active role by acting as implementing agent of the government project for the communal farmers, this include presenting incentive for farmers who comply with the grazing plans in place. The incentives may be in the form of animal health programmes and assistance with accessing markets.

2.9 Sustainability of communal beef cattle grazing systems

According to Hueting (1990), a sustainable action is equivalent to the recycling of natural resources. It also ensures that the pressures exerted upon ecosystems do not cause the natural system to collapse. Moreover, it provides the natural system sufficient space to maintain its functioning (Hueting, 1990). An interdisciplinary approach has potential to develop sustainable systems for rangeland management (Swain *et al.*, 2007; Elser, 2016). Sustainable livestock systems are characterised by being; 'environmentally friendly, economically viable and socially acceptable' (Lebacq *et al.*, 2013).

In the food production sector, the question of which livestock or grazing management systems are the most sustainable has become a contentious subject (Capper, 2013). The concept of stocking rate will be discussed with reference to the economist's theoretical approach to overgrazing (Jarvis 1984). The assumption is that, there is a fixed area of land that produces the same quantities of forage annually, and the question is how many animals (beef cattle that are identical in all respects) should be grazed on that land (Jarvis 1984).

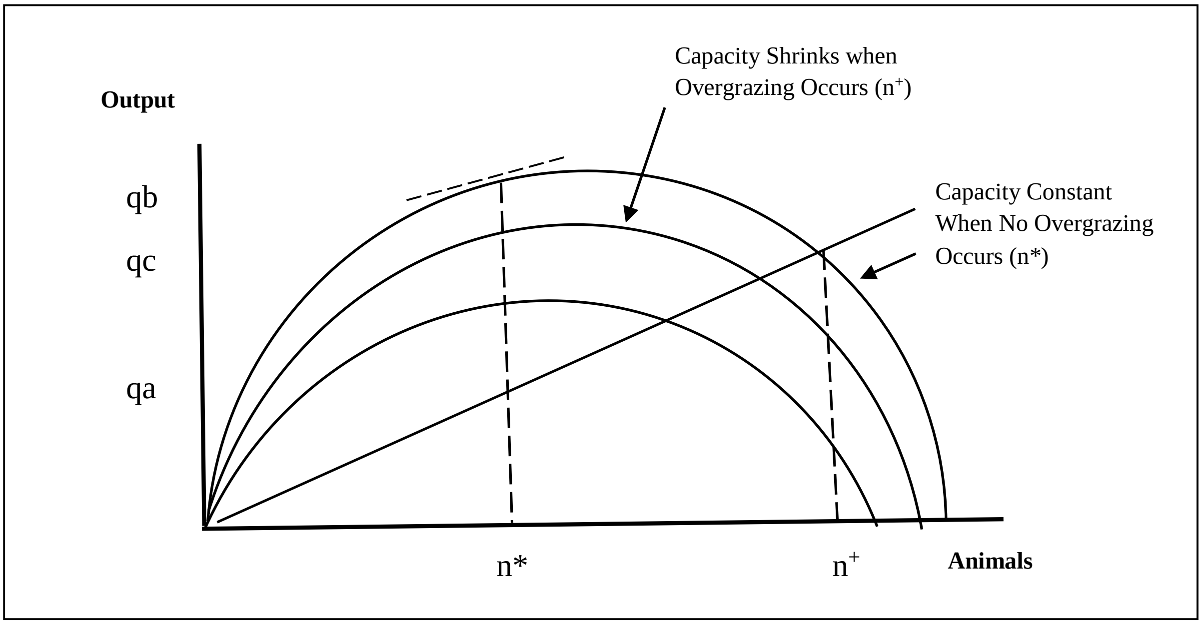

Figure 2.4: Relationship between quantity of output and number of animals on the rangeland. The output quantities are represented by (qa), (qc) and (qb). The number of animals are represented by (n*) (n $^{+}$).
Source: (Jarvis, 1984)

Figure 2.4 indicates that when the number of animals increase on a fixed the grazing area from (zero to n*) there is an increase in the quantity of output per animal from (qa, qc until qb). The optimum level is reached at (qb), this is the most sustainable level for production, because at this point the forage requirement of the animals on the grazing area, is equal that the amount that the land can provide. The carrying capacity of the rangeland is reached at the highest output level (qb). From point (n*) to (n^{+}) the number of animals on the rangeland increase, resulting in competition for the available forage, this causes a decline in the quantity of output realised per animal. Quiroga *et al.* (2009) concluded that the high stocking rate has negative environmental impact. Therefore, an increase in cattle numbers on a fixed grazing land should be managed to an optimum stocking rate to avoid overgrazing and rangeland degradation. As noted by many authors, the condition of rangeland and animal production are affected by the stocking rate (O'Reagain *et al.*, 1992). Therefore, the stocking rate can be used to determine if the communal grazing systems are sustainable or unsustainable.

2.9 Conclusion

The land tenure system in some rural areas of SA created conditions that forced farmers to practice collective herding. This method of farming is also known as communal farming. The selection of a specific grazing management system such as the continuous or rotational grazing system has variable ecological, social and economic impacts. Some studies indicate that the rotational grazing system is more beneficial compared to the continuous grazing system, because it allows recovery/rest of the rangeland. However, other studies have found that the differences between these grazing systems are due to management and the influence of abiotic factors in the specific environments where they located. The meta-analysis study conducted based on the few studies that were found indicated that the effects of continuous and rotational grazing systems on cattle weight gain and profit (revenue) generation, are statistically insignificant. These results align with the outcomes of qualitative literature review. Livestock stocking rate is a key variable of management for optimising the production of livestock on the rangeland. The solutions for addressing problems associated sustainable communal grazing systems are management orientated, rather than absolute or once-off solutions.

Chapter 3: Materials and methods

3.1 Introduction

Grazing systems include a wide variety of methods for managing livestock. The continuous grazing systems does not restrict where the cattle should graze, whereas, the rotational grazing system alternates cattle from one camp to the next with a specific goal of allowing the rested camp to regrow vegetation. This is essential for ensuring the availability of forage during dry seasons and to avoid overgrazing. There are many ways of achieving this goal and each one requires a different level of investment to establish the system, and different management inputs to maintain the system and ensure that it reaches the goals. Circumstances that farmers face usually determine which system would be best suited for a specific area can include, among others, access to capital, management skills, veld condition and goals.

This study should create an understanding of the common key success factors of sustainable grazing systems which include socioeconomic and ecological factors. For this reason, a mixed methods approach was adopted as a broad methodological framework. To begin, a meta-analysis (Glass, 1976) was adopted to conduct a quantitative literature review about the effects of continuous and rotational grazing on beef cattle weight gain and profitability. According to Glass (1976), meta-analysis is used to statistically used analyse ‘a large collection of analysed results from individual studies for the purpose of integrating the findings’.

The case study approach as motivated later in this chapter was the primary method for the data collection part of this research (Yin, 2009). The archival record analysis technique of case study research was used to evaluate the financial gains of the three case studies. The case study research method was used to determine the implications and challenges of implementing and managing different grazing systems under different conditions. This method is ideal when assessing whether a specific factor (i.e. the implementation of a grazing system positively contributes to a specific goal under various conditions). This study investigated three different areas, namely Motseng, Moiketsi and Mafube, each with a unique set of characteristics, challenges and advantages. Case studies allow for an in-depth investigation of the communal grazing systems in their real life context as they operate.

Lastly, the Ecological Index Method (Hardy *et al.*, 2013) was used to assess the grazing areas on which the grazing systems are operating. Through this method the data about the current veld condition, grazing capacity, grass biomass, land cover, litter to include a few could be quantified. It is essential to assess the impact of current grazing operations on the land and potential areas of improvement if the grazing systems are to be financially viable and ecologically sustainable.

3.1.1 Selection of studies for the meta-analysis

First, the researcher searched through literature for existing studies. Databases used during the search include EBScohost, Scopus, Springer, Google Scholar and Science Direct. The following key terms were used: "beef cattle, production, rotation, continuous grazing, systems", "animal production", and "cattle production". These key terms were combined in various ways, using Boolean operators such as OR, AND or NOT to broaden the search.

The researcher then applied a snowball method to search for other relevant papers, based on references found in papers retrieved from the databases. The article search was limited to papers that compared continuous and rotational grazing systems in terms of beef cattle production, presented the results in statistical manner, and had clear control and treatment possibilities. The search was limited to peer-reviewed journals.

Overall, the search retrieved 350 papers. However, a large number of these was excluded because many studies have either control or treatment, not both; or no correlation was indicated between stocking rates, cattle weight gain, and profitability. This allowed for concentration on assessing the grazing system without having stocking rate as a confounding factor.

A total of 26 papers met the set inclusion criteria, and the researcher loaded these into a new database, classifying the information under the following headings: author, journal title, year of publication, breed type, duration of study, location, size of plot, stocking rate, unit of measure, population size, sample, treatment and control, season, land tenure, commercial and experimental design type.

3.1.2 Effect size

According to Glass (1976), the effect size is 'the mean difference on the outcome variable between treated and untreated subjected subjects divided by the within group standard deviation'. Osenberg *et al.* (1999) state that, when conducting a meta-analysis, the effect size estimate should be calculated for each measurable variable in order to express the magnitude of the treatment effect. The effect size estimate selected for this study is the weighted mean difference (WMD). WMD indicates the difference between the treatment mean ($\overline{X_a}$) and the control mean ($\overline{X_b}$), and is computed and expressed as a percentage difference of ($\frac{\overline{X_a}-\overline{X_b}}{\overline{X_c}} \cdot 100$). For this study, the Quality Effects Model (see Doi & Thalib, 2008) was used in the MetaXL (v2.2, Epigear International) together with size estimates weighted by the variance at the confidence interval of 95%. Additionally, a quality index score (Qi) was used to assess any possible biases in the papers as a result of errors in the experimental design (Doi & Thalib, 2008). Thereafter, the researcher calculated the Qi based on six questions (Table 3.1). The values obtained were also loaded into the model on MetaXL (v2.2, Epigear International**)**.

Table 3.1: A quality scoring system used in the Quality Effects Model for the meta-analysis.

Question	**Score**
1. Did the experimental layout use randomisation or another appropriate sampling strategy?	0 = No or not reported 0.5 = In part 1 = Yes
2. Were the groups comparable at the baseline?	0 = No or not reported 0.5 = In part 1 = Yes
3. Were treatments clear and not confounded by e.g. soil type, cultivation history, tillage?	0 = No 0.5 = In part 1 = Yes
4. Was the trial conducted over an adequate period to allow differences to emerge?	0 = 1–5 years 0.5 = 6–10 years 1 = 11–20 years 2 = >20 years

5. Was the analysis clearly reported and appropriate?	0 = No 0.5 = In part 1 = Yes
6. Were protocol deviations or losses during the study acceptable (<20%)?	0 = No or not reported 0.5 = In part 1 = Yes
Quality Score (Qi) = $\frac{Sum of scores}{7}$	

Source: Adopted from medical studies (Doi & Thalib, 2008) to be relevant to rangeland studies.

3.1.3 Analysis of meta-data

The results were analysed by comparing the control and treatment groups. For this study, the control group is the continuous grazing systems and the treatment group is the rotational grazing systems. The researcher used MetaXL (v2.2, Epigear International) to record the names of the studies, sample sizes, means and quality index values to produce so-called Forest plots (see Chapter 2, section 2.6).

3.2 Case study location

The research study areas are situated in the Matatiele Local Municipality (MLM) in the Eastern Cape Province (Figure 3.1). This local municipality is located in the Alfred Nzo District Municipality (ANDM), comprising four local municipalities. The MLM occupies 4 352 km^2 (58%) of the ANDM and is situated alongside the Drakensberg and Maluti mountain ranges. This area includes various endangered species (Matatiele Local Municipality, 2014). The researcher identified three case study villages representative of various communal beef cattle grazing systems found in the MLM.

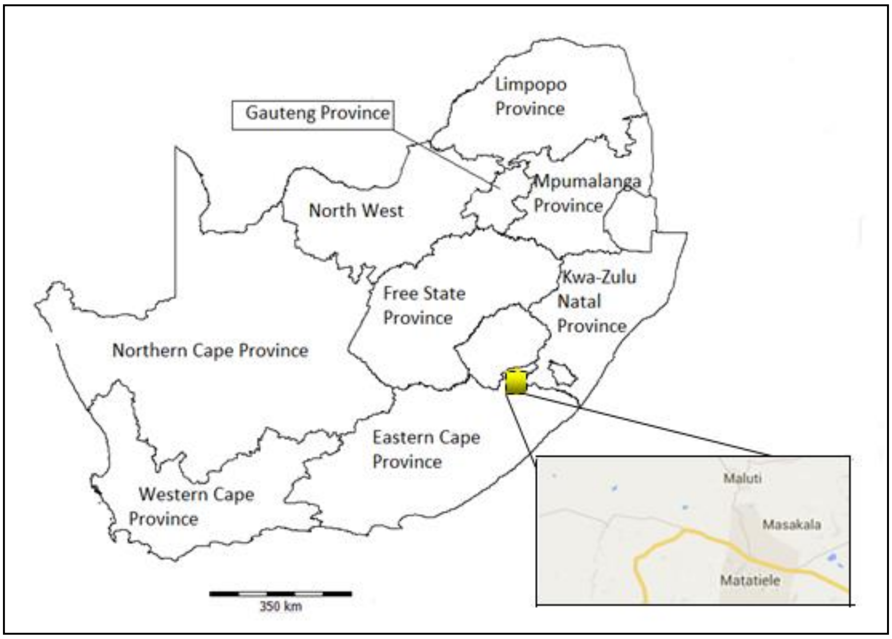

Figure 3.1: The location of Matatiele Local Municipality in the Eastern Cape Province of South Africa. (Synbiosis software and google maps)

The MLM is characterised by large areas of degraded grasslands in communal areas. However, it is a bioregion that has a relatively high species abundance and rate of species proliferation correlated with changing slope, altitude and environmental conditions. The area also falls within the uMzimvubu catchment, one of the important 'water factories' of SA with an annual rainfall ranging from 550 mm to 1 000 mm.

Unfortunately, the MLM has a history of overgrazing with concomitant erosion, loss of grazing services, and siltation of the important uMzimvubu catchment potentially leading to eventual reduction of water services. Various institutions identified the MLM area as a priority site to engage local, private and communal farmers based on both ecological and social surveys (Hawkins *et al.*, 2014). A multi-stakeholder platform called the uMzimvubu Catchment Partnership Program (UCPP) provides a governance structure and supports local government in terms of research and development in the area. Additionally, the Natural Resource Management (NRM) program of the Department of Environmental Affairs supports development projects in the area, which includes the funding of the so-called Ecorangers. Some of these Ecorangers are herders in rotational grazing systems, and some clear invasive alien plant species (IAPs).

3.3 Motivation of case study research method selection

The case study research method is an 'empirical enquiry that investigates a contemporary phenomenon in-depth and within its real-life context, specifically when the boundaries between the phenomenon and the context are not always clear' (Yin, 2009). This method is used in agribusiness research studies as a tool to collect data, build theory and evaluate theory (Sterns *et al.*, 1998). Yin (2014) mentions four principles of data collection, namely using multiple sources of evidence, creating case study research databases, maintaining a chain of evidence, and taking caution when using data from electronic sources. Case study research is known for its use of multiple sources of data as well as the techniques for data collection (Farquhar, 2012; Yin, 2014). The researcher selected this method for this study as it presents appropriate tools for studying the communal grazing systems in their real-life context and identifying other significant factors which may influence the positive contribution of the proposed grazing systems to financial and ecological sustainability.

3.3.1 Case selection

The study was conducted at three villages in the Matatiele Local Municipality in the Eastern Cape Province, namely Motseng, Moiketsi and Mafube. The researcher selected these three villages because they displayed some broad similarities. All three are members of the uMzimvubu Catchment Partnership Programme (UCPP), and they have similar challenges relating to management of grazing areas coupled with issues of soil erosion and lack of market access for their livestock. The main unit of analysis in these selected cases is the communal beef cattle grazing system. Two of these grazing systems were innovative pilot projects (modified HPG and rotational rest grazing system), whereas the third continuous grazing system was an old, conventional grazing system.

3.3.2 Case study design

The research questions were designed to meet the objectives of this study and focus on determining both the inputs and the outputs of each communal beef cattle grazing system. A case study research method is ideal for investigating the mechanics of 'how' things function and 'why' they function in that manner. Although the unit of analysis is communal beef cattle grazing systems, the three villages are not directly comparable as they practise different grazing systems. However, these villages have the same objectives: profitable cattle production and improved grazing areas. A stratified random selection method was used to select these villages; the grouping already existed because the villages are members of the UCPP, hence this grouping was logistically feasible for the purpose of this study.

Data collection techniques that were used include semi-structured interviews, focus-group sessions, grazing site direct observation, physical artefact viewing, documents, archival and reports analysis. The various sources of data include implementing agents, Ecorangers, communal farmers, communal grazing sites, artefacts, documents and archival records, and various reports. Moreover, the researcher conducted telephonic follow-up conversations with a senior herder at Moiketsi village to verify livestock numbers and collect missing data. The Department of Agriculture in the Eastern Cape Province validated livestock numbers (Eastern Cape Department of Agricutlure 2015, pers. comm).

3.3.3 Selection of participants within each case

A stratified random sampling method was employed to select the participants within each case. The researcher invited community members who farm with livestock and have joined the collective grazing programme in their village. The invitation was done via the implementing agens, then the tribal chief.

The attendees were 23 people from the Motseng village , but only 13 people (56%) who attended were interviewed as part of the study because they farm at the Motseng village. The group consisted of farmers and Ecorangers. Thirty community members from the Moiketsi village had an attendance of 30 community members and all (100%) were interviewed. The tribal chief played an important role in facilitating the question-and-answer session as a translator was needed to translate from English and Setswana to Sesotho. The chief role was more facilitating the researcher interaction with farmers because of the language barrier. The farmer were free to give answers and discuss.

The implementing agent in the Mafube village community was not cooperative initially because the grazing project leader is consultant whom was not fully updated about the intention of the research study even the letter of request what send to the organisation. This meant that the researcher could not gain access to the village. The issue was later resolved, but because of the time and budget constraints, only the Ecorangers, the project manager, other consultants and one extension officer from the Department of Agriculture, who are also working on the Mafube grazing system, were interviewed. The implementing agent organisations (‘A, B and C’) were non-randomly/deliberately selected as interviewees since limited staff members were directly involved in the communal grazing programs. The interviewees included the grazing project manager, coordinator, field workers and managers. The interview sessions were conducted over a period of four months, and approximately three visits were made, the focus sessions and interview lasted for atleast 30 minutes to 1hour 30 minutes. The months of visits were consecutive.

This study used a case study research protocol as a guide to identify potential sources and types of data needed**.** The interviews were aimed at identifying the types of grazing systems found in these villages and how they were planned, implemented and operated on a daily basis, particularly during the grazing season. In addition, the interviews were aimed at identifying the benefits that can be expected from the grazing systems. The researcher visited all the grazing sites included in the study to observe how the systems are implemented in real-life contexts. The equipment and instruments used in the grazing sites were also identified through artefact viewing.

3.3.4 Protection of key participants

The three implementing agent organisations that participated in this study are directly involved in the implementation and the operational management of some of the communal grazing systems. In order to protect the privacy of these organisations, they are referred to as implementing agents (A), (B) and (C), as indicated in Table 3.3a. Furthermore, the participants from the villages are not be mentioned by name for the same reason. However, the case study communities are mentioned by their real names, namely Motseng, Moiketsi and Mafube.

Table 3.2, indicates the data that was expected during preparation for the data collection process from the implementing agents (A) and (C).

Table 3.2: Identified sources of field data collection at Motseng, Moiketsi and Mafube village as part of the case study investigation.

Type of evidence	Sources and techniques used	Contact person
-Grazing plan design -Grazing plan implementation inputs -Grazing system financial records.	-Grazing project documents -Archival records -Semi-structured interviews -Documents.	Implementing agent (A) and (C) (Personnel from this organisation).
Access to Motseng and Moiketsi communal farmers and grazing systems.	Visit Motseng and Moiketsi village. Host focus-group sessions with communal beef cattle farmers. Observe grazing systems, participation, and identification of artefacts.	
Grazing plan design, grazing plan implementation inputs, grazing system financial records.	Grazing project documents, archival records, semi-structured and unstructured interviews.	Implementing agent B (Personnel from this organisation).
Access to Mafube communal farmers and grazing systems.	-Visit Mafube village -Focus-group sessions with communal beef cattle farmers -Observe grazing systems, -participation identification -Artefacts.	

3.3.5 Data collection for case studies

In preparation of the data collection, the researcher conducted a literature review of current communal beef cattle grazing systems, developed a case study research protocol and submitted request for appointment letters to implementing agent organisations. Also, the researcher completed the application for human ethics clearance at Stellenbosch University. Additional resources such as laptops, recording sheets and a camera were organised. Telephonic calls were made to finalise appointments with implementing agents and communal farmer structures, and contact details of the research supervisors were collected.

Table 3.3a: Grazing sites and key participants visited at Motseng, Moiketsi and Mafube as part of the case study investigation.

Area name	Grazing system type	Participants
Motseng village	(Modified HPG system)	Implementing agent (A and C), Farmers in the community and Ecorangers
Moiketsi village	Continuous grazing, no herders	Tribal chief and communal farmers
Mafube village	Rotational Rest using herders	Implementing agent (B), Extension officer and Ecorangers

The data collection approach took the form of semi-structured interviews (see Annexure A). Some structure to the interview process was fundamentally important for keeping in scope with the main inquiry of the study, and to prompt discussions that are in line with the objectives of the study. A semi-structured interview format and explorative approach was preferred over a strictly structured approach because it allowed the interviewees to provide additional answers not included in the questionnaire. This allowed the researcher to better understand the information and records provided. This also allowed the researcher to ask the interviewees to support their answers using multiple sources for example records, referrals. Additional information was also obtained through grazing site observation and physical artefact identification, for example mobile fences, kraals, grazing plans.

The semi-structured interview were conducted one-on-one or using focus groups. The one-on-one interview schedule was relevant to the implementing agent organisations because there was only one grazing project manager appointed to oversee the operation of the grazing systems in the village. Whereas focus groups were appropriate for interviewing communal farmers. Firstly, the grazing systems are communally managed and the land is also communally owned, it was necessary for all farmers to be available to validate all answers provided about the grazing system. Secondly, it could have been logistically difficult to interview all farmers individually. (For a list of research questions, refer to Annexure A). Supplementary information was obtained through follow up telephone interviews where needed.

The data collection process was separated into two phases: the first phase was the pilot case study and the second phase includes the data captured after case study research protocol had been refined and tested. The pilot case study was used to evaluate and fine-tune the case study research protocol regarding the type of questions asked and steps in planning interview sessions. The researcher conducted the pilot case study at the Matatiele Local Municipality, with assistance from the three implementing agents and Ecorangers. This proved to be a crucial step as most of the research questions were later rephrased to suit the context of each case study village, while still remaining comparable and answering all the research questions. Interviews were conducted over a period of three weeks, and participants were limited to selected respondents who were familiar with the case study research areas and with sufficient practical experience gained from working with the communal farmers. The research data collected were both qualitative and quantitative in nature (see Annexure A).

The implementing agent organisations were the first point of contact in the data collection process (Figure 3.2), as they have earned the trust of the communities in the selected areas. Furthermore, the implementing agents understood the community better and they were fully involved in the planning and the management of the communal grazing systems. They facilitated the daily operations of the grazing systems in collaboration with the communal farmers. The implementing agents directed the researcher to the grazing sites. The researcher observed the sites and current grazing operations

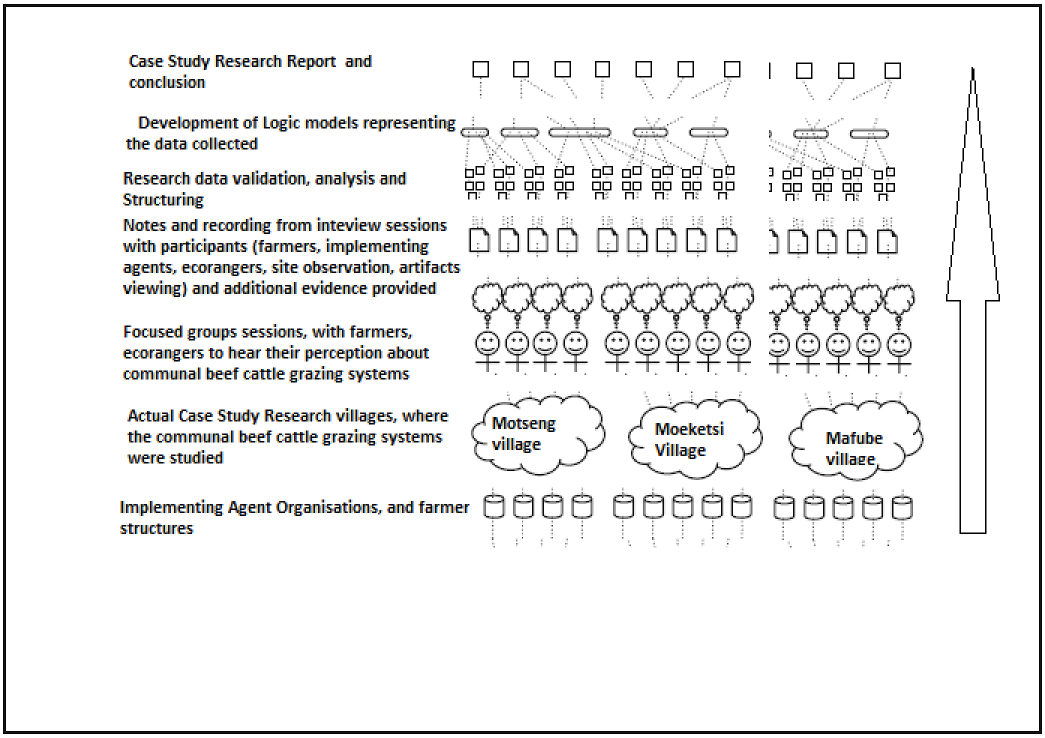

Figure 3.2: Overview of the case study research data collection process, the participants interviewed were the implementing agents and farmers structures, and the communal farming villages were visited for grazing sites observation, and the case study reports was written (see Chapter 4).
Source: modified from Runeson & Höst (2008)

The implementing agents introduced the researcher to communal farmers, tribal chief, Ecorangers, herders and community members. The researcher explained the purpose for the visit, and requested for permission interview the farmers, Ecoranger and Herders. The Focus group approach was ideal because the farmers were practising collective grazing, and in other instances they were only sharing the grazing area without mixing their livestock. The questions were asked and the participants were answering, the researcher kept requesting for evidence that can support the answers provided. It will also be noted in Chapter 4, that pictures were taken, archival data analysed. An outline of who participated, where, evidence provided see Table (3.3b).

Table 3.3b : A summary of data collection techniques used at Motseng, Moiketsi and Mafube as part of the case study investigation.

Participants	Village in which the interview was conducted	Data collection technique	Source of data	Case study evidence
Participant 1	Motseng village	Focus group interview session	Communal farmers	Answers to interview questions, site visits to observe grazing operations.
		Semi structured interview	Implementing agent A & C, Ecorangers	Grazing plan Map, communal farming records, pictures, animal weight records, sales records, site visits, grazing system training manuals.
		Semi-structured	Implementing agent A and C, and ecorangers	Answers to interview questions, and site visits, list of grazing systems establishment inputs.
		Grazing site observation and physical artefact identification	Grazing sites, Ecorangers and farmers	Site instruments, electric mobile kraal, current grazed site, previous grazed site, daily plans and executions.
Participant 2	Moiketsi village	Focus group interview session	Communal farmers, and tribal chief	Answers to interview questions.
		Direct site observation	Grazing sites visit, Herder	Actual observation of the grazing site and grazing operations. Artefact identification and capturing of pictures.
Participant 3	Mafube village	Semi-structured interview	Implementing agent B,	Grazing plan map, pictures and answers research questions, guidance principle of the grazing system based on literature.
		Site observation and physical artefact identification	Grazing sites	Site visits and artefact identification.
		Telephonic interviews	Grazing Project Manager, Department of Agriculture Eastern Cape.	Livestock numbers data, grazing system establishment budget.

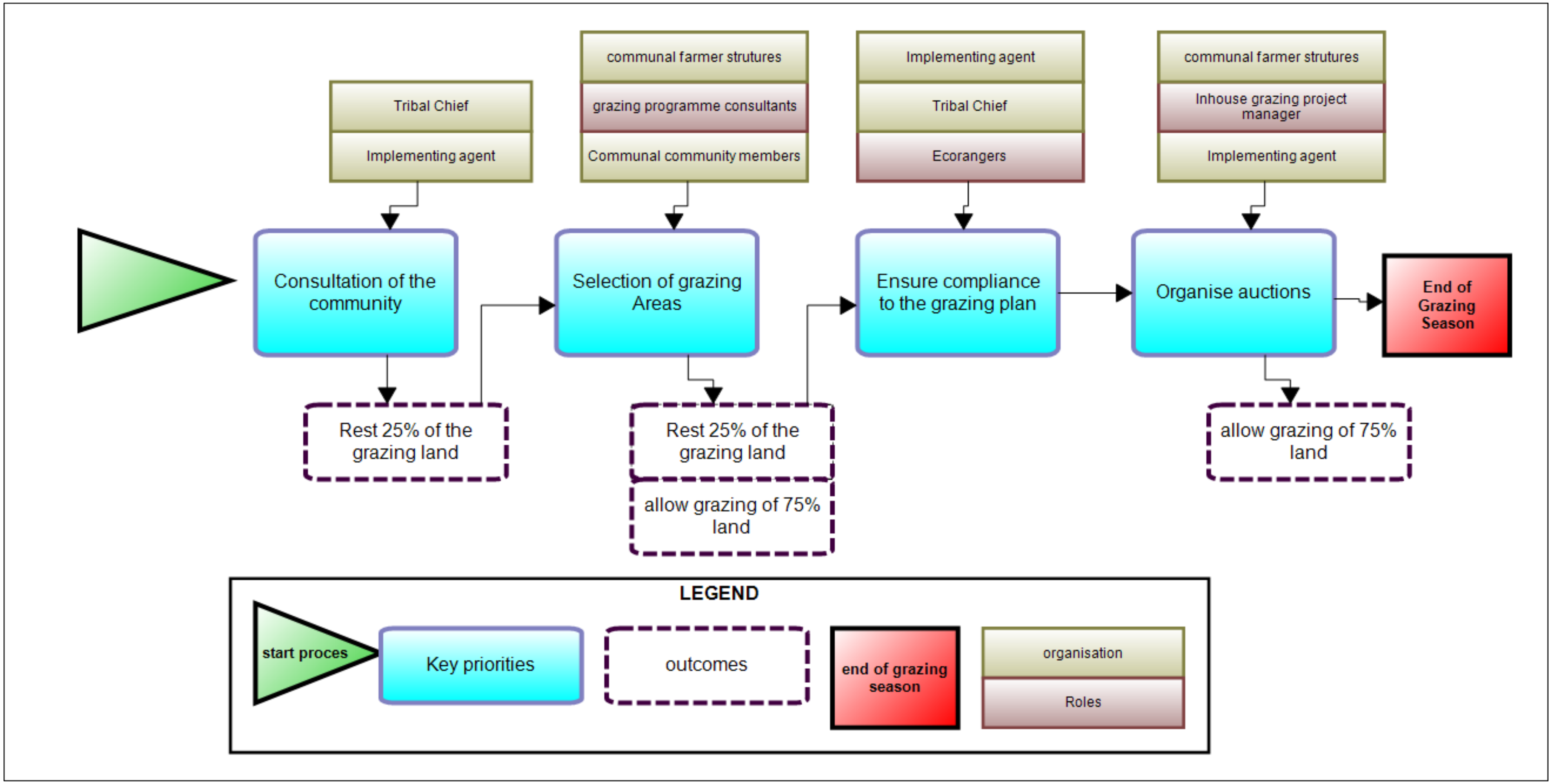

Figure 3.3: Overview of Mafube village grazing system establishment process. (xBML)

* Note: Model for implementing the modified HPG/short duration rotational grazing system, highlights key priority activities, roles responsible for those activities, expected outcomes, start and end of the process.

All the grazing sites were visited for the purpose of direct observation and rangeland condition assessments.

3.3.6 Case study research data analysis

The data collected through interviews, focus groups, from communal farming records, and direct and participant observations was entered into an Excel database sheet (Annexure B). The populated Excel spreadsheet was then loaded onto the Computer Assisted Qualitative Data Analysis Software (CAQDAS) for analysis and a query report was generated see (Annexure C). The query tool retrieves data in the form of quotations through quotes or combination of quotes across primary documents (Contreras, 2015). The researcher created electronic folders for each case and, within each folder, different themes were used to systematically store the evidence (Annexure D).

For the purpose of data validation, further analysis and structuring, a logic model called Business Modelling Language was used to develop a “how” model of the Communal Beef Cattle Modified HPG System. Business Modelling Language (BML) is a logic modelling approach well known for its competency in describing business processes through a framework of the five W’s, namely ‘Who does what, with which information, where and when?’ (Tyler & Baker, 2007). This approach is equally efficient both for modelling and for analysing case study evidence because of its ability to integrate the five W’s to develop the “how” model. This, in turn, can be analysed to answer the ‘why’ questions. The ‘how’ or ‘why’ questions are central to case study research (Yin, 2014). This modelling approach uses data sourced using two techniques, namely documents co-formulation and subject matter experts (SME) consultation.

Document co-formulation refers to a thorough review of all the documents and other forms of reading material presented as case study evidence by the participants. SME consultation is similar to interviews with key participants with an added advantage of data validation with the participants. This approach is unlike most other modelling approaches, because it provides the advantage of proper validation using terminology understood by participants instead of complex equations and graphs that do not capture of context of the study area. This modelling approach is based on the few rules of the five W’s, namely WHAT (activities), WHO (role, person, technology), WHERE (location), WHEN (time), WHICH (information needed to perform the activities) (Tyler & Baker, 2007).

Table 3.4: Case study research report structure for Motseng, Moiketsi and Mafube village as part of the case study investigation.

An outline of the case study report
Background for each case
Detailed description of the communal beef cattle grazing systems for each case
Financial costs of implementing a communal beef cattle grazing system for each case
Beef cattle sales and financial returns for each case
Summary of each case
Rangeland condition assessment results of each grazing site
Financial implications of the grazing systems
Potential ecological and financial benefits
Consolidated case study research report summary
Conclusion

In reporting the case study research findings, the structure presented in the Table 3.4 was adopted for case study reports (see Chapter 4).

3.4 Selection of sites for conducting a rangeland condition assessment

Motseng and Mafube started pilot rotational grazing systems at the beginning of 2014; Moiketsi has been practising its current grazing system for more than two decades. The difference in the period of grazing system implementation between the villages is one of the reasons these villages are not directly comparable. Grazing sites selected at Motseng and Mafube were those first grazed at upon implementation of the respective grazing systems. In Moiketsi, a grazing site was selected based on its distance from the residential area, and the frequency of grazing. The other aspects that were considered in selecting the three grazing areas include relative slopes, similar vegetation type, minimum or no exposure to mechanical disturbances and ease of access. A detailed table with descriptive categories of each of the case study village is presented in Chapter 4 (Table 4.11) as it forms part of the results section.

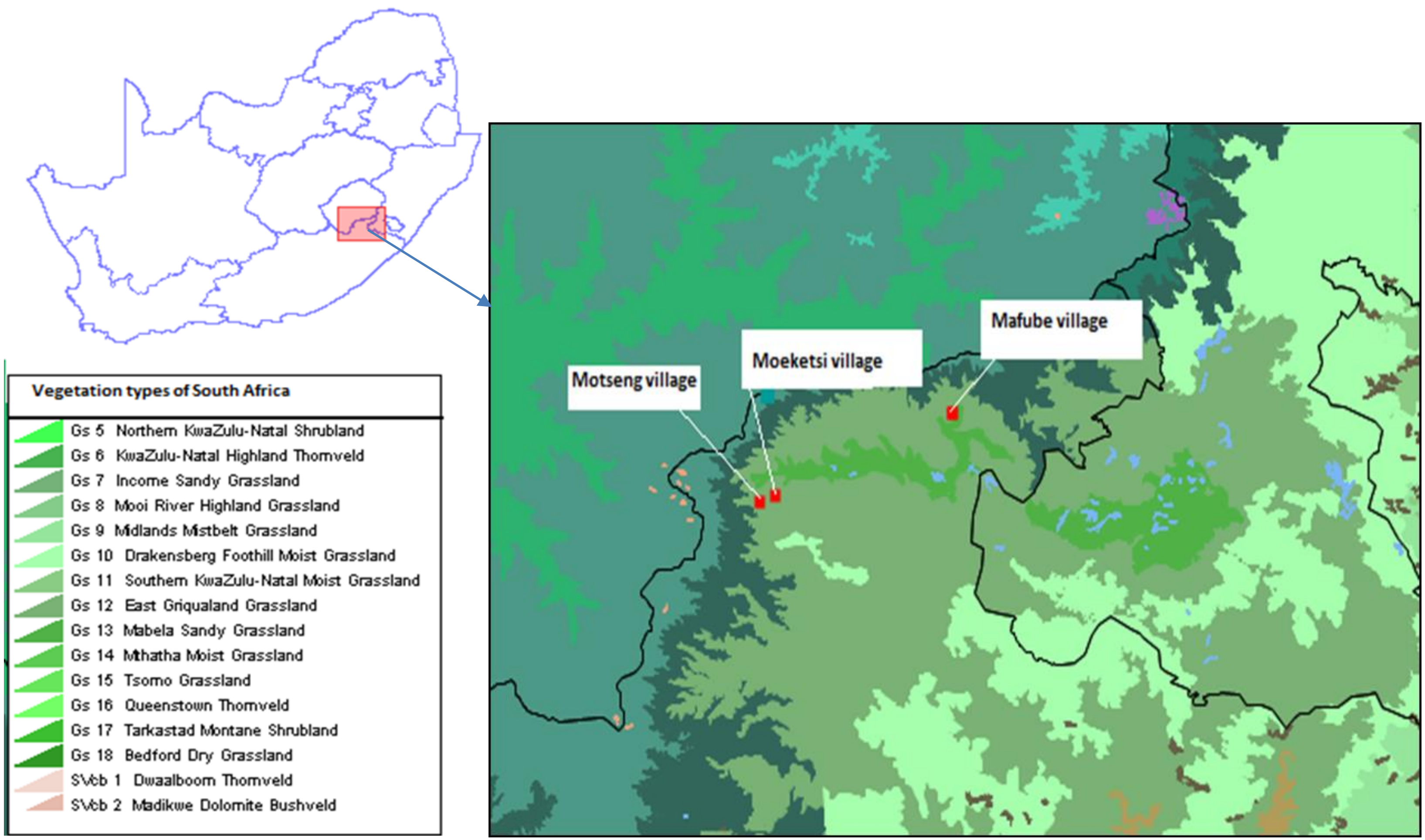

Figure 3.4: Map of South African vegetation types found at the case study research sites in the Eastern Cape Province at Matatiele Local Municipality. (Synbiosis)

To fully understand and measure the impact of these grazing systems on the selected grazing areas, rangeland condition assessments were conducted in the grasslands in the areas indicated (Figure 3.4). The vegetation type found at Motseng, Moiketsi and Mafube village was indicated as East Griqualand Grassland. The biome type found in this region is mostly Grassland biome.

3.4.1 Rangeland condition assessment data collection

The Ecological Index Method (Hardy *et al.,* 2013) as rangeland condition assessment method as adapted by Nel *et al*., (2013) was used to conduct a rangeland condition assessment at the case study sites. The rangeland condition assessment was conducted using line-point intercept transects to determine cover and species composition, and the disc pasture meter to determine the biomass. The outcomes of this assessment were rangeland condition scores, basal cover percentage, litter cover percentage, bare cover percentage, biological crust cover percentage, 'veld' condition score, grazing capacity, average standing vegetation biomass (kg ha^{-1}), as well as grazing potential based on the overall rangeland condition score, and biodiversity.

More specifically, 4 x 50 m transects of 50 points, resulting in 200 points, were conducted per case study research site. The transects were aligned along North South (NS), South North (SN), East West (EW) and West East (WE) cardinal headings in a wheel spoke manner (Figure 3.5)

The key species and soil surface at each 1 m point along the 50 m transect were recorded in the intercept data form. The functional groups, ecological group, grazing value and benchmark were used to calculate the 'veld' condition score and grazing capacity.

When a dropping pin was not guided, it fell freely to the ground. Whatever it landed on was recorded, for example, plant species (dead or alive) as basal cover. Each species was recorded once for basal cover. In the instances where both the alive and dead canopy for the same species was hit simultaneously, the alive canopy was recorded. In the instances where no leaf or plant base was intercepted, it was recorded as 'None'. A database of the most common species was created by populating the form with codes to simplify the recording process (see Annexure E).

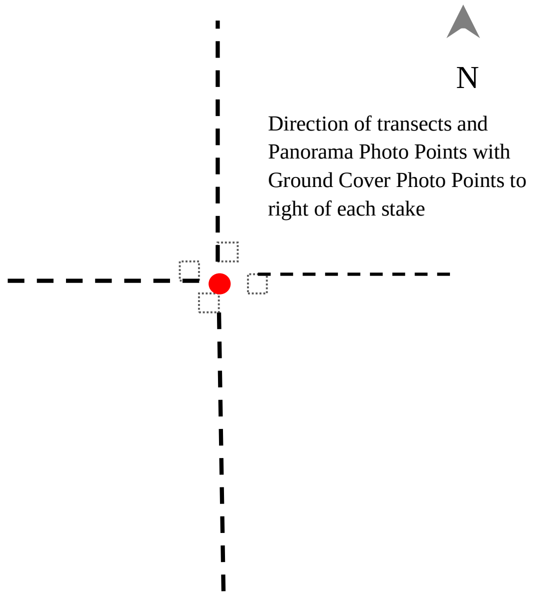

Figure 3.5: Wheel spoke layout used for rangeland assessments.

Species identified through these transects were categorised with reference to the ecological groupings that are founded on how the vegetation responds to utilisation (Hardy *et al.*, 2013):

1. Decreaser spp: species that decrease with over- or under-utilisation
2. Increaser I spp: species that increase with under-utilisation
3. Increaser II spp: species that increase with excessive over-utilisation
4. Increaser III spp: species that increase with extensive over-utilisation

A disc pasture meter was used to measure the standing biomass on the grazing area. This method is suitable for estimating the 'biomass of large areas, as a procedure that is non-destructive, objective, repeatable and simplistic' (Smallwood, 2009). This instrument has a flat-surface disc that is connected to a rod. Another thin graduated rod centred on the disc plate, allows the disc to be lifted up to a height 60 cm (Smallwood, 2009), and then released down. The measurements are taken from the graduated middle rod in centimetres as a measure of the height of the vegetation biomass (Figure 3.6; Trollope & Potgieter, 1986; Smallwood, 2009).

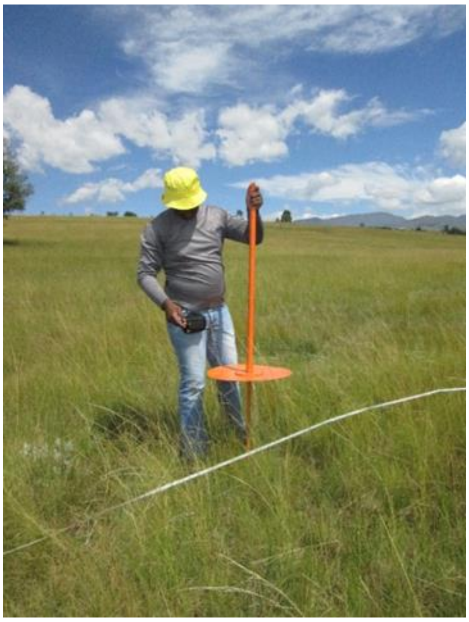

Figure 3.6: The disc pasture meter (Africa Land Use Services Ltd Pty).

The disc pasture meter (see Figure 3.6), was used for measuring the standing biomass on the grazing land. The values obtained from measuring the standing biomass with the use of the disc pasture meter were recorded using biomass data form (Annexure F). The biomass was measured every 2m, along the four 50m length transects (indicated in Figure 3.6).

3.4.4 Analysis of the rangeland condition assessment data

The bare ground percentage was computed by observing state of the ground, if it has species or barren soil, then record the frequency of occurrence which as later multiplied by two, and for basal cover only points with plants were recorded then multiplied by two.

The following formulas, codes and calculations were used to analyse the rangeland condition data

The rangeland condition score was calculated as:

$$(Decreaser\ spp, Increaser\ I\ spp, Increaser\ III \div Benchmark\ grazing\ score)$$

Benchmark grazing score (950) is the site with the highest rangeland condition score in the survey undertaken by the implementing agent A, for the Matatiele Local Municipality (Nel *et al.*, 2013).

Grazing capacity is defined as the production of the grazeable area of the vegetation community and the quantity of grazing units sustainable on a unit area of the land (Smallwood, 2009; Nel *et al.*, 2013). This calculation is based on the assumption that a 500kg animal unit (AU) consumes 10kg of biomass each day, and therefore, the calculation is the amount required by the animal per year divided by the quantity produced (Nel *et al.*, 2013).

$$\text{Grazing capacity } (ha\ au^{-1}) = \frac{\boldsymbol{D \times R}}{\left\{\left[(\boldsymbol{MAR} \times \mathbf{0.8}) \times \left(\frac{\boldsymbol{VC}}{\mathbf{100}} \times \mathbf{5}\right)\right] \times \boldsymbol{W} \times \boldsymbol{A}\right\}/\mathbf{2}}$$

D = Utilization period (Days)

R = Requirement of the animal per day (one animal unit requires 10kg DM/day_)

MAR = Mean annual rainfall

VC = Veld condition as percentage of the benchmark

W = Woody species impact (woody alien invasive plant species were excluded from the sites)

A = Accessibility factor (it is determined by rockiness and slope)

Measuring standing biomass:

Estimating grass fuel load (kg ha^{-1}) for management purposes in Africa (Trollope *et al.*, 2000).

$$y = -3019 + 2260\sqrt{x}$$

Where

y = mean fuel load (kg ha^{-1})

X = mean disc height of readings (cm)

Grazing potential based on rangeland condition score

Table 3.5: Rangeland condition scoring used to assess case study sites

Grazing potential	**Range condition score**
Very high	>750
High	650–750
Medium	550–650
Low	450–550
Very low	<450

(Source: Herdy *et al.*, 2013)

The benchmark site was the site with the highest rangeland condition score obtained during the rangeland condition assessment in 2013, where this value was slightly higher than the published value for the municipality (Nel *et al*., 2013).

$$Rangeland\ conditon\ score = Rangeland\ condition\ scores\ (Total\ of\ grazing\ scores)$$
$$Veld\ condition\ score = [\ RCS\ of\ the\ site \div RCS\ of\ benchmark\ site]$$

3.5 List of equations that were used for calculating the theoretical income value for the grazing systems.

To indicate the potential benefits of the three communal beef cattle grazing systems, the Increaser and Decreaser grass species found at the grazing sites were identified and listed. Their grazing values were researched. The grass species abundance of the Increaser and Decreaser grass species was determined by looking at the frequency of each grass species on 200 points randomly selected on the grazing site. The frequency values for each grass species was averaged then multiplied by its specific grazing value to determine the rangeland score, for a list of grass species and their grazing values see (Annexure G).

All the rangeland scores were summed and divided by the benchmark value of Matatiele local municipality to get the veld condition score. To determine the hypothetical value of 20% veld condition improvement for Motseng village, the frequency and composition of the Increaser and Decreaser grass species was adjusted until a veld condition score of 20% was obtained. In addition to the veld condition score of 23% , their sum is 43%.

The same process was repeated for Moiketsi, where a hypothetical value of 17% veld condition improvement was allocated and for Mafube a veld condition improvement score of 20%. It was assumed that after five or more years these veld conditions scores are presentative of potential improvements (Nel 2015, pers. comm). There assumption for allocating 20% for veld condition improvement at Mafube was that, the modified HPG system allows for alternating grazing and resting of the grazing areas, and the disturbed areas are used for overnight kraaling. During the overnight kraaling, the cattle stocking density is increased to allow concentration of cattle manure and urine in one place. The cattle hoof effect on the ground, further prepares the soil (Ecoranger 2015, pers. comm). The approach is claimed to be effective in land restoration. As a result it was anticipated that resting of the grazing area will allow the Decreaser grass species to increase in rested grazing areas, and Increaser grass species will increase in grazed area.

In the case of Moiketsi 17% veld condition improvement was anticipated because the continuous grazing systems does not allow resting of the grazing areas, allowing Increaser grass species to increase while Decreaser grass species are decrease/deteriorate. For Mafube village, a hypothetical 20% veld condition improvement was anticipated because the rotational rest grazing system allows for 25% of grazing area to be rested for a full growing season, while only 75% of the grazing area is being grazed. It assumed that this will allow both the Increaser and Decreaser grass species to regenerate.

The equations (3.5.1, to 3.5.5) were applied using existing data from the case study sites in order to compute the current status of the veld condition and finances. These equations were further used to indicate potential economic benefits as a result of improved veld condition, grazing capacity, carrying capacity and livestock production. The historic oxen price values for live cattle R Kg^{-1} were kept constant (excluding effects inflation and other market factors that may influence the rand) Hypothetical values were used for estimate veld condition improvements per case study site. The assumption for projecting potential veld condition improvement were based on the characteristics of each grazing system adopted. Factors such as e.g. rainfall, dry matter consumption per day per cattle, utilization period per year, woody species impact and accessibility factor were held constant. The rangeland condition scores (grass specie, frequency and composition) were adjusted because they influence the veld condition score, which is important to indicate the hypothetical values.

The financial and ecological data collected at Motseng, Moeketsi and Mafube village was incorporated in the equations below, in order to project potential benefits. Site specific data, such as size of grazing area, current rangelands scores, veld condition score, herd size and past livestock sale prices for oxen were used to indicate the impact of veld condition improvement on grazing capacity, carrying capacity and revenue. For the outcome of these computations (see Table 4.8, 4.9 and 4.10).

3.5.1 Veld condition scores

The veld condition score which is determined by the sum of the rangeland scores (Increaser and Decreaser grass species) divided by the benchmark value. This calculations was done for each grazing site. Below is an example for Mafube village grazing area, indicating the current veld condition score.

$$\text{Veld condition score} = \frac{\text{Rangeland scores (increasers and decreasers grass species)}}{\text{Benchmark grazing value}}$$

$$\text{Veld condition score} = \frac{(226)}{950}$$

$$\therefore \text{ Veld condition score} = 0.23 \text{ .... (1)}$$

3.5.2 Grazing Capacity

The veld condition score of 0.23 as obtained in (equation 1) is converted to percentage of 23% before it is applied on the grazing capacity equation below, this will indicate the impact of the current veld condition score on grazing capacity. However, it should be noted the a high veld condition scores increases the grazing capacity, and contrary, it also reduces it. For the purpose of this this calculation, it is assumed that other factors such as the mean annual rainfall, grazing duration, animal feed requirement per day, woody material and accessibility will be kept constant in order to accentuate the impact of veld condition improvement on the grazing are and ultimately livestock production and profitability.

$$\text{Grazing capacity (ha } au^{-1}) = \frac{\text{D} \times \text{R}}{\left\{\left[(\text{MAR} \times 0.8) \times \left(\frac{\text{VC}}{100} \times 5\right)\right] \times \text{W} \times \text{A}\right\}/2}$$

$$\text{Grazing capacity (ha } au^{-1}) = \frac{360 \times 10}{\{[(860.06 \times 0.8) \times (23/100 \times 5)] \times 1 \times 1\}/2}$$

$$\text{Grazing capacity (ha } au^{-1}) = 2.15 \text{ .... (2)}$$

3.5.3 Carrying Capacity of the grazing area

The grazing capacity value obtained in equation (2) is used to determine the currying capacity of the grazing area. Which indicates the total number of cattle that the grazing area of a specific size in hectares is capable of sustaining over a period of twelve months based on its grazing capacity. See equation below.

$$\textit{Carrying capacity of the grazing area} = \frac{\text{Total Grazing Area}}{\text{Grazing capacity}}$$

$$\text{Carrying capacity (au)} = \frac{803 \text{ (ha)}}{2.15 (\text{ha } au^{-1})}$$

$$\text{Grazing capacity (au)} = 374 \text{ .... (3)}$$

3.5.4 Grazing Potential

For the interpretation of the grazing potential value, (see Table 3.5)

$$\text{Grazing Potential} = \text{Veld conditon x Benchmark value}$$

$$\text{Grazing Potential} = 0.23 \text{ x } 950$$

$$\text{Grazing Potential} = 226 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

3.5.5 Animal weight gain

The weight gain was computed based on the cattle production records that indicated initial weight of the cattle and final weight gain in 104 days during the grazing season. The oxen weight gain values were used in these calculation.

$$\text{Average cattle weight (kg)} = \frac{(\text{beginning weight} + \text{final weight})}{2}$$

$$\text{Average cattle weight (kg)} = \frac{(205 + 290)}{2}$$

$$\therefore \ \text{Average weight gain per animal (kg)} = 247.5 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Equation Adopted from: Understander *et al.*, 2002

The above equations were used to compute the theoretical value that can be used to determine potential ecological and financial benefits of each grazing system.

3.6 Conclusion

This chapter explained the meta-analysis method and how it is applied to determine the effects of continuous and rotational grazing systems on cattle weight gain and profit. This method uses statistical techniques for analysing quantitative research findings from other studies. An overview of the study area was presented, followed the explanation of how the case study research method was employed to investigate the selected communal grazing systems in their real-life context. This included a diagrammatic representation of the data collection process followed to engage all key stakeholders in the study. The rangeland condition assessment method was employed to assess the condition of the grazing area. These methods were used to collect data from various sources with the use of various techniques to meet the objective of the study. Furthermore, the equations used for synthesising the financial and ecological data were presented, and how these equations were used to compute the potential grazing benefits as a result of improvement in the condition of the grazing area.

Chapter 4: Case study research report of three communal beef cattle grazing systems investigated at Motseng, Moiketsi and Mafube village.

4.1 Introduction

The implementation of a grazing system in place of continuous grazing system apparently provides various benefits, while other sources in the literature maintain that there is no difference between the two systems in terms of production. However, other studies argued that management input is essential for the success of either system, and that different environmental conditions and animal characteristics also influence the outcome of either system (Chapter 2). The quantitative literature (meta-analysis) was based on few studies that were found and therefore its outcomes cannot be used as an authority for recommendation, unless more studies are added. The primary aim of this chapter is to meet the objectives of this research study (see Chapter 1, section 1.4).

In this chapter, grazing systems are assessed in terms of their financial costs of implementation, maintenance and revenues generated. Moreover, the potential financial and environmental benefits realised from each case study site are assessed. A synthesis of the ecological and financial data will be used to compute potential economic benefits that can be realised due to improvement in the veld condition. The chapter will describe and discuss each case study separately, before presenting an integrated summary of the case studies.

4.2 Case no.1: Motseng village

4.2.1 Background

<u>Before intervention/adoption of the new communal beef cattle grazing system</u>

The communal beef cattle farmers at Motseng village were practicing an uncoordinated grazing management of the cattle herd on the communal land. The livestock were allowed to graze freely without any restriction. Most of the grazing was occurring near the residential area. During the dry seasons there was shortage of forage. An animal health program was not available. Access to formal markets was a challenge because of the distance to markets, cost of transportation, poor condition of cattle and lack of access to market information.

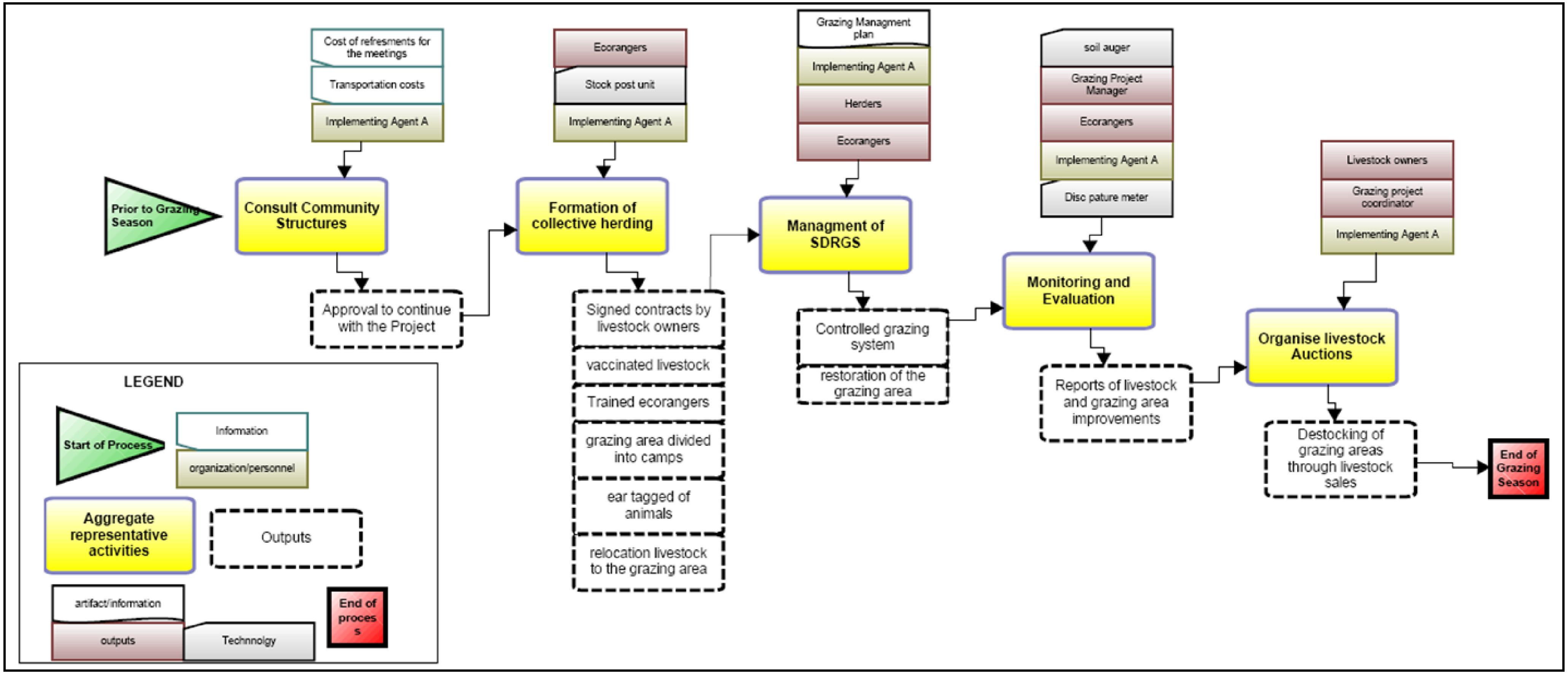

Figure 4.1 : An overview of the how model indicating the process followed when implementing the modified HPG/short duration rotational grazing system at Motseng (xBML software).

The impact of cattle grazing on the environment was negative due to selective grazing and overgrazing in some areas. In addition, alien invasive plant species had spread into potential grazing areas reducing the grazing area. These challenges attracted the attention of government implementing agents who engaged the community in discussion around new approaches for managing the livestock and the grazing area. A systemic process of stakeholder engagement and community mobilization to combat these challenges was followed (Figure 4.1).

After Intervention/introduction of to the new communal beef cattle grazing system

A total of 29 livestock owners are involved in the facilitated collective herding program at Motseng village. The livestock numbers during this study were 189 cattle, 137 sheep, 167 goats, and 48 horses. Motseng has a total area of 803 ha. In addition, 102 hectares invaded with wattle and 80 hectares is the village residential area. The current cattle stocking rate is 3.42 ha au^{-1}.

During the implementation, implementing agents from two separate institutions in collaboration with the community proposed a new system of grazing management. After a number of presentations, the communal beef cattle farmers agreed to adopt this new approach called modified Holistic Planned Grazing (modified HPG) based on HPG (Savory, 2013). The community went through a planning phase under the instruction of a HM® educator. Although high livestock densities are often characteristic of HPG, in order to achieve the alleged benefits of animal impact, the community would not increase cattle density in the first phase but would take the important step of pooling their herd, allocating grazing land outside the village, and dividing this grazing land into virtual camps (Figure 4.1). Henceforth the form of HPG used by the community will be referred to as modified HPG, being a customized form of HPG that combined more flexible grazing plans than is suggested for HPG, and moderate animal densities.

The implementing agent (A) and communal beef cattle farmers at Motseng village listed the following inputs required to establish a short duration rotational (modified HPG) beef cattle grazing system.

1. Mobile electric kraal for stock posting
2. Animal handling facilities (treatments, marking, sales etc.)
3. Livestock tagging and record-keeping on central database
4. Vaccinations as incentives and reward (for communal farmers who are compliant according to the signed contract)
5. Linkage to markets (organise auctions)
6. Ecorangers from village through Natural Resource Management funds (Department of Environmental Affairs) with existing herders
7. Signed agreements with livestock owners for set period to commit both parties
8. Rangeland condition assessments to compare stocking rates and carrying capacity and to measure change in condition over time

4.2.2 Description of the kraaling system used at Motseng village

The modified HPG system at Motseng village was piloted during 2014. A total of 803 hectares of grazing land was divided into twelve camps. The cattle were kept at the locations it grazed to minimize travel distances from home to the grazing areas. Multiple stakeholders (implementing agent A, Ecorangers, communal farmers and Herders) manage this grazing system.

Figure 4.2: Ecorangers (herder who watch livestock at night) at the cattle encamped in an electric mobile fence grazing camp. (It consist of electric solar panel connected to a fence to form an overnight kraal).

Figure 4.2, shows a single communal cattle herd. It includes cattle from farmers who are part of the grazing program at Motseng village. A total grazing area is mapped into a single grazing management unit. The community determines the grazing plan and the rangeland condition is used for monitoring the impact of grazing on the rangeland. The electric overnight kraal is located at a distance away from the village during the summer growing season in an area where the herd is managed to graze according to the grazing plan.

The stockpost (area selected for overnight kraaling) areas are always positioned near to a water source. The grazing area near the village is rested for grazing in the winter season (beginning of June to end August). The condition of the grazing rangeland is monitored by observing the veld condition to ensure that animals graze where there is enough grass. Grazing occurs on different portions of the grazing land and at different times as planned. Four quadrants in each camp are formed, and each quadrant is grazed for the duration of a week at a time in accordance with the grazing plan (see Annexure H). After four weeks, the camp is completely grazed, then the kraal and the herd are moved to the next grazing camp. The timing of the re-allocation of the kraal is subject to other factors such as rainfall conditions and the availability of grass. With flexible management, adjustments to the period that cattle spend in each camp are conducted. Records of actual animal densities, stocking rates and days of grazing per camp were current. The herders manage the cattle herd during the day. The Ecorangers are responsible for the overnight kraaling of the cattle herd. The overnight kraaling sometimes had a two-fold function. It provides kraal for the cattle and serves as a grazing land restoration method. Where high stocking density of the cattle is practised, the cattle hoof trampling effect is accentuated. Concentrated manure and urine on the previously disturbed or wattle-cleared area also stimulates grass growth (Figure 4.2 and 4.3).

Figure 4.3: Wattle cleared area on the grazing rangeland at Motseng village.

An estimated 44 hectares of the grazing land at Motseng village was infested with *Acacia dealbata* (silver wattle). Figure 4.3 shows what the area looks like after it has been cleared of wattle. To restore this area, the communal livestock farmers use this cleared area as an overnight kraal for the communal herd.

Figure 4.4: Kraaling area that was occupied by cattle over-night for a period three to four weeks at Motseng village.

The overnight kraaling area appears muddy after three to four weeks of overnighting (Figure 4.4). The positioning of kraals is on areas that are level or have slight slope. The intention was to avoid soil erosion through water runoff under rainy conditions, as the effect of animal hoofs on ground loosens the muddy soil.

The Ecorangers and farmers/herders usually broadcast the native grass seed over the kraaling area when it is still muddy. The grass seeds are harvested by hand from nearby native grasses with seeds ready for planting. Under heavy rainy conditions, the cattle herd spend less time in each camp to avoid land degradation caused by the effect of high stocking density in a small muddy area because of compaction. The short duration rotational beef cattle grazing systems is labour intensive. It requires accurate monitoring and evaluation skills and techniques from management of both the cattle and grazing areas.

Figure 4.5: An overnight kraaling area showing soil mixed with cattle manure and urine at Motseng village.

The overnight kraaling area two days after evacuation of the kraal (Figure 4.5). The soil appears to have been mechanically tilled. A closer look reveals the hoof prints of cattle. This process happened during overnight kraaling for three to four weeks. The cattle hoof mixed the soil with cattle manure, urine and grass.

4.2.3 Livestock Production

Since the project started in 2014, the livestock numbers have decreased by 109 cattle from 291 to 182 cattle. The communal livestock farmers reported a decrease in livestock numbers, is due sales (14 sold in the recent auction) and members who exited the program with their livestock. The reason why other member left the programme were not stated. Mortality is still relatively low, but was low even before the start of the program. Seasonal changes also affect production, due to the unavailability of palatable grass during winter, and death as result of exposure (Focus group discussion 2015, pers. comm). The cattle growth records indicated consistent weight gain. Overall, cattle weighed an average of 292.03kg live weight before joining the grazing programme, after 104 days the cattle weighted 329.73kg live weight. However, the growth rate could not be attributed exclusively to the grazing system as various factors were introduced at the same time, namely rotation grazing, cattle vaccination and the removal of cattle from the village area.

The livestock owners are actively involved, and the implementing agents continue to offer technical support, for a summary of the key activities undertaken each day (Figure 4.6).

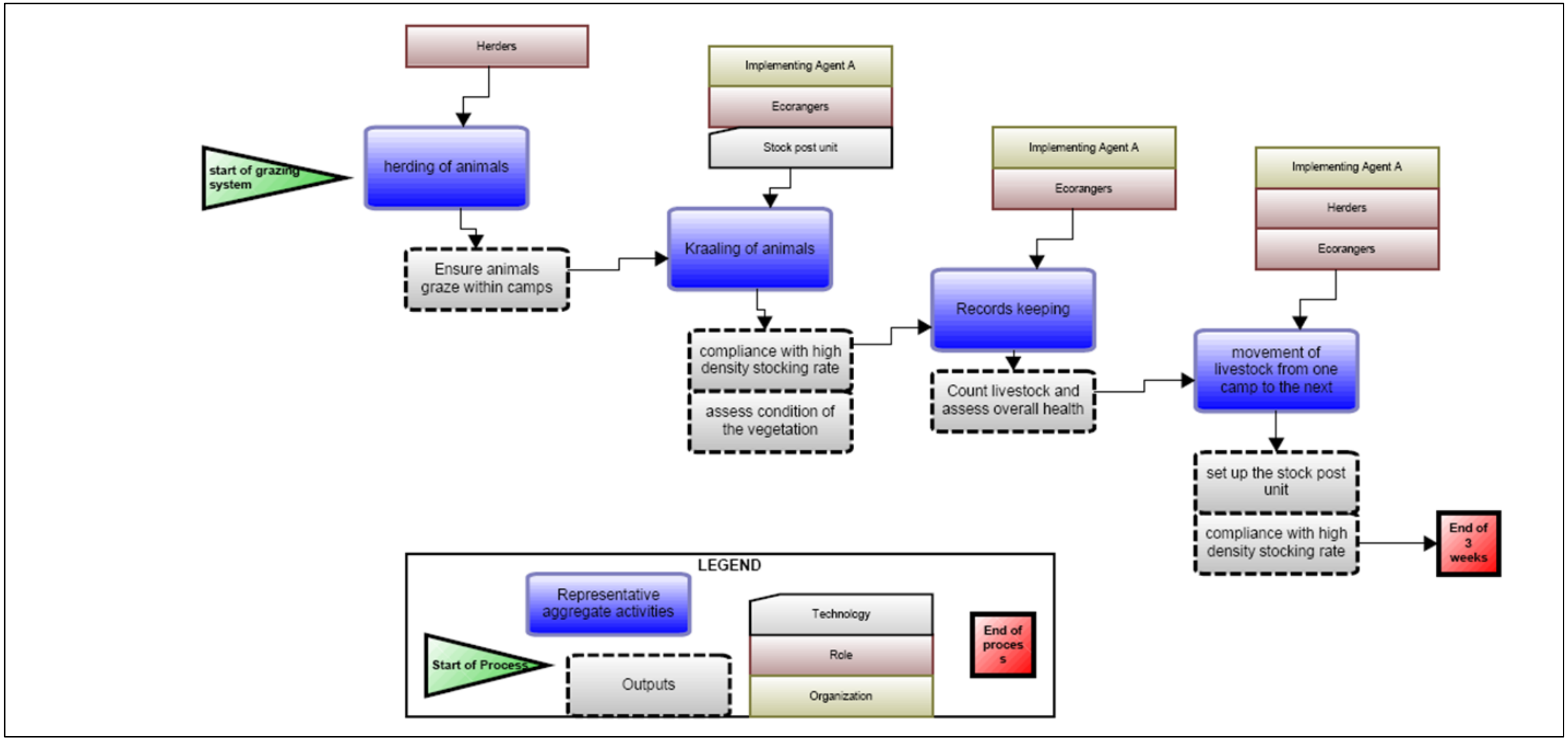

Figure 4.6: How model indicating a summary of activities for managing the modified HPG at Motseng village (xBML software).

4.2.4 Financial implications of implementing the short duration (modified HPG) communal beef cattle grazing system

The inputs required for implementing the modified HPG system, excluded the cost of the grazing. This is because the land is communally owned. Furthermore, the grazing land users are clearly defined, because only village members are allowed to graze on the grazing area within Motseng village. The cost of cattle was also excluded because the new grazing systems were adopted by existing communal livestock farmers. The money used for payment of the inputs and operation costs was received as a donation from various donors including the government. In other words it was attempted to include factors that would be direct.

Table 4.1 and 4.2 indicate the initial cost of inputs for implementing the modified HPG was R 94 602 and the operational cost in the first year was R71 600. For the second year the operational costs was R71 600. The total cost incurred for inputs and operations was R237 802.

Table 4.1: Financial budget for inputs used for implementing the modified HPG system at Motseng village.

Item	Description	Period of supply/duration of service	Cost rands (R)
Animal health	Vaccination before change in main feed (winter and summer)	R11.00/Large Animal Unit Large Animal Unit (LAU)/1st year	291x11= R3201.00
	State Vet	Offer veterinary service during the vaccination of collective herd	R0.00
Mobile electric overnight kraal	Safix solar powered energizer and netting fence with posts	Stock posting unit that will be used for a period of six months (summers)	R10 000 per herd
Camping tent	One herd		R3000.00

Mobile handling facilities	Taltec mobile livestock handling facilities (Shared between six villages)	Used when weighing, treating and loading animals	R65 000 Once off + 5 % maintenance per year.
Eartags (Animal ID & traceability)	GMP Tags with 2D bar code For traceability purpose	duration of year	R11,00 per livestock unit 291 = R3 201.00
	Software and applicator (x2)	For duration of data capturing	R1500 start fee
Livestock owner agreements	Translation to Sesotho by first language speaker	As needed	R1000.00
Ecorangers equipments	Sleeping bags (one per Ecoranger) and mat Posts and pans Small solar charges for cell phones	Used by four Ecorangers in the rangelandfor six months of each year.Spotlight light exhibit enough light to see the whole herd at night should the need arise	4 Sleeping bag = R550.00 posts and pans = R300.00 Spotlight R600.00
Transportation cost for collection of grazing equipment from another province	Livestock handling facilities, transported from Gauteng to Eastern Cape	Equipments used during the grazing season (6 months)	R3000.00 per month
Total cost			R94 602.00

Table 4.2: Financial budget for operating the modified HPG.

Item	**2014**	**2015**
Salaries and training of four Ecorangers (Seasonal labourers) Range 2500 (salary +Training). Even though the trainings were not conducted every month, but whenever the need arise.	Four seasonal workers; 4x2500 = R10 000.00 Total over a period of seven months; 10 000 x 7= R70 000.00	R70 000.00
Airtime per Ecorangers team for two weeks	one month = R100, therefore six months = R600.00 (total cost per annum)	R600.00
Stationary	R1000.00 per month	R1000.00
Total Cost	R71 600.00	R71 600.00

4.2.5 Beef cattle sales

Market linkage is an important aspect of the incentives offered by the UCPP. It is supported by organising a livestock sales auction toward or at the end of each grazing season (June and April). Through the livestock auction, the communal beef cattle farmers who are willing to sell livestock are brought together with potential buyers. The implementing agent has facilitated and pioneered the organisation of these auctions for the communal farmers in Motseng village.

Market linkage was described as having a major environmental benefit according to the implementing agent A, because it assists with destocking the communal grazing areas. This is seen as a positive way of managing the stocking rate. The communal cattle farmers also reap some financial benefits from selling their livestock. Table 4.3 indicates the outcomes of the first and second official auctions for the communal farmers at Motseng village. An amount of R57 700.00 and R75 750.00 was generated at cattle auction sales during the year 2014 and 2015, respectively.

The best timing for livestock sales, to many of the communal beef cattle farmers, proved to be at the end of the grazing season. This is because livestock are in prime condition for selling. The other advantage was that they could reduce the number of cattle before winter season, because there is not enough forage for cattle on the sour rangeland grazing areas.

The highest price obtained for selling live cattle was R8 400.00 in 2014, and R6 750.00 in 2015. On average, the bulls were sold for R13.23kg in 2014 and R9.82kg in 2015, oxen were sold R11.55kg in 2014 and R9.66kg in 2015, and the cows were sold at R12.60kg in 2014 and R8.52kg live weight. The law of demand and supply among other factors can explain a decline in the price of cattle in 2014 versus 2015. The higher the supply of beef than the demand, the lower the prices and by contrast, the higher the demand than the supply, the more the increase in price.

Table 4.3: Livestock auction sales at Motseng village for 2014 and 2015.

Motseng village		
Date	23-Jun-2014	01-Apr-2015
No of stock offered	14	16
No of stock sold	11	14
No of stock not sold	3	2
% Sold	78.57%	87.50%
Highest price	R8 400,00	R6 750.00
Lowest price	R3 100.00	R3 900.00
Ave R kg^{-1} offered	R11.50	R9.58
Ave R kg^{-1} sold	R8.88	R10.59
Total turnover	R57 700.00	R75 750.00
Total no of bulls offered	3	1
Total no of bulls sold	3	1
Ave R kg^{-1} bulls sold	R13.23	R9.82
Total no of oxen offered	7	9
Total no of oxen sold	5	8
Ave R kg^{-1} oxen sold	R11.55	R9.66
Total no of cows offered	3	6
Total no of cows sold	3	6
Ave R kg^{-1} cows sold	R12.60	R8.52

The initial financial investment for implementing the modified HPG system, including the operation costs for the first year was R166 202. In the second year the operation costs were R71 600. Through the two auction sales (Table 4.3) a total revenue of R133 450 was generated.

A challenge with the financial management in the current communal grazing system is that the revenue generated through livestock sales is not re-invested into grazing system. Instead, the revenue generated is paid to the livestock owners without charging any commission. The auction is organised and managed by implementing agent through external funding. This approach is only sustainable because of the flow of money from donors into communal grazing systems. This may however promote dependency on external funding to sustain current operations. The auction market is preferred by most farmers; as the stock sold, seem to increase from the first auction sale to the second one. Other farmers at Motseng disclosed that, they use some of the money they receive from selling their livestock to buy new marketable stock, which is a form of reinvestment.

4.2.6 Summary of the findings

The type of grazing systems used at Motseng is a modified HPG system. This system was introduced to aid communal cattle farmers at Motseng to improve the condition of the grazing areas, while maximising livestock production in a sustainable manner. The initial financial investment for implementing the modified HPG system at Motseng was R166 202.00 (inputs and operation cost for the first year). The farmers did not have any infrastructure on the grazing area, hence the initial investment was high. In the second year only R71 600 was incurred for the operation costs. Most of this money was spent on labour to pay Ecorangers who looked after the cattle herd at night. The total economic revenue generated through livestock auction sales from 2014 to 2015 was 44% of the initial finance invested.

The establishment of formal markets as in the case of auction sale, created awareness about the financial value of cattle based on weight gain. Moreover, the sales recorded indicated that *ceteries paribus*, the payback period would be less than three years. The implementation of the new grazing system is an improvement of the old system, because the cattle herd is not grazing near the resident area where there grass was considered to be of low grazing capacity. At the end of each grazing season when the cattle are still in good condition, the are sold to the market at good prices. Not all these services were therefore the implementation of the new grazing system.

4.3 Case no.2: Moiketsi Village

4.3.1 Background

The village of Moiketsi is under a Tribal Authority type of leadership. The history of grazing around this village dates back prior to a democratic government. The communal farmers used to practise a rotational grazing system also called 'Maboela' in the local language. The grazing camps were demarcated with permanent fences. With the dawn of a democratic government, the communal farmers no longer received government support (Focus group 2015, pers. comm). As a result, they discontinued practising rotational grazing. The infrastructure that was established to support and enforce rotational grazing system became obsolete and vandalised over time.

Communal farmers in this area switched from practising rotational grazing to a continuous grazing system, and as a result, the grazing area was no longer divided into camps. The situation worsened because communal livestock farmers did not receive essential agricultural support services from the government extension officers, such as animal health management programmes.

This led to deterioration in the condition of the grazing areas, as well as the condition of the livestock. The livestock was allowed to freely graze everywhere without any restriction. During the winter season, there is usually a shortage of feed. Animals practice selective grazing during the summer season, therefore, this created condition favourable for unpalatable plant species to increase. There is an overall loss in plant species biodiversity, and coupled with the effects of rainwater runoff, this has caused soil erosion and dongas particularly uneven areas.

4.3.2 Description of the continuous beef cattle grazing systems at Moiketsi village

The total grazing area is 1160 hectares as highlighted (see Annexure J). Of these 44 hectares was infested with wattle. In 2014, there were 60 livestock owners at Moiketsi village. In 2014, the livestock numbers were 471 cattle, 575 sheep, 278 goats, 71 horses and two donkeys.

Figure 4.7: Cattle under continuous grazing system at Moiketsi grazing site.

In Figure 4.7 shows a presentative area of Moiketsi that is freely grazed by cattle herd throughout the year without any restriction. For grazing plan map (see Annexure I). The current stocking rate at Moiketsi is 1.9 ha au^{-1}. The communal livestock farmers at Moiketsi do not practice any permanent rotational grazing system. They are not practising collective herding, and there is no grazing management plan. However, the livestock graze freely.

4.3.3 Financial analysis of costs and returns associated with this grazing system.

The communal farmers from Moiketsi village benefit from selling their cattle at auctions organised by implementing agents supporting other villages. Table 4.4 indicates that Moiketsi communal farmers sold some of the livestock at a maximum price of R7800.00 and minimum price of R6000.00 during the auction in 2014. The total revenue generated from selling only two oxen was R13 800.00. In 2015, there was an increase in the number of cattle made available for sale. A total of 13 cattle were offered but only 11 cattle were sold, and generated a turnover of R55 950.00. The communal farmers in Moiketsi also sell their livestock at informal markets. For the purpose of the study, there was no sufficient data or evidence presented to be recorded about informal cattle sales, and the salaries paid to herders could not be disclosed. When the farmers were asked about the availability of animal health programme, they explained that they are situated far from the markets where the medication is sold and transportation cost are limiting (Focus group discussion 2015, pers. comm).

Table 4.4: Summary of Moiketsi village livestock auction sales for the year 2014 and 2015.

Moiketsi village		
Date	23-June-2014	29-April-2015
No of stock offered	2	13
No of stock sold	2	11
No of stock not sold	0	2
% Sold	100%	84.62%
Highest price	R7 800.00	R7 500.00
Lowest price	R6 000.00	R4 000.00
Ave R kg^{-1} offered	R14.38	R10.68
Ave R kg^{-1} sold	R14.38	R10.70
Total turnover	R13 800.00	R55 950.00
Total no of bulls offered	0	1
Total no of bulls sold	0	1
Ave R kg^{-1} bulls sold	R0.00	R11.25
Total no of oxen offered	2	9
Total no of oxen sold	2	6
Ave R kg^{-1} oxen sold	R14,38	R11.66
Total no of cows offered	0	9
Total no of cows sold	0	3
Ave R kg^{-1} cows sold	R0.00	R10.23

4.3.4 Summary of the findings

The communal farmers at Moiketsi rely heavily on the grazing area as the main input and source of feed for their livestock. Without any form of technical support from implementing agents, the communal farmers have managed to sustain the cattle herd. They generated a revenue of R13 800.00 from auction sales in 2014 and R55 900.00 in 2015. Access to auction markets assisted by destocking the grazing area, because a total of 13 cattle were sold. Transportation costs to town when an individual farmer wishes to medicate his animals, and the price of medication, are some of the costs incurred by the individual farmers.

Case no.3: Mafube Village

4.4.1 Background

Mafube, Motseng and Moiketsi village are located in the same Ward eight of Matatiele Local Municipality. The implementing agent is responsible for facilitating the management of the grazing area at Mafube. Prior to the introduction of the new grazing system, the communal farmers in this village used to practise a continuous grazing system, as a grazing management system for their cattle herd. Through this system, the entire grazing areas are open for grazing at all times, without any physical restrictions. The landscape where the cattle graze has uneven distribution of slopes. The land has signs of degradation, such as dongas. Alien invasive plant species spread and reduced water level in the rivers. In 2014, a new grazing system called the rotational rest was introduced and implemented.

4.4.2 Detailed description of the communal beef cattle grazing systems at Matatiele Local Municipality.

Figure 4.8: Cattle from the herd at Mafube, grazing on the opened grazing site.

In Figure 4.8, a small herd in the open grazing site is indicated. The management of the grazing area at Mafube village is aimed at restoring plant vigour and basal cover, as this has potential to increase water retention capacity, hold soil together, reduce soil erosion and reserves grass that can be grazed later. In order to achieve this, a grazing system called rotational rest was adopted. This system of grazing requires that out of a total grazing area of 2 084 hectares, only 75% of this land is opened for grazing, whereas 25% is rested for a full growing season every year, which is from the month of October until the end of May (**see** Annexure J**)** for the grazing plan map.

The areas rested are marked with poles as camps but there is no fencing. The herder-rangers and individual herders employed by livestock owners ensure that the rested camps are kept free of livestock during the rest period. There were 677 cattle, 630 sheep, 888 goats, and 66 horses at Mafube village (Extension officer, Government of Eastern Cape, pers. comm.). Communal farmers at Mafube village still receive governmental support in the form of animal dipping. Farmers in this village do not mix their herds, even though they graze in the same areas.

Table 4.5: Financial budget for input used for implementing the rotational rest grazing system at Mafube village.

Item	**Costs in rands (R)**
Training for Ecorangers	R2500 per Ecoranger x 8 = R120 000 (per annum)
Profession hours for training/educating community members about rotational rest grazing system	R5000-6000 per day; on average = R5 500.00
Training Material (textbook, flip charts, other stationary)	Estimated: R1000.00
Total costs	R126 500.00

In Table 4.5, the initial estimated input costs, for introducing the rotational rest grazing system to the community. The major expenditure is on labour. The role of Ecorangers role transcend keeping the livestock away from entering the rested areas, but also include active restoration of the grazing areas by fixing donga, and the path that animals travel on from home to the grazing area. The estimated training materials are shared among farmer during the training. However, the training and payments of Ecorangers is an item that was carried out into the second year, and it is not once off.

4.4.3: Financial returns from cattle sales

Table 4.6 indicates the cattle sales generated during the first auction organised for the communal farmers at Mafube. The major limitation about the sales auction was that it was monopolised, as there was only one buyer. As a result, out of 65 cattle offered for sale, only 26 or 40% were sold. The total revenue generated was R119 400.00. The indirect management of the livestock grazing through the rotational rest grazing and the shared responsibilities by various stakeholders in this communal area, has significantly lowered costs of operating the rotational rest grazing system.

Table 4.6: First official livestock auction for communal farmers at Mafube village.

Mafube village	
Date	20-May-2015
No of stock offered	65
No of stock sold	26
No of stock not sold	39
% Sold	40
Highest price	R7 700.00
Lowest price	R2 300.00
Ave R kg^{-1} offered	R11.25
Ave R kg^{-1} sold	R11.76
Total turnover	R119 400.00
Total no of bulls offered	9
Total no of bulls sold	4
Ave R kg^{-1} bulls sold	R8.23
Total no of oxen offered	49
Total no of oxen sold	19
Ave R kg^{-1} oxen sold	R9.06
Total no of cows offered	7
Total no of cows sold	5
Ave R kg^{-1} cows sold	R10.32

When the project managers' of the rotational rest grazing system were asked if this grazing system is cost effective, it was reported that it is effective within the scope to project but payments of

Herder-rangers needs to be considered if it is to be applied elsewhere. The system does not require fencing as herders keep livestock out of closed areas.

4.4.4 Summary of the findings

The implementation of the rotational rest grazing system, allows for 25% of the grazing to be rested for a full grazing systems. Whereas, before its implementation no portion of the grazing area was rested. The cost associated with implementing a rotational rest grazing system is R126 500.00 . The cattle produced at Mafube village generated of R119 400.00from the auction sales. The involvement of state extension officer contributes to the reduction in the cost of livestock production. The services offered include animal health improvement programs.

4.5 Rangeland condition assessment results of the three case study sites

The economic benefits are just one aspect of the benefits that can be realised from adopting either the modified HPG, continuous or rotational rest grazing system. The other benefits include the improvement of the condition of the grazing area. Since these benefits cannot be easily expressed in monetary terms, rangeland condition assessments were conducted on each grazing site to measure the impact of each grazing system on the site. It is however, acknowledged that it is too soon to deduce about the impact on the grazing systems on grazing sites that were recently being introduced to a form of grazing approach, specifically at Motseng and Mafube.

Table 4.7, indicates the vegetation type found at Motseng, Moiketsi and Mafube villages. This vegetation type is called the East Griqualand Grassland. The rangeland condition score is based on the scores of each of the grass species and the frequency of each species. The grass was assigned a grazing score that ranges from one to ten. Based on these scores, the grasses can be divided according to their 'ecological status' as Decreaser, Increase I, Increaser II, and Increaser III (see Chapter 3, section 3.4.3). The rangeland condition score is a total of the grazing scores from all species on the grazing sites. The rangeland score was then divided by a benchmark value of 950, which is the highest in the area. The veld condition scores is a product of dividing the rangeland condition score by the benchmark value. Motseng grazing site had a veld condition score of 0.23, Moiketsi 0.24, and Mafube is 0.39. Veld condition scores indicate the proportion of grass that is suitable for grazing purpose. The lower veld condition scores are good indicators of areas that need restoration or improvement to increase proportion of palatable grass for livestock production.

Table 4.7: Rangeland condition assessment results for Motseng, Moiketsi and Mafube grazing sites.

Variables	Motseng grazing site	Moiketsi grazing site	Mafube grazing site
Vegetation type	East Griqualand Grassland	East Griqualand Grassland	East Griqualand Grassland
Veld condition score	0.23	0.24	0.39
Basal%	60.50	71.75	69.50
Litter%	4.88	14.25	0.0
Biological crust%	0.13	0.38	3.50
Grazing capacity (ha au^{-1})	2.15	1.81	1.07
Average Biomass (kg ha^{-1}) from dpm (Potgieter & Trollop 1985)	1604.10	1462.23	814.28
Grazing potential	LOW-VERY HIGH	LOW-MEDIUM	HIGH
Biodiversity (H)	1.28	1.11	0.98

The basal cover percentage indicates the proportion of the ground that is covered, at Motseng grazing site, 60.5% of the ground is covered, Moiketsi 71.75% and Mafube 69.50 %. These grazing sites have significantly high basal cover percentages. Litter percentage, which refers to the plant loose litter on the ground measured at the grazing sites, at Motseng grazing site it is 4.88%, Moiketsi 14.25% and Mafube is 0.0%. The rainwater runoff and the wind could have removed the loose litter at Mafube grazing site, because the area is elevated and there are dongas. The biological crust on soil from moss, lichen, cyanobacteria at Motseng grazing site is 0.13%, Moiketsi 0.38% and Mafube 3.50%.

The grazing capacity is the productiveness of the grazeable/palatable grass expressed as the land area required to sustain one animal unit through a long duration/period without degenerating the veld. Motseng grazing site has a grazing capacity of 2.15 (ha au^{-1}), meaning that one animal unit requires 2.15 ha per year, Moiketsi site has a grazing capacity of 1.81 (ha au^{-1}) and Mafube is 1.07 ha au^{-1}. Compliance to the grazing capacity is important to sustain the cattle herd on grazing area for year, over stocking above the grazing capacity is unsustainable because there will be more cattle than there is forage. However, current stocking rate at Motseng is 3.42 (ha au^{-1}), Moiketsi 1.9 (ha au^{-1}). This means additional land is required at Motseng and Moiketsi in order comply with the grazing capacity. The other alternative is reducing the number of animal on the grazing area. For Mafube grazing site, there were no records provided to account for the current stocking rate, but the rangeland condition assessment results indicate that each animal at Mafube requires only 1.07 (ha au^{-1}).

The grazing potential is a classification based on the overall range condition score value. The ranges are as follows, a rangeland condition score greater than 750 or (>750) is Very High, (>650 but ≤750) is High, (>550 but ≤650) is Medium, (>450 but ≤550) is Low and (<450) is Very Low. Motseng has a grazing potential of Low Very High, meaning that in different sampled areas that were assessed at the study site, the range condition scores were Low and Very High (>450 but > 750), hence Low-Very High, Moiketsi is Low-Medium (>450 but ≤650), and Mafube is High (> 750) (see Table 3.5).

The average biomass (kg ha^{-1}) was measured using a disc pasture meter, the following was recorded at Motseng 1604.10 (kg ha^{-1}), Moiketsi 1462.23 (kg ha^{-1}), and for Mafube is 814.28 (kg ha^{-1}). The biomass is a good indicator of the biomass fuel. The grazing sites are located in an area that is under threat of fires, quantifying the vegetation biomass informs contingency plans aimed at combating possible fire hazards. The overall Shannon Wiener plant biodiversity (H) indicates the effective number species found on the transect sites. In the case of Motseng a biodiversity (H) value of 1.28 was computed, implying that on average there are 1.28 dominantly occurring plant species, likewise, at Moiketsi there is 1.11 reoccurring plant species and for Mafube it is 0.98. The higher the biodiversity number the higher the number of grass species on the sample area: this could be because the area has not been disturbed mechanically, chemically or by any other means possible.

The interpretation of the biodiversity (H) in relation to veld condition score on the grazing area, reveals that although Motseng has a high biodiversity, the veld condition score of 0.23, indicates that only 23% of the grass species is palatable to the livestock. Moiketsi has a moderate biodiversity, and the veld condition score of 0.24, indicates that only 24% of the grass is palatable and in the case of Mafube, the biodiversity value is low, and the veld condition score of 0.39, indicates that 39% of grass is palatable to the livestock. Therefore, it is deducible that a high biodiversity value does not necessarily mean that the grazing site is highly grazeable, but instead it is a value that simply accounts for the number of different species without considering their relevance for livestock grazing.

4.6: Financial implications

The initial investment required to implement a grazing system was relatively high in the case of a modified HPG system adopted at Motseng village. This excluded costs associated with land, livestock and daytime labour. The cost of infrastructure was incurred once off in 2014. In the following year cost decreased because, only the operational activities were financed. The infrastructure required for operating this grazing system is in place. A smaller fraction of money would be required to maintain the infrastructure. The revenue generated through modified HPG in 2014 was R57 000.00. In 2015 was 75 750.00. This implies an overall increase of 57%. The average sale price of cattle produced through the modified HPG system in 2015 was R9.82 kg^{-1} for bulls, for oxen R9.66 kg^{-1} and R8.52 kg^{-1} for cows. The sale price of cattle produced through modified HPG system dropped quite significantly in 2015 when compared to 2014 cattle auction sales. This is because of an increase in the number of cattle supplied for sale in 2015. The supply of cattle was higher than the demand.

The continuous and rotational rest grazing systems were least costly to implement. This is because no new infrastructure was required. Communal farmers also adopt these systems relatively easily. Farmers still graze their cattle on the same area without mixing their herd, because of sufficient grazing area available. Farm financial and cattle production record keeping is absent among most communal farmers. The following cattle sales prices were obtained in 2015. For livestock produced through the continuous grazing system a bull sold for R11.25 kg^{-1}, oxen R11.66 kg^{-1} and cows R10.33 kg^{-1}. For the cattle produced through the rotational rest grazing system, the sale price were as follows, for a bulls R8.23 kg^{-1}, oxen R9.06 kg^{-1} and cows for R10.32 kg^{-1}. There was only one buyer for cattle produced through the rotational rest grazing system. This created competition among farmers, resulting in lowered prices.

The livestock sales through auction markets are transparent, with clearly defined rules for trading. The cost managing collective the herding grazing systems were sourced through the implementing agents. The implementing agents provide the facilitation and technical support to the communal farmers. In the case of Moiketsi, after the communal livestock farmers discontinued receiving support from the relevant government department more than two decades ago, there has been an overall deterioration in the state of the grazing land, infrastructure and livestock condition. In the absence of government support the rotational grazing system became unsustainable at Moiketsi, hence the communal farmers changed to continuous grazing system.

The anticipated outcomes of the cattle grazing systems among the stakeholders involved were not the same, as some stakeholders were more concerned about the condition of the grazing area, others about the condition of the livestock, and in some cases both cases were prioritised. The financial investment facilitated by implementing agents primarily aimed at improving the condition of the grazing area, while ensuring livestock production and job creation. The opportunity cost of the current collective grazing systems is that the income from the sales of livestock is not reinvested into the grazing operations. This creates dependency on external funding. This makes the system almost unsustainable by itself without government support. The approach of using market linkage as a tool for destocking that grazing area has both economic and environmental benefits.

The data about the state of the grazing sites shows that the sites are different, with the exception of the vegetation type, namely East Griqualand grassland. The veld condition scores indicated that a range of 23 -39% of grass is suitable for grazing purpose. The basal cover percentage of all site is high, the litter percentage for Motseng is 4.88 %, Moiketsi is 14.25% and Mafube has 0% litter on the grazing site. The grazing capacity which a function of the veld condition indicates grazing hectares required to sustain each animal unit over a period of a year. This value informs decisions about stocking rate. The difference between the ideal and the implemented stocking rate, differentiate grazing capacity from stocking rate. Motseng and Moiketsi grazing sites are over stocked. The grazing potential which based on the rangeland scores indicates that Motseng has a grazing potential that is low very high, Moiketsi is low-medium, and Mafube is high, (see Table 3.5 for interpretation). The biodiversity value indicated number of different species found across grazing sites. However, the veld condition scores indicated no correlation between the biodiversity value and veld condition score. The rangeland condition assessment results can be used for measuring the impact of each grazing system over time.

4.7 Potential economic benefits as a result of the improved veld condition on the grazing areas

It is anticipated that one would only see an impact of the various grazing systems on the grazing area after a number of years, likely more than five years or (>5 years) (Nel 2015, pers. comm). For the equations used to compute values in Tables 4.8, 4.9 and 4.10 (see Chapter 3, section 3.5). Grass species abundance with high grazing values improve the veld condition score, whereas, grass species of low abundance and low grazing value decreases the veld condition score. When quantifying the these grazing species, their frequency is determined, then weighted according their grazing value to get the rangeland scores. The rangeland score can be of Increaser or/both Decreaser grass species. The veld condition scores as explained, refers to how much of the grazing area is suitable for livestock grazing.

There are other factors that influence rangeland scores, and this include annual rainfall distribution, soil type, topography, grazing duration and the presence of alien invasive plant species. However, in computing the potential benefits as a result of improved veld condition score, the other factors were held constant to accentuate the impact of veld condition improvement on grazing capacity, carrying capacity, cattle production and revenues generated.

The current and future state grazing situation was modelled, and projection of possible benefits in five or more years was estimated. Table 4.8 indicates that in 2015 there was 5.72 % Decreaser grass species (e.g., *Monocymbium ceresiiform*, *Themeda triandra* and *Brachiaria serrata*) and 88.56% Increaser grass species (e.g., *Tristachya leucothrix, Eragrosis capensia, Heteropogon contortus, Eragrostis racemosa and Microchloa caffra*). These grass species have different grazing values and react differently to grazing pressure. It should be noted that not just a general increase in grass leads to improved veld condition, but specific species with high grazing value and occurring more frequently. The veld condition score in 2014 was 0.23.

In a hypothetical scenario where the modified HPG improves rangeland condition in 2020, the grass composition would have changed so that the veld condition score is increased to 43%. This potential veld condition improvement value was based on the assumption that activities such as the clearing of alien invasive plant species, use of overnight kraaling approach and broadcasting of grass seeds on prepared soil, has potential to accelerate the restoration process. Moreover, the modified HPG system rotates cattle from one camp to the next after four weeks. This approach is anticipated to increase Increaser grass species where the cattle is grazing and increase the Decreaser grass species in camps that are rested. The hypothetical value of 43% veld condition improvement was obtained by adding a hypothetical value of 20% to the current veld condition score of 23%. When computing the hypothetical value, grass species composition and abundance values were adjusted until a veld condition score of 20% was obtained, as explained in Chapter 3 (section 3.5).

Table 4.8 indicates that as the veld condition score increases, the grazing capacity value decreases, this mean that as the veld condition improves few hectares are required to sustain each animal. Contrary to this, as the veld condition score decreases or the veld deteriorate, more hectares are required to sustainable each animal unit. The veld condition score and grazing capacity are linked to the carrying capacity of the grazing area. Improved veld condition is characterised by a high grazing capacity, which implies less hectares per animal, this also implies that a fixed area of land can accommodate even more animals (carrying capacity), whereas, if the veld condition is deteriorated only few animals can be sustained on the same area.

At Motseng, the total grazing area is 803 ha and in 2015 the veld condition score of 0.23, had the grazing capacity of 2.31 (ha au^{-1}) indicating that 2.31 ha are required per animal. With improved veld condition score of 0.43 in 2020, the grazing capacity of 1.21 obtained, this indicates that only 1.21 ha is require per animal as compared to 2.31. Few hectares per animal means that farmer can either buy for animals or expand the current herd without negatively impacting the grazing land by overstocking it. The average weight gain can be maintained as there will be enough forage for all the animals, and this will lead to high production and ultimately high revenues. The potential cattle production and revenue generated were higher than the current production and revenues generated in 2015 and for 2020.

Table 4.8: The potential impact of 20% improvement in veld condition due the modified HPG system.

Improvement in Veld condition		
Variables	Motseng 2015	Motseng 2020
Decreaser grass species %	5.72	39.13
Increaser grass species %	88.56	21.75
Veld condition score	**0.23**	**0.43**
Grazing capacity (ha au^{-1})	**2.31**	**1.21**
Carrying capacity (Herd size)	**348.15**	**663.25**
Current herd size (au)	182.00	182.00
Total Grazing area (ha)	803.00	803.00
Potential herd size growth (AU)	166.15	481.25
Average weight gain in six months (kg)	594.95	594.95
Average sale price of oxen per kg live weight (R kg^{-1})	9.66	9.06
initial weight (kg)	0	0
Total Production per growing season (kg) for the entire herd	108281.25	108281.25
Assuming 50% sale of the cattle herd (kg)	54140.63	54140.63

Total Revenue generated	**R5 604.62**	**R 5 975.79**
Total potential growth per season (kg) for the entire cattle herd	207 133.87	394602.68
Assuming 50% sale of the cattle herd (kg)	103 566.93	197301.34
Potential Revenue per grazing season (R)	**R 10 721.21**	**R 21 777.19**

Continuous grazing system

Through this system, the cattle graze the entire grazing area without any restriction. Table 4.9, indicates in 2015, there was 10.7% Decreaser grass species (*Monocymbium ceresiiform*, *Themeda triandra* and *Brachiaria serrata*) and 25% Increaser grass species (e.g., *Tristachya leucothrix, Eragrosis Capensia, Heteropogon contortus, Eragrostis racemosa and Microchloa caffra*) composition. The veld condition in 2014 was 0.25. A low veld condition score impact negatively on the grazing capacity, carrying capacity, potential herd size expansion and ultimately the revenue.

In a hypothetical scenario where the continuous grazing system improves rangeland condition in 2020, the grass composition would have changed so that the veld condition score is 42%. The assumption is that because the grazing areas under the continuous grazing system is not rested, but continuous grazed, this may increase the Increaser grass species to 95.59% and constantly reduce the Decreaser grass species to 2.25%. The 42% veld condition improvement was obtained by adding a hypothetical 17% to the current veld condition score of 25%.

A hypothesis value of 17% as potential veld condition improvement value was computed by adjusting the Increaser and Decreaser grass species abundance until a the veld condition was 42%, as explained in Chapter 3 (section 3.5). Other assumptions were that the absence of direct financial and management aimed at improving the condition of the grazing area, will allow passive restoration process, which happens slowly and over a long period of time. The 17% improvement in the veld condition has potential to restore the condition of the grazing area and have a positive impact on the revenue (Table 4.9). This process might take longer though, because it is passive restoration (no direct financial investment) and if the livestock number are not well managed, it may take even longer.

At Moiketsi, the grazing area in 2020 will have improved because the grazing capacity will be 1.23 (ha au^{-1}) implying that only 1.23 ha will be required to sustain each animal instead of 2.19 ha which was the case in 2015. The effect of improved veld condition trickles down to the carrying capacity, average weight gain and potential revenues generated are higher in 2015 and 2020.

Table 4.9: The potential impact of 17% improvement in veld condition due to continuous grazing system.

Improvement in Veld condition		
	Moiketsi 2015	Moiketsi 2020
Decreaser grass species %	10.68	2.20
Increaser grass species %	78.63	95.59
Veld condition score	**0.25**	**0.42**
Grazing capacity (ha au^{-1})	**2.19**	**1.23**
Carrying capacity (Herd size)	**530.12**	**650.36**
Current herd size (au)	487.00	487.00
Total Grazing area (ha)	1160.00	1160.00
Potential herd size growth (au)	43.12	163.36
Average weight gain in six months (kg)	594.95	594.95
Average sale price of oxen per kg live weight (R kg^{-1})	11.66	11.66
initial weight (kg)	0	0
Total Production per growing season (kg) for the entire herd	289741.59	289741.59
Assuming 50% sale of the cattle herd (Kg)	144870.79	144870.79
Total Revenue generated	**R12 424.60**	**R 15 990.15**
Total potential growth per season (kg) for the entire cattle herd	315 396.01	386931.18
Assuming 50% sale of the cattle herd (kg)	157 698.01	193465.59
Potential Revenue per grazing season (R)	**R13 524.70**	**R 21 353.82**

Rotational Rest Grazing System

Through this system, the cattle graze on 75% of the entire grazing area without any restriction, and the other 25% is rested. Table 4.10, indicates in 2015, there was 0% Decreaser grass species on sampled areas (*Monocymbium ceresiiform, Themeda triandra* and *Brachiaria serrata*) and 100% Increaser grass species on sampled areas (e.g., *Tristachya leucothrix, Eragrosis capensia, Heteropogon contortus, Eragrotis racemosa and Microchloa caffra*) composition. The veld condition in 2015 was 0.39, which a good score. A high veld condition score indicate high grazing capacity, carrying capacity, and potential herd size expansion and revenue generation.

In a hypothetical scenario where the rotational rest grazing system improves rangeland condition in 2020, the grass composition would have changed so that the veld condition score is 59%. This was based on the assumption that activities such as resting of the grazing area for a full growing season and reduction in livestock numbers due to market sales will increase rate of veld condition improvement. This has potential to allow the regeneration for both the Increaser and Decreaser grass species on the rested grazing area. The value was obtained by adding a hypothetical 20% to the current veld condition score of 29%. A veld condition of 59% has positive impact cattle production and revenue (Table 4.10). This process may take longer, because it is passive restoration (no direct financial investment) and if the livestock number are well managed, the grazing area will remain in good condition. It can be expected that the Decreaser grass species will increase on the rested area, and Increaser grass species will also increase on the grazed area.

Table 4.10: The impact of 20% improvement in the veld condition due to the rotational rest grazing system.

Improvement in Veld condition		
	Mafube 2015	Mafube 2020
Decreaser grass species %	0.00	17.31
Increaser grass species %	100.00	65.39
Veld condition score	0.39	0.59
Grazing capacity (ha au^{-1})	1.36	0.89
Carrying capacity (Herd size)	853.35	1305.05
Current herd size (au)	667.00	667.00
Total Grazing area (ha)	2084.00	2084.00
Potential herd size growth (AU)	186.35	638.05
Average weight gain in six months (kg)	594.95	594.95
Average sale price of oxen per kg live weight (R kg^{-1})	9.06	9.06
initial weight (kg)	0	0
Total Production per growing season (kg) for the entire herd	396 832.93	396 832.93
Assuming 50% sale of the cattle herd (Kg)	198 416.47	198 416.47
Total Revenue generated	R21 900.27	R21 900.27
Total potential growth per season (kg) for the entire cattle herd	507 699.35	776 440.62
Assuming 50% sale of the cattle herd (kg)	253 849.68	388 220.31
Potential Revenue per grazing season (R)	R28 018.73	R42 849.92

4.8 Consolidated case study research analysis

A summary profile of the three case studies (not a direct comparison) is given (Table 4.11). These case studies are unique, and could not be directly compared because of a number of confounding variables, such as the absence of health programs in other grazing systems. However, each case presents a unique set of attributes from which lessons can be derived.

Table 4.11: Summary of the profiles of the case study research areas.

Variables	Unit	Types of Grazing Systems: Modified HPG system	Continuous grazing system	Rotational rest grazing system
Size of grazed land	ha	803	1160	2084
Herd size	No. heads	291 (yr 2014)	471 (yr 2014)	1760 (yr 2014)
		182 (yr 2015)	487 (yr 2015)	677 (yr 2015)
Calving rate	%	54%	No records	No records
Types of labourers	Permanent	Herders	Herders	Herders
	Seasonal	Ecorangers (4)	Not available	Ecorangers (8)
Market Access	Formal	Yes	Yes	Yes (monopolised)
	Informal	Yes	Yes	Yes
Ecological goals	Improvements	Yes	No	Yes
Mortality rate	%	No records	No records	No records
Records kept	Rangeland condition	Yes	No	Yes
	Livestock	Yes	No	No
	Economic	Yes	No	partial
Availability of implementing agent	Yes /No	Yes	No	Yes
Grazing capacity	(ha au^{-1})	2.15	1.81	1.07
Current stocking rate	(ha au^{-1})	3.42	1.9	Not available
Income generated through Auction sales	Rands	2014 : (R 57 700) 2015 : (R75 750)	2014 : (R13 800) 2015 : (R55 950)	Not available 2015 : (R119 400)
Income generated per animal sold in 2015 auction sales	R kg^{-1}	Oxen: 9.66 Cow : 8.52 Bull : 9.82	Oxen : 10.23 Cow : 11.66 Bull : 11.25	Oxen: 9.06 Cow : 10.32 Bull : 8.23

4.9 Conclusion

Communal beef cattle grazing systems such as the modified HPG, continuous, and rotational rest grazing systems, require different management approaches for the livestock and the grazing land. Depending on the objectives of the implementers and communal farmers involved, a modified HPG system requires a high initial capital, and post implementation, labour requirements are too high.
The benefits of this grazing system in cattle production include a potentially improved basal cover on the grazing area. The livestock travel shorter distances because they are kept in grazing land over the growing season and do not return to villages every day.

The potential ecological benefits associated with the modified HPG systems include restoration of the previously disturbed areas, and it improved the quality of poorly managed or overgrazed areas. This is achieved through demarcation of grazing areas into camps, which allows resting of grazing areas. Additionally, the use of overnight kraaling units facilitates the process of land restoration, because the cattle are bunched in one place to concentrate their excretion in the form urine and manure in one area leading to increased grass growth compared to invasive plant species. The hoofs potentially aid in the process, as the hoof action turns the soils to allow the mixing of the soils with manure and urine.

The continuous grazing system practised at Moiketsi was implemented by default for the last two decades . Prior to this, the communal farmers at Moiketsi used to practice a rotational grazing system, with areas demarcated with fences into separate grazing camps. This system flourished because the government enforced it. However, with the change of government, the support that the Moiketsi communal farmers used to receive was withdrawn. In the absence of enforcement, the infrastructure used for dividing the grazing camps was removed. The farmers started practising a continuous grazing system. The implementation cost of the continuous grazing systems could not be determined, because it emerged in the absence of planning or intentional development. However, the livestock production is continuing through this system, and the animal weight gain is still sufficient for the market.

The evaluation of this grazing system's economic viability without reliable detailed farm records made the process difficult. The general condition of the grazing area according to the communal farmers was deteriorating, and this was confirmed by the rangeland condition assessment to a moderate degree. The communal beef cattle farmers at Mafube village implemented a rotational rest grazing system. This system rests 25% of the grazing area for a full growing season. Their focus is less on the management of the cattle. The main similarities in terms of the evidence are that with less than optimal management of the herd and the grazing area there are clear indicators of deterioration in the condition of the grazing area. The implementation of an alternative system requires not only more management that is intensive but also financial investment. A stricter grazing system has more costs. In all instances, the carrying capacity potentially improved with the adoption of a grazing system. Financial benefits are possible under these hypothetical scenarios, but may be only possible with initial inputs from outside funding such as government.

Chapter 5: Conclusion, summary and recommendation

The primary objective of the study included identifying different types of communal beef cattle grazing systems practiced at Matatiele Local Municipality. The specific objectives were to explore them in terms of their cost of implementation and management in cattle production and improvement of the condition of grazing areas. Two of the grazing systems studied were pilot projects implemented by the NGOs, implemented in the year 2014, while the continuous grazing system has been operating for more than two decades.

5.1 Conclusion

This research study was aimed at determining the cost effectiveness or extent to which implementation and management of the selected communal beef cattle grazing systems can support beef cattle production whilst ensuring ecological and financial sustainability. The grazing systems identified are the modified holistic planned, continuous and rotational rest grazing system.

The research methods adopted for this study, namely meta-analysis, case study research, and veld condition assessment were effective in generating knowledge needed to answer the research questions. A meta-analysis method was employed to determine the effects of continuous and rotational grazing systems on cattle weight gain and profit (revenue) and to achieve this, a review of the existing research studies was conducted, following a systematic protocol for study selection and analysis. The results of the meta-analysis indicated that continuous and rotational grazing systems have no significant effect on cattle weight gain and profit. These results are consistent with what was found through the narrative literature review.

Through the case study research method, the communal grazing systems were investigated in their real life context. Through this approach, multiple techniques such as various types' of interviews, artefact identification, and other techniques were applied to gather data from different sources. The communal beef cattle grazing systems identified were modified HPG, rotational rest, and continuous grazing system. These systems presented a range of effort in terms of management in that the modified HPG required high management input, rotational rest required moderate input and the continuous grazing system required little management input. The findings revealed that the modified HPG system requires a high initial once off financial investment for the system to be established and operated in the first year. An initial investment for implementing this grazing system was R166 202.00 and within two years of its establishment, a total revenue of R133 450.00

was generated. The initial investment costs excluded the price of the land, initial marketable and breeding cattle stock, and salaries of daytime herders.

The implementing agent (A) offered technical support on general management of the modified HPG. The social benefits were job creation for Ecorangers and income of communal livestock farmers. Although this thesis did not quantify the social benefits, it is worth noting that knowledge and skill transfer were among some of benefits realised from this grazing system. The communal farmers planned the modified HPG system holistically together with the implementing agent A, and the market access component was included at the end of each grazing season. This had economic benefits and environmental benefits that may be realised over time. The communal farmers received income from selling their livestock and the number of livestock on the grazing area was reduced, resulting in reduced stocking rate. This grazing system has potential to improve the condition of the grazing area, herd size, reduce costs in the long-term, as well as safeguard natural resource reserves/base. Only actual monitoring of the system will determine whether this potential is realised.

The continuous beef cattle grazing system was not managed collectively by livestock owners. The cattle freely grazed on the land without any restrictions. The communal cattle owner’s perceptions of the continuous grazing system were that it is not economically viable, and that it affects the environment negatively. There was no implementing agent assisting the communal farmers with technical support on grazing management. However, the community members acknowledged that with external support from the implementing agents and relevant government departments may enable them to farm better. The markets access opportunities are still a challenge, even though some communal farmers sold their livestock at auctions organized by or for other villages and informal markets. The revenue generated through auction for sale of thirteen cattle in the year 2014 and 2015, was R69 750.00.

Rotational rest grazing system practiced at Mafube village focus more on keeping 25% of the grazing land rested for a full growing season. The major costs incurred when implementing this grazing system, were mainly on stationary, transport to and from the village and hiring a professional to educate and train community members on how the rotational rest grazing system works.

The management of the grazing sites under communal land tenure system proved to be difficult in areas with weakened traditional authority. The difficulty experienced with the application of the case study research method was in cases when participants could not provide any evidence to support their answers; other challenges included the unwillingness of other implementing agents to share information. However, most the data required for this study was obtained.

There was no major difference between how the data was planned to be collected and how it was actually obtained. It was only the translation of research question from English and Setswana to Sesotho, and that the cattle production records were not with the farmers but with implementing agents. The main results of the study were that continuous and rotational grazing systems with initial financial investment, clear farming objective and optimal management can achieve cattle production goals and potentially improve the condition of the grazing area. However, the success of each system probably depends on the collectiveness of the community/communal farmers and relations with other key stakeholders. These communal grazing systems are not directly comparable, because the condition of the grazing sites were different, distinct, the number of livestock and size of grazing areas are not equal and the amount of initial investment was not equal. The stocking rate is the main variable of management for optimal livestock production and improvement of the grazing area. Financial investment in labour and materials is essential to implement any grazing plan e.g. in Mafube and Motseng. Contrary to this, in the case of Moeketsi village, when the infrastructure become obsolete and vandalised the rotational grazing system could no longer be enforced and by default, the continuous grazing system was adopted.

A hypothetical value of veld condition improvement over time was used to hypothesise potential benefits from each of the communal beef cattle grazing systems, it was anticipated that these benefits could be experienced at least after five years. Furthermore, drawing from the characteristics of each grazing system, it is anticipated that, a grazing system that allowed resting of the grazing area for a certain period, also allows regeneration of Decreasers species on the rested grazing area. Whereas, for a grazing system which does not rest the grazing area, it is anticipated that this may potentially allow for the increase of Increaser grass species. An improvement of the rangeland condition has a direct effect on the veld condition score, which also influences the grazing and carrying capacity of the grazing area. With improved veld condition, the livestock production will also improve and increase the revenue. The financial investment is key to active restoration of the grazing area and livestock production. The hypothetical impact of the modified HPG system on the environment is an increase in Decreaser grass species in rested camps, and increase of Increasers grass species in grazed camps. The other grazing systems (continuous and rotational) were hypothesised to be passive in the process of grazing land restoration, because of the absence of direct financial investment or herd management.

The implementation of the modified HPG system at Motseng village has assisted communal farmers with coordination of their farming activities, animal health programs for their cattle herd, improved cattle production, access to markets, knowledge and skills transfer and job creation for the young people in the village. The continuous grazing system has operated for more than two decades and its impact on the grazing area indicates a low medium grazing capacity, this is an indication that the system is not sustainable under current management. There is potential for financial improvement in this system, because without sound grazing management the revenue generated is still relatively high. In the case of Mafube village, the grazing potential is high. However, this cannot be attributed to the grazing system because it has been operating for less two years. The financial and environmental status of these grazing systems need to be assessed overtime. Crucial to the success of the high investment systems is the successful withdrawal of implementing agent with ownership being taken by the communities.

5.2 Summary

The role of communal beef cattle grazing systems in beef cattle production at the rural areas was briefly discussed in Chapter 1. Communal livestock farming systems are confronted with multiple challenges that impede communal farmers to commercialize. Some of the challenges highlighted include the shortage of feed, diseases and pirasites management. The environmental impacts associated with communal livestock farming systems include overgrazing and soil erosion due to lack of proper management systems.

In Chapter 2, a review of previous studies that focused on beef cattle grazing systems was conducted. The emphasis was more on a communal context. The concept of tragedy of the commons was described as being a theory base that accurately depicts the nature and scope to the problems that communal beef cattle farmers are confronting. However, a further breakdown of the theory of the commons into types of land access was used, to distinguish between complete unrestricted access to the land by all users versus access to land by a clearly defined user group only. The types of grazing management types, such as rotational, continuous and their variations were also explained.

The concept of stocking rate was conspicuous in most the studies about grazing systems. It was found that the outcomes obtained through either grazing system, are area specific, and therefore, generalizing what the outcomes of a specific grazing system was confounded by environmental variations such as climate, plant species type, soil type and animal breed. The ecological impacts of different grazing systems were also discussed. It was found that the land tenure system in place greatly influenced the execution of a particular grazing system.

In discussing the economic context of communal beef cattle grazing systems, it was found that, the farming objectives of communal beef cattle farmers were distinct from those of commercial and emerging farmers. The use of livestock, markets access and the total capital employed in beef cattle production were, least costly in the case of communal farmers. The land tenure systems found in communal areas is constraints that made management of communal grazing systems difficult. The outcomes of the meta-analysis study show the continuous and rotational grazing systems do not have a significant effect on cattle weight gain and profit.

A sociological perspective of the role of communal beef cattle grazing systems were discussed, and it was found that beef cattle support the livelihoods of people living in rural areas. Furthermore, it was found the cattle are central to some to the cultural practises such as payment of Lobola for the bride, slaughter during the funeral ceremonies. The role of institutions such as traditional authority, implementing agents, government and civil society organisations, are crucial in supporting communal livestock farmers, in terms of creating a favourable environment that eliminates factors limiting the effectiveness of cattle production systems, which also improve the condition of the grazing area. The sustainability of communal beef cattle grazing systems were discussed with reference to the framework of wicked problems.

In Chapter 3, meta-analysis, case study and rangeland condition assessment method were explained. These methods were employed for research data to collect, analysis, structuring. The case study research method as a data collection tool was instrumental in exploring the communal beef cattle grazing systems in their real life context. To determine the health state of the grazing areas rangeland condition assessment was conducted.

In Chapter 4, a case study research report indicates that there is a variation in the cost incurred when implementing different types of grazing systems. The modified HPG system has a high initial capital investment. The rotational rest grazing system had low costs, and the continuous grazing system was the least costly. The economic returns realised from these grazing systems were high, however the accounting systems could only be carried to a low degree due to the lack of record keeping systems among communal farmers. The rotational rest and continuous grazing systems required less active management of either grazing area/livestock. The technical knowledge and skills requirements for operating the modified HPG system were high.

The cost effectiveness of the modified HPG system in cattle production and improvement of the grazing area could be measured because all items bought were identified. It was found that in the first year, the costs were high and the financial returns were low. However, in the second year, the costs were low and the returns were higher. The environmental benefits of this grazing system, in restoration the land, could be witnessed. The farmers at Motseng explained that this grazing system was effective in cattle production and improvement of the rangeland condition. The rangeland condition assessment indicated an overall improvement in the basal cover of the grazing area. The major challenges acknowledged by the communal farmers, were that, the system required more time to gain its financial independence from the external funding. The gap that was identified in the systems was the lack of effective communal livestock management committee.

The continuous grazing systems at Moiketsi represent a case in which external agricultural support was absent. The communal farmers forced by circumstances such as lack of proper infrastructure to enforce rotational grazing system, changed to continuous grazing systems because of the ease of implementation and management. However, the environmental and financial outcomes were unsatisfactory to the farmers, hence; the farmers felt that the systems was not cost effective. The implementation of the rotational rest grazing system was aimed at managing the grazing area, without paying much attention to the livestock-stocking rate, and the implementation costs were low.

5.3 Recommendations

This research study exposed critical areas about communal beef cattle grazing systems. The complexity of a communal grazing system requires that the future researchers should employ the systems analysis and simulation models, in order to show the interaction between social, economic, and environmental aspects in the long term, and use experimental approaches that employ repetitions and control. The case study research approach was limited in that it could not directly compare the grazing systems with scientific trials and assessment.

The government as funder should be involved in the early planning and development of the grazing systems and throughout its management. Studies comparing the communal beef cattle grazing systems to commercial beef cattle grazing systems can enhance understanding needed to gauge and identify areas improvement in communal farming systems, e.g. record keeping systems.

The adoption of transdisciplinary approaches (multi-disciplinary research that includes stakeholder participation) when investigating the communal beef cattle grazing systems has potential to yield results that include social, environmental and financial aspects.

Other areas of exploration include investigating the role of implementing agents in assisting communal livestock farmers to produce commercially in an environmentally and socially acceptable manner. To measure the impact of the grazing systems on the grazing area, it is recommendable for future studies to be conducted over a long period to monitor changes.

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Annexure

ANNEXURE A: DATA COLLECTION QUESTIONS

1. *Questions for implementing agents (Implementing Agent A, B, C)*
What types of beef cattle grazing systems do you implement in the communal area?
How was this grazing system developed and implemented?
What are the components of this system?
What are the inputs used to start this grazing systems?
What are the outputs of this system?
What are the external drivers in this system (climate, policies etc.)?
What are the guiding principles or goals for implementing this type of grazing systems?
How does this grazing system improve beef cattle production and what evidence can be provided to prove this?
What is the impact of this grazing system on the grazing land and what evidence is available to prove this, and how was this evidence collected?
How much was the start costs for this type of grazing systems?
How much operation costs for keeping this systems running?
Did this grazing system meet the expectation that were set for it?
In your opinion, is this grazing system cost effective?

2. *Questions for Communal Farmers and Ecorangers*
What type of grazing do you use (e.g. continuous, rotational ...)?
Do you have any inputs used to start this grazing system?
What are the outputs of this system (social, economic and environmental)?
What are the external drivers in this system (climate, policies etc.)?
What determines the quality of this grazing system?
How long have your cattle being part of this grazing system?
How many cattle did you have when you first started grazing in this way?
What reasons can you give for an increase or decrease in cattle number?
How many cattle do you have now?
Have you seen any improvement or decline in the quality of your cattle because of this grazing system?
How is this grazing system affecting the grazing land?
Do you think this grazing system needs to be improved, if yes, how?
Do you think this grazing system is cost-effective (e.g. can it be maintained without the assistance of government and other findings)?

ANNEXURE B: CASE STUDY RESEARCH EVIDENCE DATABASE SHEET

Participants	**Village in which the interview was conducted**	**Data collection technique**	**Source of data**	**Case study evidence**	**What type of grazing do you use (e.g. continuous, rotational..?)**	**Do you have any inputs that you use to start or implement this grazing system?**	**What are the outputs of this system (social, economic and/environmental)?**
Participant 1							
Participant 2							
Participant 3							

Participants	**Village in which the interview was conducted**	**Data collection technique**	**Source of data**	**Case study evidence**	**Village in which the interview was conducted**	**What are the external drivers in this system?**	**What determines the quality of this grazing system?**	**How long have your cattle being part of this grazing system**	**How many cattle did you have at the start of the grazing system**
Participant 1									
Participant 2									
Participant 3									

Participants	Village in which the interview was conducted	Data collection technique	Source of data	Case study evidence	Village in which the interview was conducted	What reasons can you give for an increase or decrease in cattle	How many cattle do you have now?	Did you see any improvement or decline in the condition of the cattle?	How is this grazing system impacting the grazing land
Participant 1									
Participant 2									
Participant 3									

Participants	**Village in which the interview was conducted**	**Data collection technique**	**Source of data**	**Case study evidence**	**Village in which the interview was conducted**	**Do you think that this grazing system needs to be improved, if yes, how?**	**Do you think that this grazing system is cost effective (e.g. can be maintained without assistance from the government or other external funders.**
Participant 1							
Participant 2							
Participant 3							

ANNEXURE C : QUIRY REPORT

(a)

HU: Case Study (Query Reports Generation)

File: [F:\Case Study Areas\Case Study (Query Reports Generation).hpr7]

Edited by: Super

Date/Time: 2015-07-22 04:43:24

P1 : refers to Motseng village

P2 : refers to Moiketsi village

P3 : refers to Mafube village

---

3 Quotations found for query:

"Do you think this grazing system is cost-effective (e.g. can it be maintained without the assistance of government and other findings)?"

P 1: Motseng village

In the short term no, but in the medium to long term, it is promising that it will become self-sustained. The number of local communal farmers joining the program is increasing because; they are starting to see the benefits.

P 2: Moiketsi

No, there is currently no support received from implementing agents but we hope to go ask for their assistance soon.

There is lack of funding for fodder during winter season

Licks not available

Transport costs high, making it hard for us to go to town to buy some of the inputs needed for the livestock such as medication

P 3: Mafube

It is cost effective within the scope to project but payments of Ecorangers needs to be considered if it is to be applied elsewhere. The system does not require fencing as herders keep livestock out of closed areas, with oversight provided by Ecorangers (Answered by implementing Agent)

(b)

Query Report

HU: Case Study (Query Reports Generation)

File: [F:\Case Study Areas\Case Study (Query Reports Generation).hpr7]

Edited by: Super

Date/Time: 2015-07-22 06:01:28

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3 Quotations found for query:

"How is this grazing system impacting the grazing land?"

P 1: Motseng village

Positively, the areas which used to be infested with wattle, have now been turned into grazing areas with native grasses growing prolific

P 2: Moiketsi village

Negatively

P 3: Mafube village

?????? (Question for communal farmers only)

(c)

Query Report

HU: Case Study (Query Reports Generation)

File: [F:\Case Study Areas\Case Study (Query Reports Generation).hpr7]

Edited by: Super

Date/Time: 2015-07-22 06:01:08

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3 Quotations found for query:

"What reasons can you give for an increase or decrease in cattle number?"

P 1: Motseng

Decrease in livestock numbers are due sales (14 sold in the recent auction) and other member left the program with their livestock. Mortality is still low, but it has always been low even before the start of the program. Seasonal changes also affection production. There was 54% calving rate according to records kept.

P 2: Moiketsi village

Decrease: lack of bulls, lack of medication and proper animal health program

Increase/Decrease: Seasonal changes

Increase: lack of access to market and just keeping of animals for cultural reasons.

P 3: Mafube

????? (question for communal farmers only)

(d)

Query Report

HU: Case Study (Query Reports Generation)

File: [F:\Case Study Areas\Case Study (Query Reports Generation).hpr7]

Edited by: Super

Date/Time: 2015-07-22 06:00:46

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3 Quotations found for query:

"Have you seen any improvement or decline in the quality of your cattle because of this grazing system?"

P 1: Motseng village

There is rather an increase in the quality of cattle produced, the animal coats are very healthy and the animals have gained weight

P 2: Moiketsi village

No, the animals are thin and sickly

P 3: Mafube village

????? (Question for communal farmers only)

(e)

Query Report

HU: Case Study (Query Reports Generation)

File: [F:\Case Study Areas\Case Study (Query Reports Generation).hpr7]

Edited by: Super

Date/Time: 2015-07-22 06:01:53

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3 Quotations found for query:

"How long have your cattle being part of this grazing system?"

P 1: Motseng

Since 2014

P 2: Moiketsi village

More than two decades

P 3: Mafube village -

Since 2014

(f)

Query Report

HU: Case Study (Query Reports Generation)

File: [F:\Case Study Areas\Case Study (Query Reports Generation).hpr7]

Edited by: Super

Date/Time: 2015-07-22 06:00:23

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3 Quotations found for query:

"What are the outputs of this system (social, economic and environmental)?"

P 1: Motseng village

Job creation for community members. Income for land stock owners. restoration of the grazing areas

P 2: Moiketsi village

Items]

Social : produce milk for consumption, and they a store of wealth

Economic : Allow the animal to multiple an sell in terms of emergency

Environment: the impact is negative, there is soil erosion, compaction and loss of biodiversity in general, and there is no rested area.

P 3: Mafube village)

Rest 25% of the grazing land for full season each year

Improve grass species composition and basal cover.Low input, low management system makes it easy to scale and replicate

Re-enforcing of pre-existing traditional systems

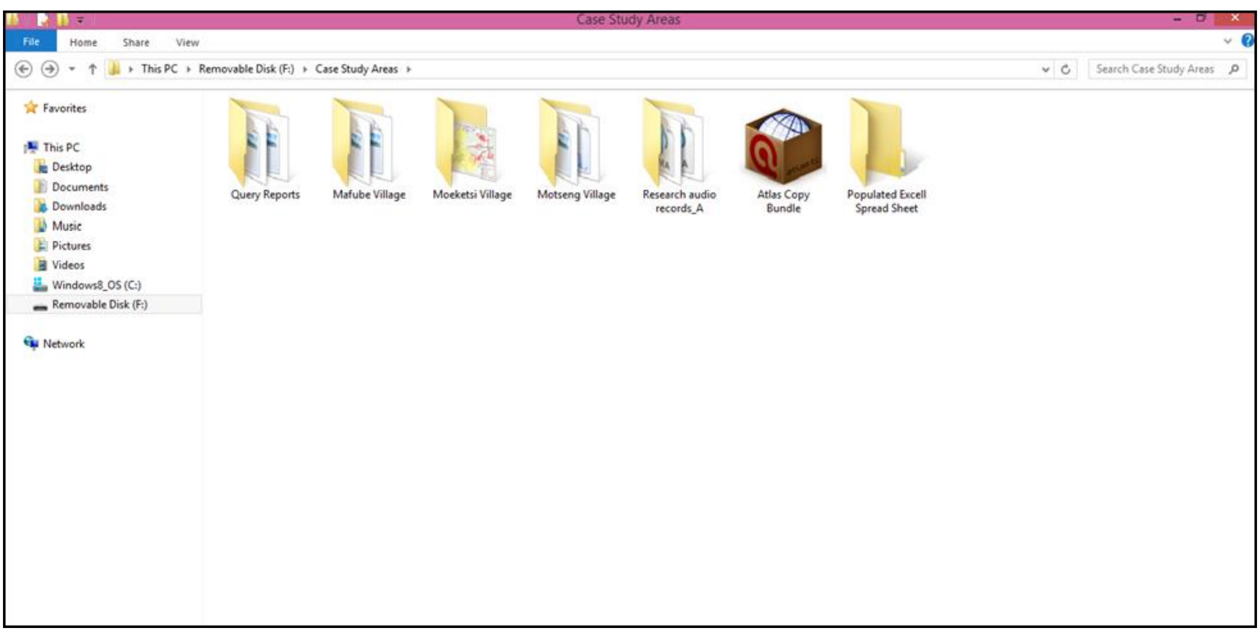
Reliance / onus on community and traditional leadership for compliance. Rest for grasslands: improved recovery, Biodiversity, resilience

Re-establishment of traditional grazing systems

Improved productivity off rangeland(over time) – increased health / weight gain of livestock

Re-establishment of livestock association for improved management and movement towards commercial farming

ANNEXURE D: ELECTRONIC DATABASE



ANNEXURE E : LINE-POINT INTERCEPT DATA FORM AND THE CODES

Pnt.	PLANT SPECIES, "NONE" or SOIL COVER TYPE	Pnt.	PLANT SPECIES, "NONE" or SOIL COVER TYPE
1		26	
2		27	
3		28	
4		29	
5		30	
6		31	
7		32	
8		33	
9		34	
10		35	
11		36	
12		37	
13		38	
14		39	
15		40	
16		41	
17		42	
18		43	
19		44	
20		45	
21		46	
22		47	
23		48	
24		49	
25		50	

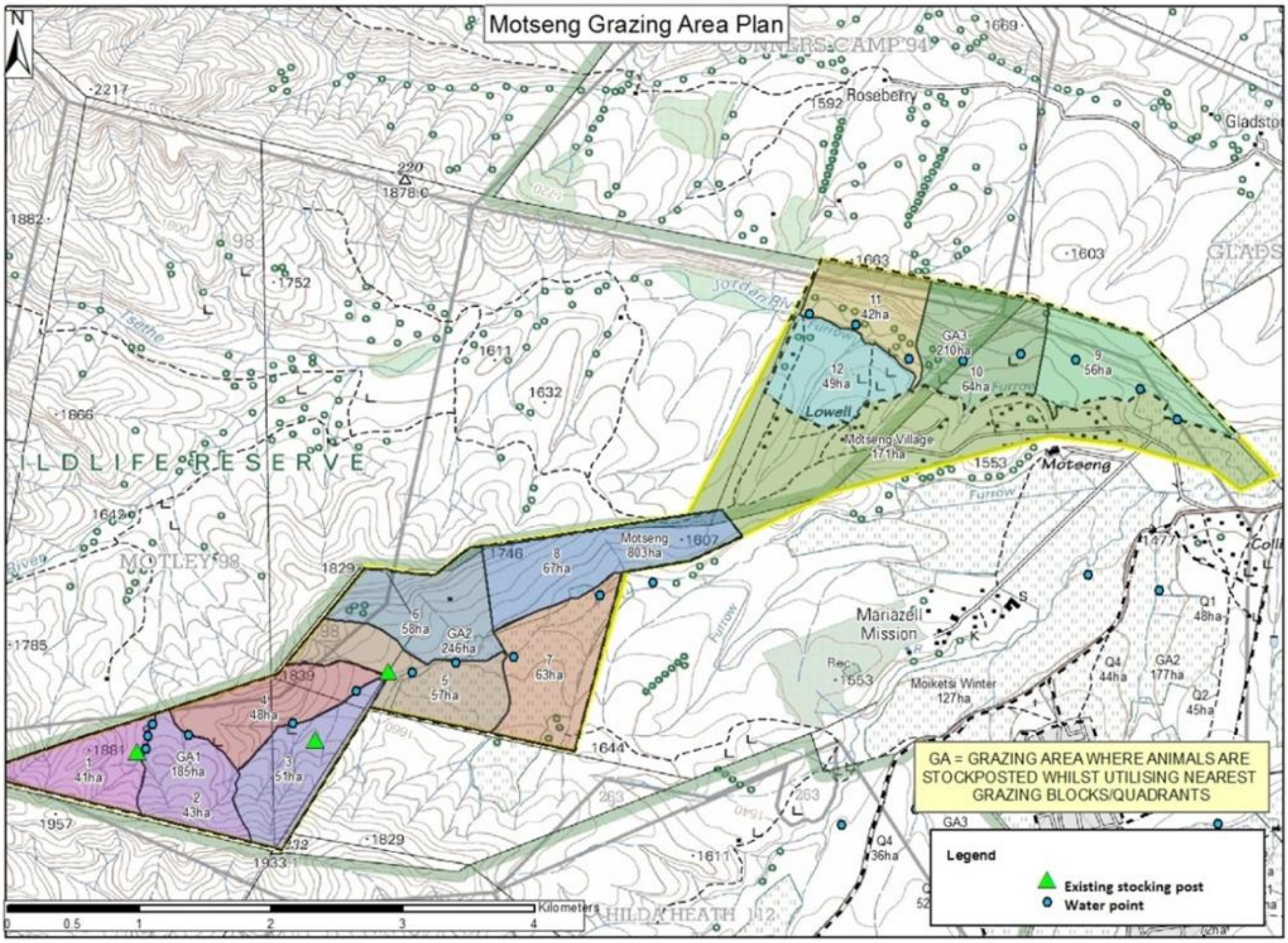
ANNEXURE F : BIOMASS DATA FORM

Pnt.	BIOMASS (cm)	Pnt.	BIOMASS (cm)	Pnt.	BIOMASS (cm)	Pnt.	BIOMASS (cm)
1		26		51		76	
2		27		52		77	
3		28		53		78	
4		29		54		79	
5		30		55		80	
6		31		56		81	
7		32		57		82	
8		33		58		83	
9		34		59		84	
10		35		60		85	
11		36		61		86	
12		37		62		87	
13		38		63		88	
14		39		64		89	
15		40		65		90	
16		41		66		91	
17		42		67		92	
18		43		68		93	
19		44		69		94	
20		45		70		95	
21		46		71		96	
22		47		72		97	
23		48		73		98	
24		49		74		99	
25		50		75		100	

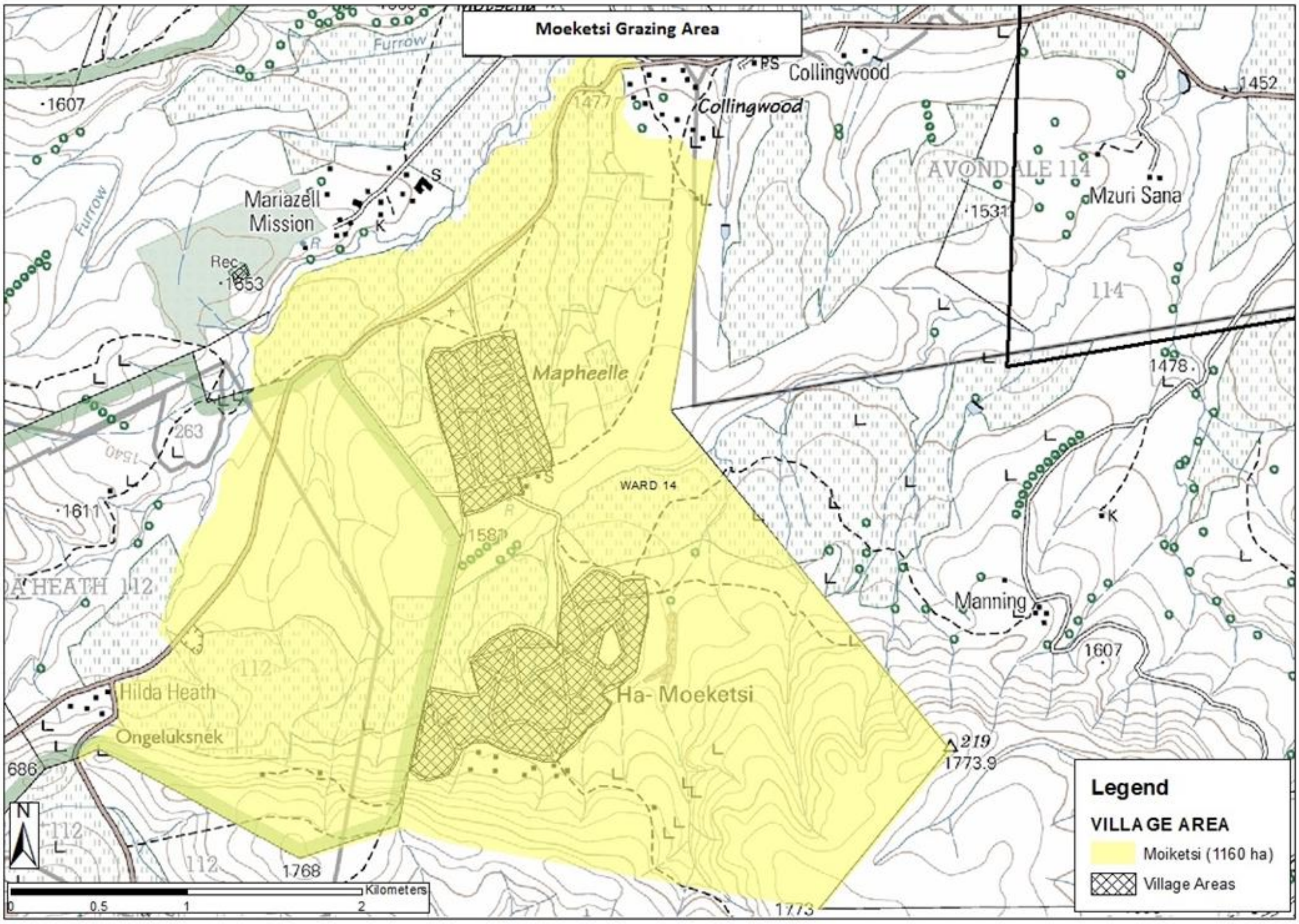
ANNEXURE G: LIST OF INCREASER AND DECREASER GRASS SPECIES AND THEIR GRAZING VALUES.

SPECIES			**Grazing value**
Brachiaria serrata	Perennial graminoid	Decreaser I	3
Monocymbium ceresiiforme	Perennial graminoid	Decreaser I	6
Themeda triandra	Perennial graminoid	Decreaser I	10
Tristachya leucothrix	Perennial graminoid	Increaser I	9
Eragrosis capensis	Perennial graminoid	Increaser II	2
Heteropogon contortus	Perennial graminoid	Increaser II	6
Eragrostis racemosa	Perennial graminoid	Increaser II	2
Microchloa caffra	Perennial graminoid	Increaser II	1

ANNEXURE H: GRAZING PLAN MAP (MODIFIED HPG)



ANNEXURE I: GRAZING PLAN MAP (CONTINUOUS GRAZING SYSTEM)



ANNEXURE J: GRAZING PLAN MAP (ROTATIONAL REST GRAZING SYSTEM)