ASSESSING THE EFFECTS OF GRAZING ON VEGETATION COVER AND ASSOCIATED SOCIO-ECONOMIC LIVELIHOODS IN THE CLARENS NATURE RESERVE IN THE FREE STATE, SOUTH AFRICA

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Abstract

The presence of the Clarens nature reserve at the foothill of the mountainous Maluti is one of the treasured natural ecology of the Free State Province. A primary challenge to the ecological integrity of this small reserve is the nearby location of Kgubetswana Township, which boasts an increasing number of livestock owners. Hence, this study aims to assess the vegetation cover and socio-economic conditions associated with livestock grazing in the Clarens nature reserve. The objectives were to; i) identify vegetation cover; ii) assess the community' perception of environmental effects associated with livestock grazing at the Clarens nature reserve; iii) and assess the socio-economic conditions associated with livestock grazing at the Clarens nature reserve. Maximum likelihood classification and NDVI techniques were applied to remotely sensed images from the Landsat 5 TM, Landsat 7 ETM+ and Landsat 8 OLI sensors to map vegetation cover for the Autumn season of the years 2004, 2008 and 2016. A questionnaire survey was conducted to capture the perceptions of livestock owners and the reserve' management committee.

Firstly, over 50% increase of unpalatable vegetation was detected in the vegetation cover of the Clarens reserve. Secondly, qualitative data reveal that 71% of livestock farmers attribute land degradation to rainfall variability, while the management maintain that livestock overgrazing is the source of negative environmental degradation in the reserve. Change in the vegetation cover has not demonstrated any noticeable effects on the socio-economic conditions of the community. Hence, major dissimilarities in the perceptions of both stakeholders, which are influenced by the sense of responsibility of the two parties towards the reserve. The knowledge and understanding of livestock grazing in a protected area developed in this study could be used as a case study to establish grazing management strategies that could sensitize livestock owners to actively participate in the daily maintenance and managing of the reserve for sustainable use of natural resources. And, to forge good working relationships between the management of protected areas and the surrounding communities.

Keywords: Grazing, vegetation cover, Clarens nature reserve, socio-economic conditions, grazing management

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Declaration

I declare that this dissertation "assessing the effects of grazing on vegetation cover and associated socio-economic livelihoods in the Clarens nature reserve in Free State, South Africa", is my own work and that it has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and duly acknowledged by complete reference.

Ntebohiseng Mpho Sekhele July 2018

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Abbreviations

CNR : Clarens Nature Reserve

CVC : Clarens Village Conservancy

IUCN : International Union for the Conservation of Nature

GIS : Geographic Information Systems

RS : Remote Sensing

TM : Thematic Mapper

ETM+: Enhanced Thematic Mapper Plus

OLI : Operational Land Imager

NDVI : Normalized Difference Vegetation Index

NEMA: National Environmental Management Act

DEA : Department of Environmental Affairs

SADC: Southern African Development Community

CHAPTER 1

BACKGROUND AND ORIENTATION TO THE STUDY

1.1 Introduction

Arid and semi-arid landscapes account for one quarter (40%) of the world's land area, and of this, 88% is used for rangelands (Anderson, 2012). More than 10 million indigent people in the Southern African Development Community (SADC) region depend on livestock production (Thompson, Penrith, Atkinson, Atkinson, Cassidy, and Osofsky, 2013). In the context of South Africa, more than 80% of the natural vegetation is utilized for livestock (particularly cattle) rearing purposes. It is for this reason that grazing by domestic livestock is regarded as the second major disturbance of vegetation, after fire (Anderson, 2012). Moreover, according to statistics by the Department of Environmental Affairs (2007), of the 57 million South African population, almost 43% reside in rural areas and are greatly dependent on natural resources for their survival.

Subsequently, literature has continuously highlighted the negative effects triggered by livestock grazing, in particular the disruption it causes on the stability of the ecosystem (Anderson, 2012; Mandema, Tinbergen, Ens, and Bakker, 2013; Samuels, 2013). In this regard, the disturbance imposed on natural resources is attributed to over-grazing. Livestock over grazing is known to have caused much damage to the biota and habitats of various species. If not abated, this will continue to be a critical issue, particularly in the nature reserves (English Nature, 2005). Although the degree of response by the ecological units to grazing may differ, with varying cumulative environmental impacts thereof, soil erosion and overgrazing of natural vegetation remain the two predominant sources of negative effects on the environment (Wangchuk, 2002).

On the contrary, Reiner and Craig (2011), stress that substantiated literature (Sprinkle and Bailey, 2004; Du Toit, Snyman and Malan, 2011; Samuels, 2013; Bezuidehout, 2015) has thoroughly highlighted the mutual interaction that exists between monitored livestock grazing and plant species population, in that the former

is dependent on the grassland as a source of nutrition; whereas the latter's aggressive species are kept under control by livestock grazing. Moreover, grazing has been noted as one of the key activities that enables nutrient cycling in African savannas (Du Toit, Snyman and Malan, 2008). From a social perspective, Twine (2013) asserts that livestock rearing plays a crucial role in diversifying livelihoods of poor and vulnerable rural households; particularly since most farmers who make use of common rangelands are often unemployed, with low levels of education.

According to Little and Theron (2014:4) "the biological diversity of South Africa is currently inadequately safeguarded". Essentially, the establishment of protected areas around the world, such as nature reserves are an immediate response to the dire natural and anthropogenic causes of the reduction in biodiversity. To illustrate a classic example of the cumulative negative impacts of human activities on the ecosystem and its habitats, Burgess (2012) makes reference to China. A country that once boasted an approximated '60-80%' of the world' biodiversity. These staggering statistics began to decrease directly proportional to the development of the country. In other words, China considerably degraded the quality and quantity of its natural environment over economic growth in the previous years.

Exclusive of the environmental legislation, impacts of livestock grazing on natural protected areas, the identification of the socio-economic composition of the surrounding community is essential. According to Wangchuk (2002:64) "the socio-economic environment under which a policy is framed and implemented has a direct bearing on the effectiveness of the policy. The value and purpose of livestock ownership in a society has great influence on the use and access of protected areas, since the laws and regulations alone will not succeed in enforcing the regulated use of pastoral lands and resources".

In the same token, it is important to determine the state of the grazing land and condition of vegetation composition and distribution prior to grazing. This way, initial indicators of the rangeland in its non-grazed state will serve as the bases for change monitoring (Anderson, 2012). In the context of this research, grazing lands and rangelands refer to pastures that are used for grazing by livestock. Therefore, the terms will be used interchangeably throughout the research.

Numerous researchers (Archer, 2004; Anderson, 2012; Thompson and Gilbert, 2013; Mekasha, Gerard, Tesfaye, Nigatu and Duncan, 2014) have alluded the significant influence of climate variation has on livestock rearing and vegetation cover change. Climate variability regulates ecological systems, which can also influence the availability of water sources and palatable grass (Samuels, 2013). However, for the purpose of this research, meteorological influence on vegetation cover has been excluded from the scope of the study. Mainly because of the limited time frame specified to complete the study. Nonetheless, climatological effects will specifically be considered for advanced future projects in the Clarens nature reserve.

1.2 Problem Statement

Clarens Nature reserve (CNR) was established in May 2004. Surrounding the reserve is the Kgubetswana Township, which boasts an increasing number of livestock owners amongst the residents. Permission was however granted, during the early period of the development of the reserve to destitute residents of Kgubetswana to graze a limited number of five cows per household in the protected area. As time progressed, a steady in flow of wealthy individuals' livestock was observed grazing in the reserve. This unregulated and unauthorized increase of cattle continued to a point where livestock from neighboring small towns were also introduced into the reserve, again without permission from the management of the reserve.

At present, there is now a larger number of livestock in the Clarens nature reserve area than what was initially anticipated. The livestock is left to roam freely without herdsmen. Consequently, the nature reserve has experienced serious grazing impacts which has resulted in an extensive reduction in the grass cover and distribution, and exposing bare land patches with simultaneous severe soil erosion. Goats, on the other hand, have destroyed the indigenous and protected scrubs and flowers along the hiking trails in the reserve. Clarens Nature reserve is challenged with domestic livestock grazing beyond the designated rangeland and unregulated stocking rates.

1.3 Study Aim

Therefore, the aim of this study was to assess the effects of grazing on vegetation cover and socio-economic livelihoods in the Clarens Nature reserve.

1.4 Study Objectives

The following were the study objectives:

i. To identify vegetation cover associated with livestock grazing at the Clarens Nature reserve;
ii. To assess the community' perception on environmental effects associated with livestock grazing at the Clarens Nature reserve;

iii. To assess the socio-economic conditions associated with livestock grazing at the Clarens Nature reserve

iv. To develop recommendations for addressing environmental and socio-economic effects linked to livestock grazing in the Clarens Nature reserve in Free State Province, South Africa.

1.5 Study Questions

The following were the study questions:

i. What are the vegetation cover classes associated with livestock grazing at the Clarens Nature reserve?

ii. What are the community's' perception of environmental effects associated with livestock grazing at the Clarens Nature reserve?

iii. What are the socio-economic conditions associated with livestock grazing at the Clarens Nature reserve?

1.6 Justification of the Study

The primary objective of a nature reserve is to protect natural habitat on the farmlands including the vegetation and wildlife. Moreover, these protected areas have contributed to the conservation of specific biodiversity hotspots, provided green corridors for the movement of game, and protected habitats and occurrences of rare and endangered species (Proposed Management Plan for Clarens townlands, 2014).

The rate at which the overgrazing by livestock is occurring in the reserve, undoubtedly compromises the sustainable development of the natural environment. Since the ecosystem is an interconnected community of nature, assessing the cumulative effects that are a result of overgrazing will provide insights on the situation that is occurring between the Kgubetswana livestock owners and the management of the Clarens Nature reserve.

After all, research should inform policy through reliable quantitative data about vegetation cover change associated with livestock grazing and related socio-economic livelihoods. The betterment of rangelands through controlled grazing and vegetation conservation will sustain the productivity of nature reserve, for the use of future generations.

1.7 Significance of the Study

After the completion of this research study, livestock owners and management committee of the Clarens Nature reserve will be informed of the environmental and socio-economic impacts of livestock grazing in the reserve. Furthermore, the quantitative data gathered from survey questionnaires will provide significant perspectives of both stakeholders on the matter of livestock grazing in the reserve. On the other hand, the vegetation change analysis model will display a visual representation of the environmental impacts of livestock grazing, if any, in the Clarens nature reserve. Upon realizing the state of the reserve, the research hopes to create awareness on nature conservation; and strengthen the working ties between the livestock owners and the management of the reserve, for the greater benefit of the

Clarens Nature reserve's sustainable development. There is a great need to develop management strategies that will simultaneously satisfy conservation and agricultural needs. Therefore, the researcher hopes that this project will contribute to the growing understandings of conflicts in conservation.

1.8 Design Layout of the Study

The Study is divided into five (5) chapters:

Chapter (1): Introduction. This chapter provides the introduction of grazing and protected areas, in particular nature reserves, by highlighting global and local case studies. A brief discussion of the social and environmental importance of livestock grazing and nature reserves is identified. The problem statement, aim, objectives, research questions, assumptions, significance as well as the motivation of the study are also indicated in the chapter.

Chapter (2): The literature review. This chapter documents and discusses the primary objectives of protected areas, with a particular focus on the role of nature reserves in South Africa. Then, a contextual analyses of the historical changes experienced by the legislature governing these environmentally sensitive sanctuaries is also discussed from an international and national perspectives. The literature further deliberates the positive and negative effects of grazing, and also provides an understanding towards the socio-economic importance of keeping livestock by rural communities. Lastly, the chapter considers driving forces that leads to conflicts in conservation.

Chapter (3): Research methodology. This chapter begins with a biophysical description and geographical positioning of the Clarens nature reserve, before it continues to explain various research methods of research design, data collection, analysis and presentation used in the project to achieve the objectives and research questions of the study.

Chapter (4): Results and study findings. These are the results obtained from questionnaire surveys that were administered to the livestock owners whose animals graze in the Clarens Nature reserve, as well as the management of

the reserve. Results that were acquired from the Remote Sensing technique are also presented in this chapter.

Chapter (5): Discussion, Recommendations and Conclusion. A thorough synthesis of the research findings is determined. The aim, objectives, research question and the assumptions of the study are accomplished. This chapter concludes with a summary of the main findings of the study, and opens a new line of enquiry around the impacts of grazing and associated socio-economic livelihoods.

1.9 Definition of Concepts

Environmental effects : any change imposed onto the natural environment, caused by an activity which could either harm or restore the environment (Aucamp, 2008).

Socio-economic : "based on a combination of social and economic conditions. For example, quality of people's lives, unemployment and education" (Longman Exams Dictionary, 2006:1465).

Nature reserve : "a protected area that is managed by the relevant local authority, with recourse to the relevant ordinance (s) and with various objectives". The regulations and management objectives set for the protection of nature and wildlife are customised to the local area' needs, which may vary across regions and provinces (National Environmental Management: Protected Areas Act, 2003; Du Toit, 2010:23).

Nature conservancy : "a conservation area that is legally owned and/or occupied by one or more landowners, but which is managed as an ecological unit to achieve a common conservation goal" (Du Toit, 2010:23).

Grazers : animals that feed and depend on growing grass (Longman Exams Dictionary, 2006).

Overgrazing : excessive consumption of grass plants by grazers without rest, until the reserved nutrients in the plant are depleted.

Consequently, the roots are weakened and the plant die off (Van Oudtshoorn, 2012).

Under-grazing : little or no feeding of grass plants by grazers, which can result in the accumulation of organic material called moribund. Eventually, the tuff is suffocated and can die off (Van Oudtshoorn, 2012).

Grassland biome : predominantly consist of grass and limited trees. Trees are mostly present on rocky outcrops, along riverbanks and in the deep narrow valleys of the mountain ranges (Ferrar and Lötter, 2007:10).

Palatable : grass plants that are preferable and acceptable to grazers. This is mainly attributed to the grass' effective digestibility and nutritional value (Van Oudtshoorn, 2012).

Unpalatable : grass plants that are unpleasant to grazers, or grass that do not prefer grazing (Van Oudtshoorn, 2012).

Carrying capacity : maximum number of livestock which an area can accommodate, without compromising the integrity of the area and its related natural resources (Sprinkle and Bailey, 2004).

Conservation conflict : opposing priorities in relation to protected areas (Longman Exams Dictionary, 2006).

1.10 Conclusion

This chapter described the background of the study, problem statement, study aim, research objectives, and research questions, importance and justification of the study. The following chapter reviews related literature for the study. The literature reviewed is secondary data, which is information that has already been collected by another researcher for a particular purpose (Montello and Sutton, 2013). Secondary data required for this study was gathered by means of literature review of academic journals, internet articles; social research in newspapers, dissertations, government documents, policy reports and books. Reviewing the information and literature that

has been conducted on a topic is essential as it builds on the knowledge available and allows the researcher an opportunity to identify a gap and contribute to the field. Also, reviewing the literature prevents repetition of information on what has already been said and discovered (Prathapan, 2014). Succeeding is chapter two, which critically discuss the relevant literature review on grazing, its effects on the vegetation cover, and associated socio-economic conditions of grazing.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The role played by vegetation in an ecosystem and its surrounding topography is of paramount importance. Grasslands are a great source of erosion control, soil formation, nutrient cycling, storage of atmospheric carbon dioxide in biomass and maintenance of biodiversity (Miller and Spollman, 2009). Managed grazing lands are said to be the largest land use activity globally, as they occupy approximately 25% of the Earth's surface (Anderson, 2012). On a regional scale, 76% of Botswana's land surface is utilized for grazing by both domestic and wild animals (Kgosikoma, Mojeremane, and Harvie, 2013). In South Africa, agriculture and subsistence farming practices occupy 80% of the land. Of that, 11% is arable. The rest of the agricultural land (69%) is dedicated to grazing (Kori, Musyoki, and Nethengwe, 2013). Although livestock production has been gradually increasing since 1975, grazing lands have, on the other hand, declined from the 1990s (DEA, 2007). A phenomenon that (Moyo, Dube, Lesoli, and Masika, 2010) is believed to be a result of increasing human settlement and conservation, amongst many factors.

Similarly, domestic livestock ownership has been an important asset in the history of mankind. Therefore, grazing lands are of great significance. This is why Sprinkle and Bailey (2004) asserts that a healthy grazing land yields healthy livestock. There has been, however, a shift of focus to conservancy and sustainable use of natural resources. Remarkable attention has been given to nature conservancies due to their role in stabilizing the ecosystem and protecting natural resources. Consequently, this refocus on land has put immense attention on the compatibility of domestic livestock grazing and conservation of protected areas (Hall, Weinstein and McIntyre, 2005).

It is frequently the case that grazing land degradation is often detected at its late stage, because changes in vegetation cover are subtle and can be observed after a long time. Du Toit *et al* (2011) critique this status quo, as it poses a challenge for conservationists, policy makers and the general public who are concerned about the wellbeing of rangelands, soil and vegetation in response to grazing.

Du Toit *et al* (2011) therefore warns against a threshold of vegetation grazing that can occur and result in absolute degradation. In their study, Du Toit et al (2011) discovered a directly proportional relationship between the number of livestock that graze and the duration of the stocking rate in a grazing camp. In that, increase in the stocking rate to graze over a short term decreased vegetation cover rapidly, particularly in semi-arid grazing land. Overgrazing can result in a significant reduction of palatable perennial vegetation, and an increase in unpalatable vegetation. Consequently, these changes could negatively affect ecosystem' functioning (Tessema, De Boer, Baars and Prins, 2012; Samuels, 2013).

Anderson (2012) agrees that livestock quantities in a given grazing area exposes vegetation to the state of overgrazing, more so when grazing is sustained for a long period. Interestingly, Archer (2004:382) discovered that farmers in the Karoo, more specifically at the Graaff Reinet, describe land degradation in various ways. Such differences are expected, because the explanation of degradation is subjective to the end user's value chain system break-down observation; spatial and temporal variability. In his thesis, Samuels (2013) cites Frederick Clements' (1916) linear plant succession model, an equilibrium theory that reiterates the importance of maintaining the state of balance between carrying capacity of a grazing camp and livestock density. This balance allows for sustained and healthy state of vegetation growth and distribution.

Undoubtedly, livestock forms an integral part of the rural livelihood, which in turn determine the socio-economic status of livestock owners and the community at large. As a result, domestic livestock have gradually developed to adapt to graze on a specific range of vegetation types and pasturage, including uneven terrain. For this reason, grazing species have an unlimited selection of what and where they feed. Vegetation protected areas are therefore vulnerable to be consumed if these domestic animals move haphazardly without control (Wangchuk, 2002).

Availability of plant species vary with changing seasons. On the contrary to Wangchuk (2002), Bezuidehout (2015:1) states that herbivores prefer to graze palatable vegetation before they move on to less palatable grass. Therefore, preference of grazers should be considered and monitored. In addition, a thorough

veld evaluation should be conducted continuously, as this will assist in identifying any noticeable changes in the vegetation cover; structure and composition (Kori *et al*, 2013). Essentially, a large presence of sub-climax or pioneer grass species encroaching on indicator climax species will indicate a negative outcome of the veld.

2.2 Primary objectives of protected areas

Protected areas as explained by the International Union of Conservation of Nature (IUCN) in Glazewski (2005:325) are "An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources, and managed through legal or other effective means". Typical examples can be drawn from Oldoinyo Sapuk National Park in Kenya (Owino, Jillo and Kenana, 2012) and the NamibRand Nature Reserve, located in southern Namibia (Odendaal and Shaw, 2010). Both these protected areas are boasting with flourishing biodiversity and optimal ecological functioning.

The definition of protected areas by the IUCN is in line with the purposes of protected areas outlined in the Protected Areas Act. According to the National Environmental Management Protected Areas Act No.57 of 2003, the purpose of protected areas in South Africa are, amongst many functions:

(a) to protect ecologically viable areas representative of South Africa's biological diversity and its natural landscapes and seascapes in a system of protected areas;
(b) to assist in ensuring the sustained supply of environmental goods and services;
(c) to provide for the sustainable sue of natural and biological resources;
(d) to create or augment destinations for nature-based tourism; or
(e) generally, to contribute to human, social, cultural, spiritual and economic development (NEMA: Protected Areas Act, 2003).

Fundamentally, South Africa has a well-established system of protected areas, whose primary aim is to protect the natural species of the country, while at the same time educating and creating environmental awareness within communities about conservation areas and sustainable living (Burgess, 2012). Essentially, conservation areas should be considered as safe haven for vulnerable plants and animals.

Owing to its majestic topography, South Africa is home to a substantial number of trans-frontier conservation areas. Burgess (2012:15) describes the aforementioned as "...a cross-border region where different component areas have different forms of conservations status, such as Private Game Reserve, communal natural resources management areas and even hunting concession areas". Natural or artificial barriers are normally used to demarcate the different land-uses. The main stakeholders in the management of trans-frontier conservation areas are the appropriate government departments, with the NGOs and donors and secondary participants (Thomson *et al*, 2013). Conversely, the management of grazing lands is significantly affected by the social factors such as the degree of skills and obligation on rangeland management by farmers and herdsmen, effective institutions that will govern the utilization and management of rangelands through effective policies and strict enforcement strategies (Lesoli, 2011).

It is against the background of effective management of protected areas that numerous studies have been conducted to analyze the ecological systems associated with grazing in arid and semi-arid areas. The seminal theoretical framework in the studies as discussed by Anderson (2012:2) was the "balance-of-nature" concept. The main influence of the notion was the Malthus theorem, coined in the late 1700s, that population density versus food supply relationship is crucial to be maintained. Thus, should a non-equilibrium condition arise, the population will encounter dire ecological consequences. In the same token, any imbalance between the grazers and grazing land structure will impede the course of equilibrium model (Samuels, 2013).

Development is one of the major human threats to the disturbance of equilibrium of the ecosystem. Hence the demarcation and declaration of conservation areas, particularly nature reserves. Once the vulnerable plants and animal species are protected at a natural sanctuary in the form of a nature reserve, laws and regulations must be applied for guided management of a country's biodiversity.

From the 1960s to 1980s, the ideology of conservation was pioneered by a small group of concerned conservationists. Hanks and Glavovic (1999) outline the transition of the theoretical framework of nature conservancies, where almost 5

decades ago, the mandate of protected areas was exclusively to protect endangered plant and animal species. This philosophy of conservation exclusivity stemmed from the United States' National Parks system (Owino *et al*, 2012). At the time, access and anthropogenic activities which included, but not limited to harvesting natural resources, development and grazing were prohibited in and around conservation areas. These natural sanctuaries were fenced off from local communities, despite of their impoverished livelihoods and great dependence on natural resources for survival. Consequently, this created frustration amongst neighboring residents towards conservation practices (Owino *et al*, 2012).

Conversely, a significant repositioning of conservation is, to date, evident in the way selected protected areas are integrated into the society for communal use and benefits. Caution is however given to the beneficiaries to practice sustainable utilisation of the natural resources in protected areas, so as to maintain the ecological integrity and diversity of the ecosystem (Hanks and Glavovic, 1999). Upon this contemporary shift of protected areas from complete exclusivity to versatile functions, the International Union of Conservation of Nature (IUCN) was tasked to regulate sustainable utilisation of natural resources and oversee the overall wellbeing of protected areas (Glazewski, 2005).

It is for this reason that in 1990 the IUCN classified the world's protected areas into 6 categories of distinct objectives and management strategies; and developed the criteria used to identify and manage these protected natural sanctuaries. In essence, the establishment and recognition of protected areas ensures the conservation of protected habitats which shelter biodiversity, for the sustainable use of resources by present and future generation (Hanks and Glavovic,1999). Glazewski (2005) further corroborates that these protected areas are classified in accordance with their cultural, natural, historical or either scientific value to the surrounding society.
According to the draft of South African classification of protected areas in their terrestrial and marine states, in conjunction with the IUCN, the Clarens nature reserve best satisfies the selection criterion of category V: protected land (...) scape ecosystem conservation areas (Hanks and Glavovic,1999). Described as the most intricate category, due to the interaction of cultural, rural agricultural and natural activities. These multiple functions therefore require specialized management,

because the introduction of human activities onto protected areas should be harmonized with the state of the natural environment, and the integration of varied zones should be maintained throughout. Such protected areas are characterized by majestic views and aesthetic surroundings. Primary activities such as fishing and grazing are common in areas (Hanks and Glavovic,1999).

2.3 Protected areas: Legislation

South Africa is continuously celebrated for its inclusive and comprehensive Constitution. Little and Theron (2014:4) ascertains that "the South African constitution (section 24) recognizes the direct relationship between the health and well-being of humankind and the persistence of natural environment and the biodiversity therein". It is on these bases that the State, in all its spheres is the custodian of environmental and human health. Moreover, the government has been mandated to ensure that through relevant legislature, environmental degradation is prevented, while sustainable consumption of natural resources is maintained (NEMA: Biodiversity Act, 2004).

The purpose of the biodiversity Act of South Africa is in sync with section 24 of the Constitution as referred to above, as it serves as the State's trusteeship of biological diversity. Hence, the National Environmental Management Biodiversity Act No.10 of 2004, resolute:

"To provide for the management and conservation of South Africa's biodiversity within the framework of the National Environmental Management Act ***1998;*** *the protection of species and ecosystems that warrant national protection; the sustainable use of indigenous biological resources; the fair and equitable sharing of benefits arising from bioprospecting involving indigenous biological resources; the establishment and functions of a South African National Biodiversity Institute; and for matters connected therewith".*

The act is applicable where human activities affect the biodiversity and its elements. Thus, this command binds all organs of state to monitor sustainable consumption and reinforce environmental consciousness amongst all citizens. It should however be emphasized that for a successful and harmonious conservation objective to be

achieved, all stakeholders, from individuals at grassroots level to policy makers should actively participate towards the greater common good of being sensible to the environment (NEMA: Protected Areas Act, 2003; Little and Theron, 2014).

In the same token, the National Environmental Management Protected Areas Act No.57 of 2003 advocates:

"To provide for the protection and conservation of ecologically viable areas representative of South Africa's biological diversity and its natural landscapes and seascapes; for the establishment of a national register of all national, provincial and local protected areas; for the management of those areas in accordance with national norms and standards; for intergovernmental co-operation and public consultation in matters concerning protected areas; for the continued existence, governance and functions of South African National Parks; and for matters in connection therewith".

Co-operation between government and the communities, sustainable and diligent use of protected areas' resources are objectives emphasised by the above legislation. The local societies are encouraged to participate in the protection of the environment and its ecosystem, for a prolonged and secured existence of biodiversity.

National laws of South Africa such as those enshrined in the Constitution of 1996, which include the National Environmental Management Act 107 of 1998, National Environmental Management Biodiversity Act 10 of 2004, National Environmental Management Protected Areas Act 57 of 2003 and South African National Heritage Resources Act 25 of 1999 collectively put emphasis on the protection and conservation of the natural resources. However, these Acts ignore the fundamental aspect of regulating the rate of livestock grazing on natural conservancies. Nature reserves uphold a pivotal role in protecting vegetation from extinction, promoting the ecological balance that exists in an ecosystem and also preserving the natural heritage of an area (Botha, 2012). Once the stability of the vegetation is compromised, the whole system of natural resources will be disturbed.

Samuels (2013) advocates for the regulation of livestock numbers in any given rangeland. Benefits of keeping such a database is to be proactive with the maintenance of the environment and management of livestock. Also, good working relationships between pastoralists are important in order to prevent conflict; to allow active participation of all members involved; and to collectively maintain a healthy rangeland. In their study, Kori *et al* (2013) discovered that low livestock ownership led to minimal degradation of grazing lands. Social networks are regarded as ideal communication platforms for pastoralists and affected parties, simply because of the user-friendliness afforded. Overall, smallholder grazing lands have been endorsed by polices in Southern Africa as sustainable livestock management systems. This prompts grazing policy models to be adopted specifically for arid areas (Kgosikoma *et al*, 2013).

2.4 Environmental effects of grazing

Grass is one of the most crucial role-players in the ecology, particularly in the grassland and savanna biomes (Ferrar and Lötter, 2007). Some of the key functions provided by grass includes being a source of food and habitat to various animal species. In its uninterrupted form, grassland has the ability to bind and store carbon (Du Toit *et al*, 2008; Van Oudtshoorn, 2012). Cumulative environmental impacts resulting from selective livestock grazing have the capability of compromising the ecological stability, resistance levels, resilience, restoration and enhancement of natural resources. Equally important is the carrying capacity of the rangelands, which will in turn influence the sustainability of the grazing land (Sprinkle and Bailey, 2004; Wangchuk, 2002). To ensure that a harmonious environmental livelihood exists, it is important that the type, number and timing of livestock grazing is tailored to the needs of an individual grazing site. Subsequent to the variety of the type of livestock, is varied grazing styles and vegetation likings. All of these conditions should be taken into consideration, in order for grass and grazers to coexist within the ecosystem of each unique habitat (English Nature, 2015).

In the same token, the degree of inclination is an important determinant of the mobility, distribution and concentration of grazers. Having said that, grazing occurs mostly on low lying areas than neither on steep slopes, mountaintops nor foothills.

Uneven grazing distribution has been highlighted as the main concern of livestock grazing in arid regions. Normally, cattle graze in an area that has a gentle terrain, and in the vicinity of a water source (Lesoli, 2013).

Similarly, rotational grazing is important. A grazing management technique that promotes interchanging periods of feeding and resting. In response to declining land productivity, rotational grazing policy was introduced and encouraged in the Eastern Cape province of South Africa as the most advanced mechanism to counteract against degradation (Moyo *et al*, 2010). Even pastoralists in Namaqualand, South Africa, uses livestock mobility as a management tool to sustain rangeland resources (Samuels, Allsopp and Hoffman, 2013). The advantage of rotational grazing is that it immediately responds to the continuously changing spatio-temporal environmental conditions, thus requires knowledgeable and pro-active herdsmen.

To facilitate the rotation, several plots are demarcated within the rangeland which spread evenly. The intensity of grazing will then be consistently controlled throughout the grazing area and changing seasons of the year. The establishment and maintenance of plots can be costly, in terms of fencing and water reticulation (Kgosikoma *et al*, 2013). But ultimately, "objectives of both the production system and biodiversity conservation can be achieved where mobility is not constrained" (Samuel *et al*, 2013:85).

Grazers, which are described as animals that eat grass which is growing, are most common in areas of abundant grass (Longman Exams Dictionary, 2006). Typical examples include cattle, sheep, goat and horse, to mention a few. These animals consume the most grass and consequently impose a significant impact on the grassland biome. Grazers are continuously migrating for better pastures to graze on. Accordingly, there is a mutual relationship between grazers and grassland (Van Oudtshoorn, 2012).

2.4.1 Positive environmental effects of grazing

According to English Nature (2015:3) "Livestock grazing is essential for the management of many of England's most important wildlife habitats". The above is

true, because a wide spectrum of flora and fauna is directly dependent on controlled livestock to graze on a variety of vegetation cover types, in order to preserve the configuration and distribution of greenery. Limited grazing strengthens forage quality and ensures that the richness of species within a habitat is conserved, because feeding by animals, unlike mowing and burning is gradual, thus provides enough time for active species to relocate (Isacch and Cardoni, 2011). Moreover, "livestock grazing removes fuel load, which in turn reduces the possibility of fire" (Kgòsikoma et al, 2012:6).

Also very important is how through livestock grazing, the intrusion of weed and wild plant species is controlled and kept at minimal quantities. The arrangement and make-up of vegetation is strongly habitat. Van Oudtshoorn (2012:16) further reiterates the benefits of grazing on grass as follows, "Grazers remove old plant material, stimulates new growth, and also provide fertiliser in the form of manure". The fertilized soil will grow plants quicker, and subsequently retain soil minerals and enable optimal hydrological functioning (Thompson and Gilbert, 2013). Another advantage is the trampling of grazers, which physically weathers down the soil surface, allowing for germination and seedling (Du Toit *et al*, 2008).

2.4.2 Negative environmental effects of grazing

The impacts of vegetation cover change associated with livestock grazing may take different forms, depending on the end user. For example, change in grazing pattern and loss of livestock due to lack of vegetation may be an indicator to herders of land degradation. While erosion that emanates from bare soils, alien plant invasion and bush encroachment may be indicators of degradation to conservationists and range managers (DEA, 2007; Kgosikoma *et al*, 2013; Samuels, 2013).

Most often, livestock is left roaming in the veld regardless of its quality (DEA, 2007). It is for this reason that livestock over-grazing results in some major undesirable environmental impacts which includes, but are not limited to biological degradation of soils and soil layers; plant community' misconfiguration, assembly and growth. Consequently, intensified pressure on the flora community further propagates a decrease in the cover and compactness of the native vegetation, resulting in certain plants being classified as threatened (Hall *et al*, 2005; English Nature, 2005).

Overgrazing diminishes the productive ability of a grazing land, and its carrying capacity as soil is degraded biologically, physically and chemically. It also removes the protective layer of vegetation, exposing top soil to sheet erosion and rill erosion. It is during these erosion processes that soil nutrients are washed away, the functioning ability of soil diminishes and the land surface is left infertile (Sprinkle and Bailey, 2004; Van Oudtshoorn, 2012; Kgosikoma *et al*, 2013; Freitas, Roche, Weixelman and Tate, 2014).

Equally important is under-grazing. Inadequate consumption of vegetation by livestock can create imbalances between the plant, bird, insects and animal populations, which would ultimately create dysfunctionality within natural habitats. Under-grazing causes an accumulation of organic material, which suffocates the grass tuft from its core and can perish it completely. Van Oudtshoorn (2012) warns that palatable grass is usually the first to be overgrazed. Over time, upon the grass' complete consumption, grazers will eventually resort to less palatable grass. In most cases, areas that are susceptible to be overgrazed in a pasture land are normally low-lying fertile and flat areas, nearby a drainage basin. In their study, Mandema *et al* (2013) revealed that such physical grazing conditions often resulted in trampling of grounded bird nests.

Loss of vegetation compromises the livelihoods of societies residing in arid and semi-arid regions, as they depend largely on natural resources. This can be observed from subsistence and rural farmers who rely on ecosystem services for survival. As overgrazing rearranges the composition and distribution of vegetation, less robust plant species are colonized by grazing tolerant species. Alternatively, annuals and unpalatable herbaceous species overtakes the rangeland, as grazers selectively feed on palatable grass at a rate higher than regrowth (Kgosikoma *et al*, 2013). A reality that is lived by farmers in communal lands of Botswana, where palatable grass remains at a critically low quantity as unpalatable species take over the rangelands (Kgosikoma *et al*, 2012). "Increasing the grazing pressure beyond a certain threshold, often leads to irreversible effects" (Tessema *et al*, 2012:211). Vegetation crash, is one such consequence. A state of vegetation cover whereby grassland is unable to recover from overgrazing.

Eventually, a degree of vulnerability is imposed on the livestock and surrounding communities of degraded vegetation/rangelands (Anderson, 2012). Lesoli (2013) corroborates with other studies in that all of these negative impacts of grazing combined, reduces the economic productivity of rangeland ecosystem. So then, DEA (2007) warns of desertification in instances where grazing is prolonged and concentrated in a single area. Samuels (2013:70) proposes that for vegetation to recover from the state of being overgrazed, destocking is the only solution to improve rangelands condition. Rainfall can also be considered to recharge vegetation regrowth after suffering overgrazing.

2.5 Socio-economic importance of livestock keeping

It is becoming prominent in rural settlements of developing countries (like Botswana, Kenya, Zimbabwe and South Africa) that income from secondary avenues like livestock keeping contributes an average of 22% of the total household income (Kori *et al*, 2013; Twine, 2013). There are varied reasons why people keep livestock, at differing herd sizes and; manage and maintain livestock. Literature has continuously indicated that livestock farming plays a significant role in the economy of rural communities, globally (Kgosikoma, Mojeremane and Harvie, 2012; Kgosikoma *et al*, 2013).

Anderson (2012:7) alludes to "social issues and values, differing with cultural beliefs, and may range from family size and availability of herders, to risk management and recreational pleasure". Economic motivation for keeping livestock may arise from the market need. The willingness to purchase livestock at close proximity from the supplier is reason enough to trade. Above all, the existence of diverse community livelihoods further promotes commercial intentions of livestock farming. It is because of this diversity that the market is lubricant. More observed economic benefits of livestock keeping include the additional income stream benefit (Samuels, 2013). However, for a community of pastoralists in Leliefontein, a communal grazing area in Namaqualand South Africa, livestock production is motivated by subsistence reasons, and cultural and traditions practices more that profit. Therefore, livestock farming for rural families means meat, milk, ritual slaughter and bridal payment are customary socio-economic reimbursements (DEA, 2007).

Twine (2013) suggests that socio-economic benefits derived from livestock farming, and the level of dependency across households is mainly influenced by the economic status of families. Livestock plays a great role in the livelihoods of destitute families compared to their wealthier counterparts. For example, returns are mostly in the form of meat and milk than monetary sales. Livestock fulfils the role of a safety-net as it serves both as an insurance and investment. However, for the already wealthy households, livestock farming is viewed as a token of social power and prestige (Lesoli, 2013).

2.6 Conflicts in conservation

Communities surrounding protected areas plays a crucial role in the protection and prolonged existence such areas. Their interaction with nature reserves, perceptions, livelihoods, values and environmental consciousness are significantly important in determining the long term presence of conserved areas and enhances conservation (Owino *et al*, 2012; Mutanga, Vengesayi, Muboko, and Gandiwa, 2015). According to Redpath, Gutiérrez, Wood, Sidaway and Young (2015:3) "The conservation of biodiversity is an increasingly challenging endeavor". This statement is informed by the incompatibility that exists between the objectives of conservation and humanity interests. The idea of conservation is not maintained by many people, simply because at times the principles of a conservation area are not aligned with the local community' livelihood, or vice versa. In the same token, anthropogenic activities of local societies nearby a protected area may directly or indirectly negatively affect the state of the conserved area. It is against these inharmonious scenarios that conservation conflicts between human needs and conservation objectives may result.

In conservation, for instance, the conflict that arises is that of human desires versus obligation to nature. It is important to highlight that vigorous actions exacerbates conflicts in conservation, compared to passive beliefs. It is through human activities that plant and animal species become endangered; and vegetation is overgrazed. Similarly, it is through legislature that previously freely accessible and utilised pastures are fenced and declared legally protected as nature reserves. In light of the aforementioned scenarios, clashes in priorities between nature conservation and

community livelihoods emphasizes the impact of an activity asserted on another party, by the other (Redpath *et al*, 2015).

A classic example of an inevitable, yet controversial grazing custom is of herding. A grazing practice that ensured controlled and balanced consumption of vegetation by grazers. Livestock herding used to be a crucial grazing management technique which influenced the mobility of grazers and grazing pressure on vegetation. It is in recent times that some developing countries like Botswana and South Africa no longer regard herding as standard practice. Instead, livestock is left to roam freely in the rangelands throughout the year. This freedom of movements allows selective grazing and destruction of water sources like dams and boreholes (Kgosikoma *et al*, 2013).

Moreover, studies suggest that grazing lands that are grazed freely, where farmers are not obliged to pay levy, are often poorly managed and degraded. The argument is that farmers profit more as the herd size increases, hence they are continuously seeking to increase their stocking rates. Subsequently, the rangeland' carrying capacity is exceeded, thus resulting in degradation (Kgosikoma *et al*, 2013).

Grazing lands have continuously been vulnerable to overgrazing and degradation, simply because the carrying capacity on these lands are often exceeded. A mismanagement that is attributed to environmental and political neglect (DEA, 2007). Ultimately, the ecosystem functions are degraded, which threatens the livelihoods of rural communities who depend on livestock production (Kgosikoma *et al*, 2013).

In a study conducted by Kgosikoma *et al*, 2012, the results indicated that livestock farmers in Botswana were informed about changing trends of vegetation distribution, the quality of grazing lands, intrusions of alien and bush vegetation and could distinguish palatable from unpalatable grass. However, the knowledge was not evenly distributed amongst farmers. This was evident in the differences of participants' responses during the survey conduction.

In spite of admitting to degradation and unpalatable grass invasion being prevalent in the grazing lands of Botswana, the farmers who participated in the study refused to attribute livestock grazing as the source of emanating negative effects (Kgosikoma

et al, 2012). Instead, meteorological variability indicated as the main cause of environmental disturbance.

Holistically, management challenges of protected areas associated with grazing according to Burgess (2012), Owino *et al* (2012), Little and Theron (2014) are:

i. Displacement and economic disenfranchisement of local people. Communities that are bordered by protected areas, whom are often impoverished are relocated against their will as they depend on the nature reserve for food and firewood. Alternatively, the communities are enclosed off with electric fences.
ii. 'Paper park' syndrome, poor education of reserve managers, government oversight problems. Inadequate physical and human resources such as infrastructure and qualified personnel hinders the effective operations of protected areas.
iii. Lack of funding in terms of government and/or private sector financial investment and reduced operating budgets into protected areas.
iv. Irresponsible development within protected areas

Mutanga *et al* (2015:12) concludes that "the ability of conservation and livelihoods to coexist depends on the willingness of parties [livestock owners and the management of nature reserves] to recognize problems as shared ones and to discuss them collaboratively.

2.7 Conclusion

Grazing lands occupy almost a quarter of the Earth's surface, which is a clear indication of the crucial role played by rangelands in peoples' livelihoods. Developing countries, particularly in Southern Africa have proven to be most dependent on farming and agricultural practises, which makes rangelands an important commodity to be preserved. Like rangelands, livestock keeping has continuously been emphasised as an imperative asset throughout human history. The socio-economic role fulfilled by livestock results in the decline of the inequality and poverty gap within rural communities. This is through the many benefits gained from farming livestock

such as the additional income avenue it provides to households, food security and social prestige.

Conversely, a concern has been the unsustainable manner in which grazing lands are being utilised by farming communities. Rangelands are left overgrazed, with little or no rehabilitation efforts from the farmers. This thus results in land degradation which further stimulates soil erosion, bush and unpalatable vegetation encroachment and plant community' misconfiguration. All this negative environmental effects triggered by livestock overgrazing ultimately threaten the sustainability and existence of the affected community' living. There are however, also advantages to controlled grazing. Its ability to remove grass at a rate equal to that of recovery, a source of fertiliser in the form of manure and the trampling by livestock which breaks down the soil layers to enable sprouting are equally important for ecosystem functioning.

It is against the background of sustainable consumption of natural resources that protected areas were established. The demarcation of these areas altered grazing culture of farmers, by restricting mobility of livestock. As such, conflicts in conservation emerged. However, through the South African legislature which is bestowed on protecting the biodiversity of the country, sustainable grazing is encouraged and facilitated. The primary objective of protected areas is not to disadvantage mankind but to secure biological integrity. Following is chapter three which then outlined the research methodology applied in this research study.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Scientific methodology is the art of collecting and assessing related data to achieve the goals of a research project (Babbie and Mouton, 2001). Prathapan (2014:81) asserts that "methodology provides a framework for the generation of knowledge". This chapter presents the data collection methods, sampling methods and research designs that were used in this study to analyse data and ultimately answer the research questions. The chapter begins with a brief biophysical and meteorological description of the study area.

3.2 Biophysical characteristics of CNR

The study was carried out at the Clarens nature reserve, with coordinates 28.5144°S and 28.4105°E. The CNR is located at a small town in the Eastern Free State, named Clarens, which is also popularly referred to as the "Switzerland of South Africa". Clarens is a small but important tourism center located in the jurisdiction of Dihlabeng Local Municipality (Figure 3.1). In terms of its proximity to the surrounding areas, Clarens lies 34 km south east of Bethlehem in the Free State Province, 20 km from the Golden Gate National Park and 10 km from the Lesotho border (Dihlabeng Municipality IDP, 2015/16).

The Clarens area is characterized by andesitic lava of the Drakensburg formation which occurs in association with mudstones, shale and sandstones. The topography is variable and slopes range from very flat (<0.5 degrees) to very steep (>18 degrees). The elevation ranges from 1740 to 2127 meters above mean sea level. Soils are moderate to deep undulating sandy loam. Clarens lies in the summer rainfall region of South Africa, with warm to hot summers and cold winters. Mean annual precipitation ranges from 800 – 1000mm. The rainy season runs from October to March, with the highest average rainfall period from November to February (Proposed Management Plan for Clarens townlands, 2014).

The Clarens Nature reserve area is classified as land capability Class VI, which is non-arable. The land in this class has severe limitations that make it generally unsuited to cultivation and limit its use largely to pasture and range, woodland or wildlife food and cover (Figure 3.2). The Clarens Nature reserve is located in the Grassland biome (Proposed Management Plan for Clarens townlands, 2014). As alluded in the literature, based on the IUCN classification, the Clarens nature reserve best satisfies the selection criterion of category V: which is protected landscape ecosystem conservation areas that are made available for public use, only on condition that human intervention is conducted in harmony with the retention of biological diversity" (Hanks and Glavovic, 1999:690).

Figure 3.1: Vegetation cover currently prevalent in the Clarens nature reserve

Photo taken by: Ntebohiseng Sekhele (2017)

3.3 Geographical location of study area

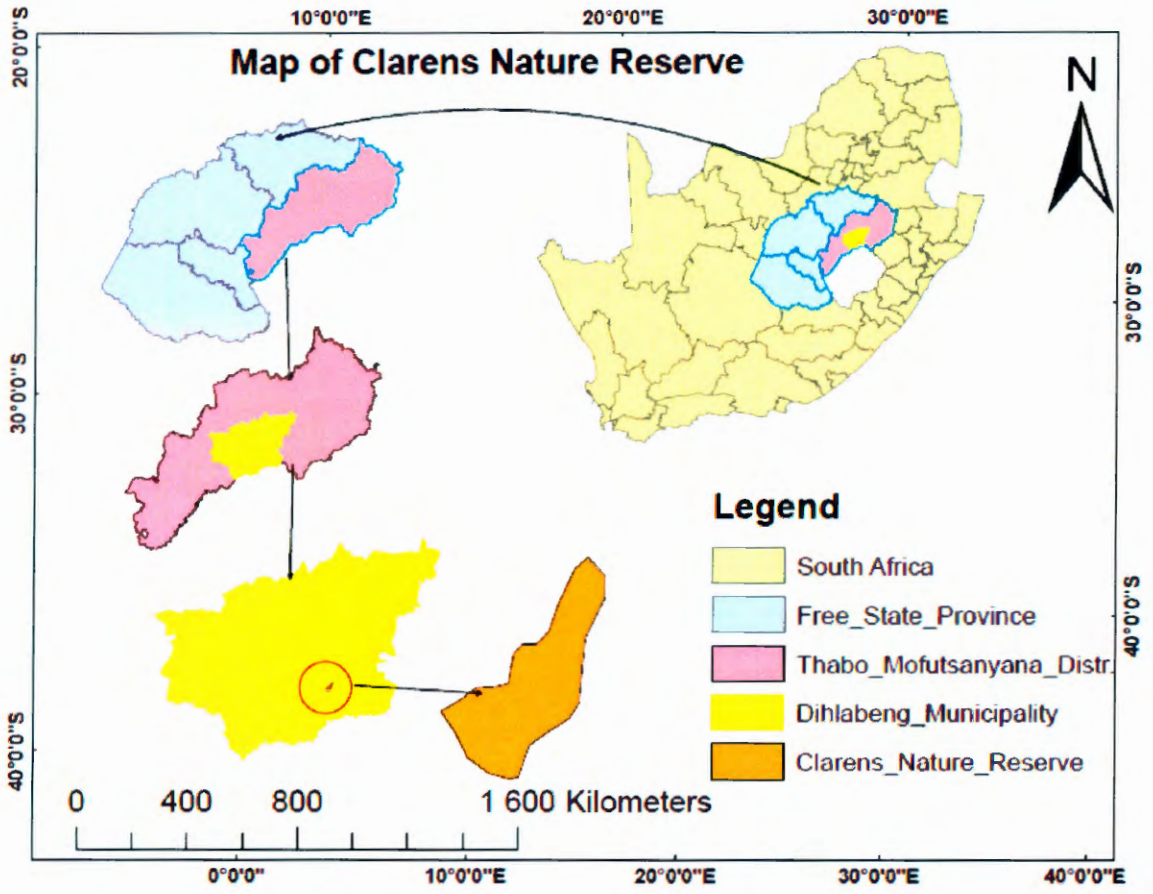

Figure 3.2: Location of Clarens nature reserve

3.4 Meteorological characteristics of CNR

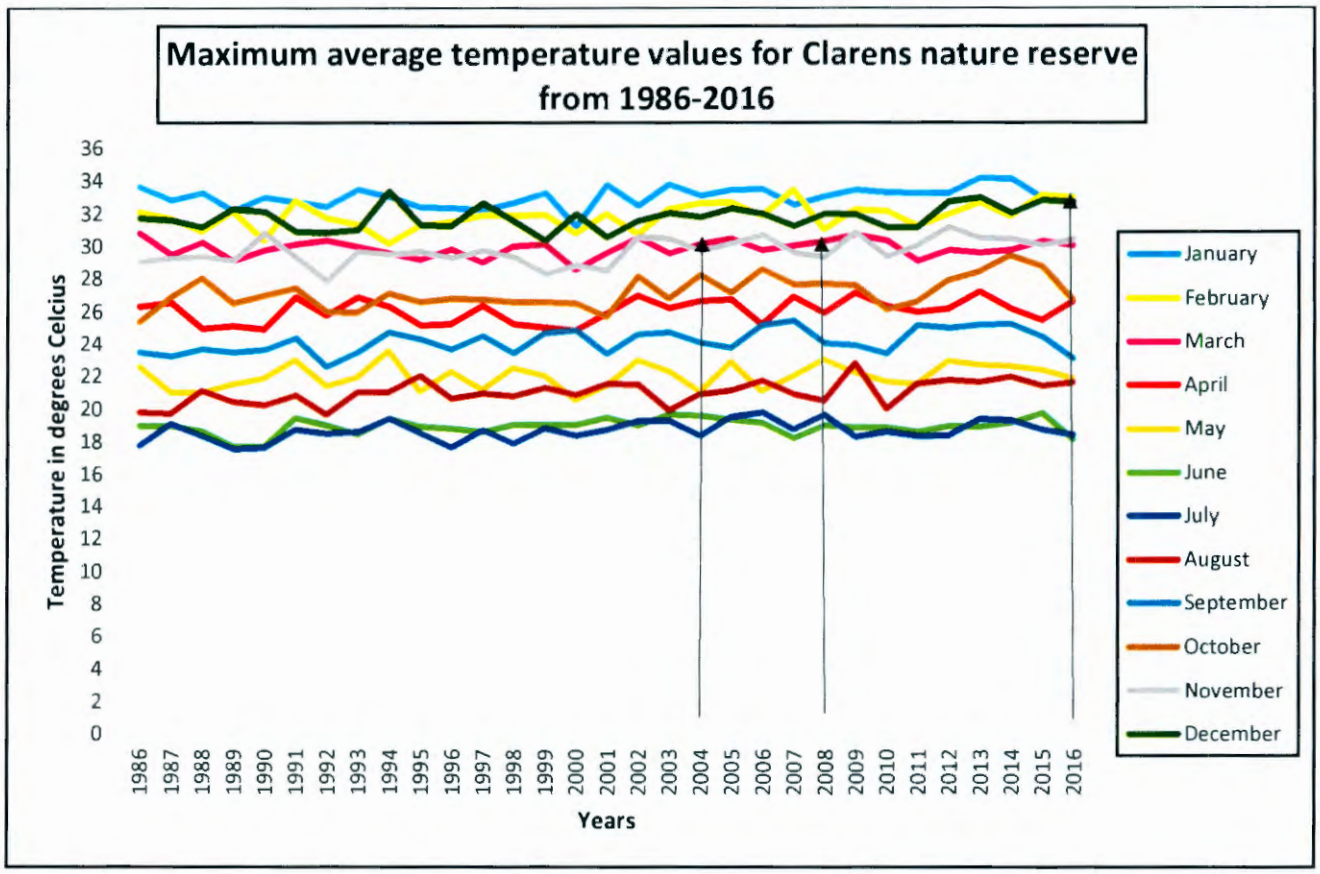

Figure 3.3: Maximum average temperature values for Clarens nature reserve from 1986-2016

Source: Climate explorer (https://climexp.knmi.nl/start.cgi)

It can be noted from figure 3.3 above, that the overall average maximum temperatures over 3 decades in the Clarens nature reserve was 26.22°C. More specifically as indicated by the three respective arrows, maximum average temperature in March 2004 was 30.19°C, March 2008 increased slightly to 30.24°C and February 2016 was 33.07°C hotter.

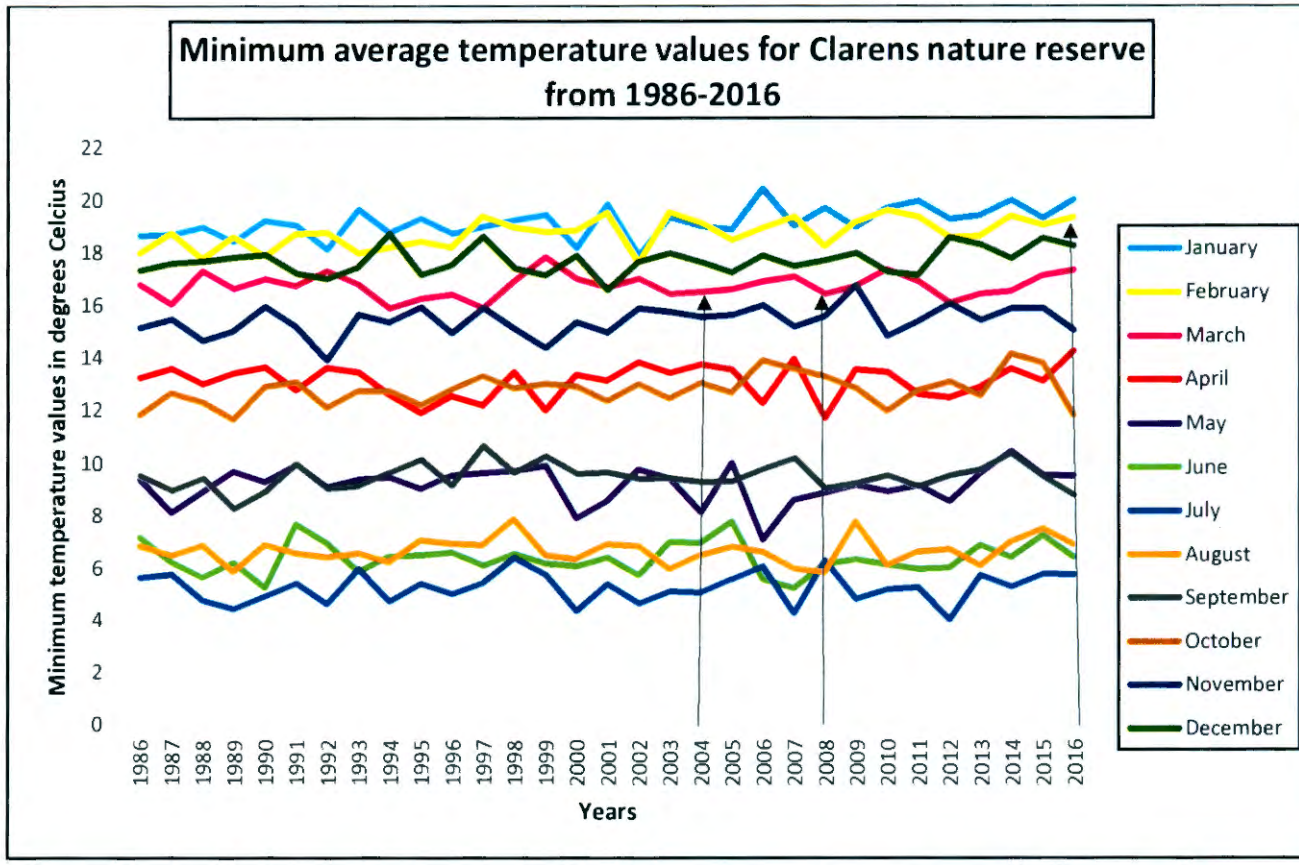

Figure 3.4: Minimum average temperature values for Clarens nature reserve

Source: Climate explorer (https://climexp.knmi.nl/start.cgi)

It can be realized from figure 3.4 above, that the overall average minimum temperatures over the 30-year period in the Clarens nature reserve was 12.55°C. In particular as indicated by the arrows respectively, minimum average temperature in March 2004 was 16.51°C, March 2008 decreased slightly to 16.45°C. The month of February 2016 was at 19.34°C.

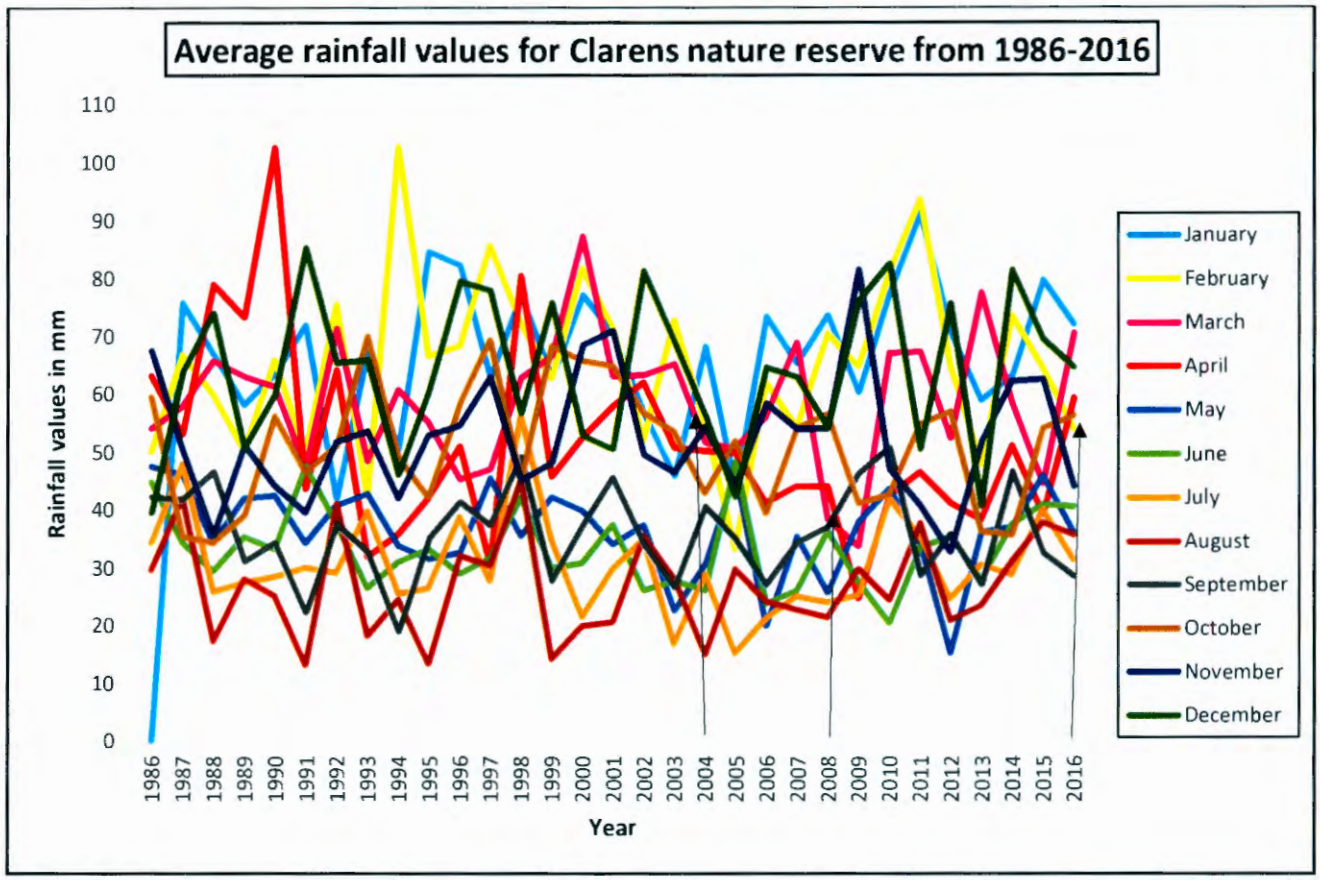

Figure 3.5: Average rainfall values for Clarens nature reserve from 1986-2016

Source: Climate explorer (https://climexp.knmi.nl/start.cgi)

Rainfall indices in figure 3.5 demonstrate precipitation received in the Clarens nature reserve from the year 1986 to 2016. Overall average of rainfall received over a 30-year period is 47.71mm. For the purpose of the specific periods being researched, March 2004 received 51.75mm of rainfall, March 2008 recorded 38.38mm of precipitation, and lastly a record of 54.05mm rain fell in February 2016.

The Clarens Nature reserve was declared a private sanctuary according to the Ordinance 8 of 1969 on 22 November 1985. The reserve is within the dominion of the Clarens Village Conservancy (CVC), and covers an area of approximately 800 hectares (Proposed Management Plan for Clarens townlands, 2014).

The reserve is under the custodianship of a group of individuals, homeowners and businesses who got together because they were concerned about the state of their environment and had aspirations to enhance and monitor the area as a natural heritage site. Collectively, these participants make up the CVC management

committee, and manage the reserve through the conservancy in terms of a Service Level Agreement with the Dihlabeng Local Municipality. Consequently, the CNR is registered with the Department of Environmental Affairs, as well as the Department of Social Development as a Non-Profit Organization (Proposed Management Plan for Clarens townlands, 2014).

3.5 Study design

Research design can be defined as a scientific structure that is developed to identify variables that will be measured or compared in order to draw correlations between the different variables that are created (Montello and Sutton, 2013). In essence, study design influences the type of questions addressed in the data, which will subsequently determine the validity of the results. According to Babbie and Mouton (2001:249) ... "data collection is one of the most crucial phases in the research process". The study was designed to collect data using both quantitative method (satellite images acquired through Remote Sensing), and qualitative method (survey questionnaire).

For the purpose of this research, Landsat satellite images of three (3) years were used to identify and map vegetation cover in the reserve. Originally, the strategy was to acquire four (4) satellite images of the reserve, starting from 2004, the year upon which the reserve was established, up to 2016. This was going to enable the researcher to systematically trace changes in vegetation cover, using a 4-year period interval since grass takes time to react to the impact of grazing (Du Toit et al, 2011). However, due to missing data in the sampled satellite images of 2012, the researcher had to resort to the three (3) years (25th March 2004, 20th March 2008 and 07th February 2016) of complete and available data in the images. Spatial-Temporal comparisons of vegetation cover was performed on the three (3) images, and relationships between them were established.

For qualitative data, open-ended structured survey questionnaires were used to address variables of demographic information, perceptions of participants on environmental effects of livestock grazing and also assess the socio-economic conditions associated with livestock grazing of the local community neighboring the

reserve. Mutanga *et al* (2015) postulate that gender, marital status, level of education, source of income, level of income and employment status play a fundamental role in determining the attitude and behavior of people towards conservation practices, particularly grazing in protected areas. On the other hand, years of farming experience, size of herd and age were variables noted to be influential socio-economic variables associated with livestock farming (Kgosikoma *et al*, 2012).

3.6 Methodology framework

The methodology used to achieve the research objectives involve a Remote Sensing analysis of NDVI data, open-ended structured questionnaire survey administration for livestock owners and the management of the reserve (Figure 3.6). The primary purpose of these data collection methods and analyses techniques were to establish the grazing conditions and distribution in the nature reserve, to assess the basic farming strategies employed by livestock owners and grazing management strategies that are practiced by the management. Qualitative results obtained from the questionnaires were validated by the overall ecological footprint of livestock grazing in the Clarens nature reserve as detected through Maximum Likelihood Classification function.

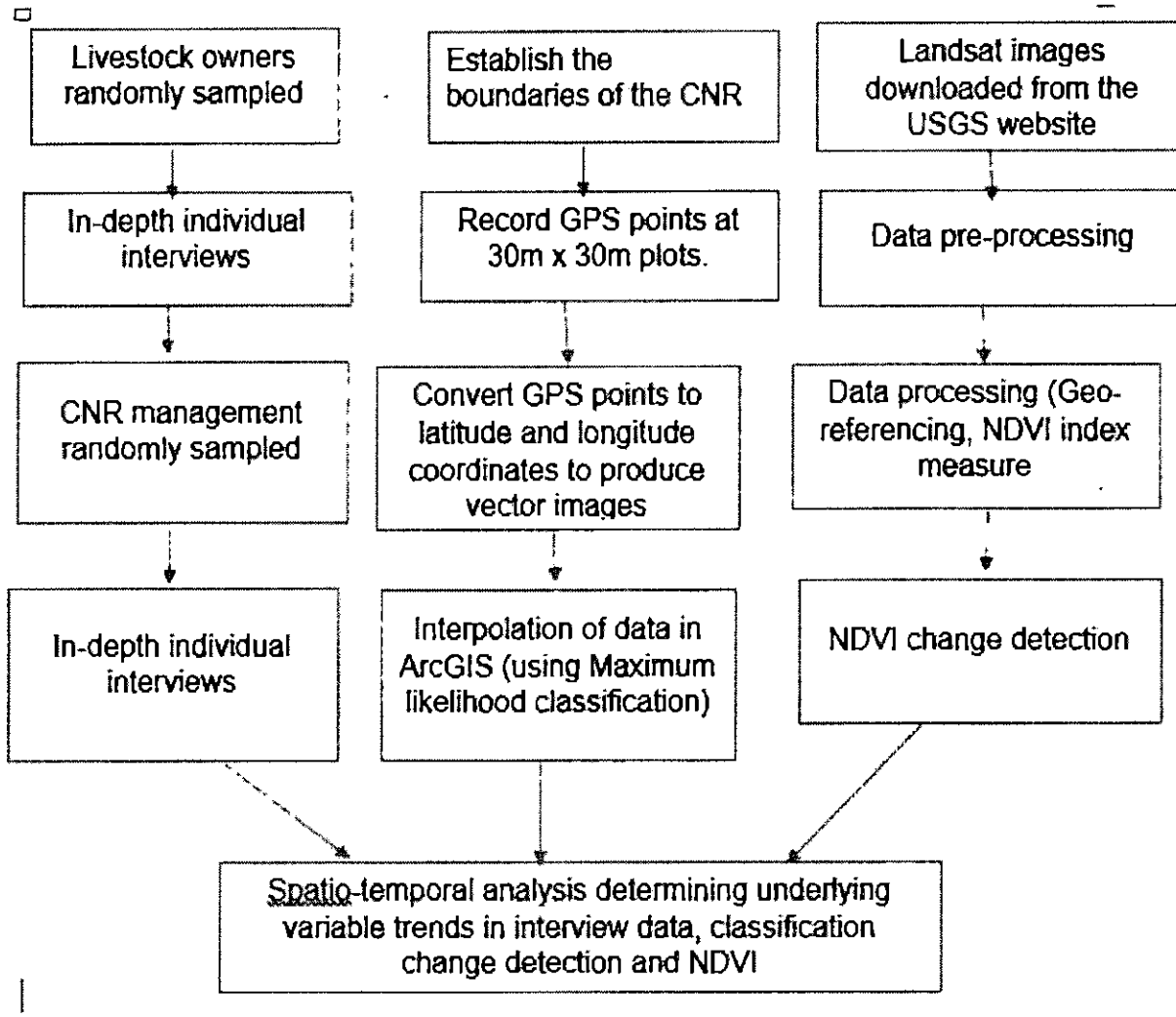

Figure 3.6: Flowchart of methodology

3.7 Study Sampling

According to Statistics South Africa census of 2011, the population of Kgubetswana township was approximately 6380. The population comprised more females (54%) than males (46%), with all racial groups represented. Black Africans were the majority population in the area, followed by whites, Asian and coloured persons, respectively. Southern Sotho is the predominant first language spoken in the area, followed by English and Afrikaans. The study population of Kgubetswana township is relevant in this case because it is the livestock of the area that is grazing in the Clarens nature reserve. Therefore, the population number is indicative of the community size.

Sampling is defined as a method of choosing a subgroup of participants from the original population of interest (Montello and Sutton, 2013). In essence, a sample is smaller in size than a population. And in the same token, a sample should maintain a true reflection of the population from which it was drawn (Adams and Lawrence, 2015). It is generally advised that the larger the population size, the smaller the sample percentage to be should be drawn. If the population itself is relatively small, as it was the case for this study, then the sample should comprise a reasonably large percentage of the population. Large samples enable the researcher to draw more representative, accurate predictions and more accurate conclusions, although the process may be costly (De Vos, 2002).

3.7.1 Sampling Procedure

Purposive sampling was used in the selection of the study area. This technique allows the researcher to select a specific area of study that will be helpful in accomplishing both the research aim and objectives (Neuman, 2000). This type of sampling is based entirely on the judgment of the researcher, in that the area comprised elements that are characteristic, representative or typical attributes that fulfil the study objectives. Accordingly, a protected area like Clarens nature reserve and its dynamics provided the researcher a perfect opportunity of assessing the impacts of grazing on the vegetation cover.

Purposive sampling was conducted in the selection of the management of the reserve. Simply because the committee is relatively small in number, and so for more conclusive results to be achieved, it was important that the management was purposefully sampled. Sampled respondents from the management included the rangers as well. A simple random probability sampling was used to select the sample from the population, mainly because there was no formal list of the livestock owners whose cattle graze in the reserve. Therefore, this particular sampling method was most appropriate for the study since every livestock owner in the population had an equal chance of being selected to participate in the survey (Adams and Lawrence, 2015). Random sampling is easy to carry out, as it is flexible and allows the researcher to cover a wide region of the study area (Stoker, 1989). The structured surveys were purposively directed to the farmers whose livestock graze specifically

in the reserve, because the researcher anticipated that they would be rich in information, which would contribute vastly to the data.

3.7.2 Sampling Frame

Montello and Sutton (2013:168) define a sampling frame as "the subset of the population from which cases are actually drawn to become part of the sample". In the case of this research study, the sample of livestock owners whose animals graze in the reserve was obtained from the sampling frame of livestock owners in the area of Kgubetswana township (Figure 3.7). Although there is no formal register of the livestock owners developed, the pastoralists where identified by a reliable source and their number was further confirmed by the respondents themselves.

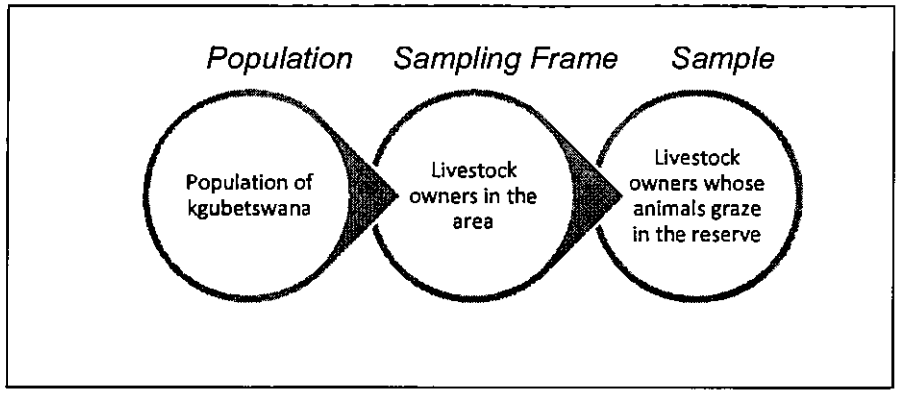

Figure 3.7: Sampling Frame

3.7.3 Sample Size

The population of livestock owners whose stock feed in the nature reserve was 7. The population of the management (which included the rangers) of the nature reserve was 6. The sample size was calculated using the formula adopted from Owino *et al* (2012):

Sample size (n) = $N/(1 + N(\varepsilon)2)$;

where

N = total number of households in Kgubetswana whose animals graze in the Clarens nature reserve,

ε = error margin derived from the selected confidence interval, for the purpose of this research, 95% confidence interval (error margin 0.05) was used.

Sample size of livestock owners:

$$(n) = 7/[1+7(0,05)^2]$$

$$= 6,88$$

Sample size of management:

$$(n) = 6/[1+6(0,05)^2]$$

$$= 5,91$$

Therefore, the sample size was 13.

3.8 Research methods

In order to achieve research question i), Remote Sensing technology was used to map vegetation cover resulting from livestock grazing in the reserve. More specifically, a supervised classification technique was applied to a remotely sensed image from the Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+) and Landsat 8 Operational Land Imager (OLI) sensors to generate thematic maps of the study area and surroundings based on field measures. Two approaches were explored: firstly, using the Maximum likelihood classification and secondly using a Normalized Difference Vegetation Index image (NDVI). The resultant thematic maps were then examined for corroborative evidence of vegetation patterns and land-use impacts measured on the ground. In essence, change analysis was the main Remote Sensing tool used to determine vegetation cover categories and resulting change from maximum livestock holding capacity.

To answer research questions ii) and iii) collectively, open-ended questionnaire survey was conducted with livestock owners, individually. The survey sought to assess the awareness and perception of the farmers towards vegetation cover associated with grazing in the reserve; as well as the socio-economic livelihoods of the livestock owners associated with livestock farming using a structured questionnaire. A purposive, random sampling method was applied to select the livestock owners. Face-to-face interviews with the management of the reserve were conducted to establish (dis)similarities in their perceptions of livestock grazing in the nature reserve and associated socio-economic conditions with those of the community. Lastly, research question iv) was answered based on the literature reviewed and the data results. Recommendations addressed critical issues that promoted sustainable use of natural resources in the reserve, for the benefit of future use.

3.9 Data collection methods

3.9.1 Survey

Data on perceptions of environmental and socio-economic effects of livestock grazing in the Clarens nature reserve was collected in July 2017 using a structured questionnaire for livestock owners whose cattle graze in the reserve; and open-ended survey for the management of the reserve (Appendix 1). The difference in the structure of the questionnaires between the two sets of sampled groups was influenced by the sample sizes of the participants. The farmers were greater in number (seven), so a structured questionnaire was used as a measure of standardizing the answers from the respondents, and also to minimize errors percentage. For the management, an open-ended survey was administered, which enabled in-depth responses and allowed respondents to share their knowledge of the state of the reserve. Montello and Sutton (2013) list a survey as one of the major explicit reports in scientific writing. According to the researchers, explicit reports allow respondents to express their opinions and beliefs of various issues freely. For ecologists, this approach is best suited to capture ecological system changes influenced by human activities.

In section A of the questionnaire, livestock owners had to indicate their demographic information such as gender, age, marital status, level of education, employment status and job occupation. This was done in order to establish the demographic composition of the farmers' community, because as suggested by Mutanga *et al* (2015) these characteristics significantly influence the perception and behavior of people towards conservation. In section B, the farmers had to indicate negative and positive effects of livestock grazing prevalent in the reserve; and list indicators of overgrazing associated with livestock. Section C assessed grazing management strategies practiced by farmers. Lastly, section D evaluated the socio-economic dependency of livestock farming by farmers, and years of farming experience. The questionnaire was a fundamental source of primary data, which Montello and Sutton (2013) describe as values and information gathered through scientific measurement and empirical observation, for the sole purpose of achieving a specific study' aim.

3.9.2 Interviews

The interviews were conducted face-to-face with all the participants of the study. Face-to-face meetings are important, especially in a country like South Africa, where there is a low level of literacy among the population (Statistics South Africa, 2015). In essence, with face-to-face interviews, the interviewer reads out the questions to the respondents and records the answers of the oral responses (Babbie and Mouton, 2001). For livestock owners' comfort and ease of communication, the discussions were conducted in Sesotho. Whilst for the management the interviews were done in English, a language most suitable for all the participants. Interviews were approximately 15 minutes in duration, conducted at a mutually agreed venue where the participant will feel safe and secure. Participation of the sampled individuals was entirely voluntary and were under no obligation to participate in this study. Confidentiality of the data was guaranteed.

3.9.3 Field points

The Clarens nature reserve was digitized from Google Earth, and the digitized KML file was converted into a shapefile using the ArcMap 10.2 software package. Coordinate location points were collected physically throughout the boundary region

of the nature reserve using a Global Positioning System (GPS). Coordinate points collected on the field were then converted into decimal degrees using Earth Point system accessed at http://www.earthpoint.us/Convert.aspx. Thereafter, the decimal degree points were entered into a Geographic Information System (GIS), and exported as a shapefile using the ArcMap 10.2 software package. The shapefile created of GPS points data validated the digitized shapefile sourced from Google Earth. The shapefile was then laid over the three Landsat Satellite images. Landsat satellite images downloaded from Earth explorer at http://earthexplorer.usgs.gov/. were additional secondary sources applied for this research. In other words, conditions in which the Landsat was captured were beyond the researcher's control. For example, the extent of the Earth surface coverage, the passing over time of the satellite, the spatial resolution of the imagery, as well as the spectral bands recorded. Therefore, the Landsat data was qualified as secondary source.

3.9.4 Landsat images

For the purpose of this study, remotely sensed images of Landsat 5 TM, Landsat 7 ETM+ and Landsat 8 OLI sensors were utilized to generate thematic maps of the study area and surroundings based on field measures. All three Landsat images have a spatial resolution of 30m (Table 3.1).

Table 3.1: Details of the Landsat sensors used

Type of Sensor	Path	Row	Cloud cover	Date of acquisition	Spatial resolution
TM	170	80	0%	25th March 2004	30m
ETM+	170	80	0%	20th March 2008	30m
OLI	170	80	0%	07th February 2016	30m

Dates of acquisition of the satellite images were intended for the Autumn season. The choice of season was selected on the basis of its moderate weather characteristics such as slow rainfall, warm sunshine and chilly night temperatures. It is against these conditions that the season is regarded as the most enjoyable and best period in South Africa. Grazing lands are rejuvenated, as vegetation regrows and blossoms. This is why picturesque beauty of the country is best experienced

during Autumn. In the Southern Hemisphere, the Autumn season starts in February and ends in April (South African weather services). Subsequently, for this study, February and March months were used for analysis. Simply because Landsat data of these months was available and had no missing data.

The images from the three years were geometrically rectified and registered to a common Projection Zone of WGS 1984, Universal Transverse Mercator (UTM) 35 South datum. For detection of vegetation reflectance, layer combination of bands 4,3,2 and 5,4,3 (false-color infrared) on Landsat 5 and 7; and 8 respectively was performed.

3.9.5 Observation

The second method of collecting data was in the form of a field observation. The researcher walked around the boundaries of the study area, while noting outstanding/protruding features and grazing patterns that could be contributing to the state of the vegetation in the reserve.

3.10 Data collection tools

3.10.1 Questionnaires

The primary tool used to collect qualitative data was the questionnaire. De Vos (2002) defines a questionnaire as a set of questions on paper that are completed by a respondent in relation to the research project. The questions can be open or closed, or alternatively, with an option of a Likert scale. The basic objective of such a questionnaire is to obtain perceptions and opinions of a phenomenon from the participants who are informed about a particular issue.

3.10.2 Satellite images

The secondary tool used to derive quantitative information of vegetation cover was remotely sensed images. The combination of Remote Sensing technology with Geographic Information Systems (GIS) has the ability to collect reliable data on vegetation cover, even in inaccessible places; and on a large spatial and temporal

scale (Shupe and March, 2004). Remote sensing allows the user to obtain information of an area or phenomenon without being physically present at the study area. Monitoring the change in vegetation cover over changing time and space using Satellite imagery is important in extrapolating local understanding and synthesizing the results in the global context (Anderson, 2012). Given its ability to survey large scales, remote sensing technology significantly reduces expenses of extensive field assessments.

Archer (2004) commends the effectiveness of remote sensing technology in its ability to produce thematic maps of vegetation dynamics; and also enables ecological modelling and monitoring of grazing lands. The additional advantage of visually representing heterogeneous land-use/land-cover provides rangers, conservation areas' managers and ecologists with an effective management tool of rangelands, in that remote areas can be displayed by remote sensing.

Broadly speaking, there has been frequent application of remote sensing technology globally. In southern Africa, there is growing interest in the use of satellite imagery for exploring and mapping plant diversity and distribution. To some extent, the system is applied on smaller scale to investigate ecological impacts of grazing (Anderson, 2012).

3.11 Data analysis and Presentation

Data analyses is a set of information representation which communicates meaning to the reader, and allows the researcher to predict and explain relationships of variables involved (Rogerson, 2006:170).

3.11.1 Analysis of qualitative and quantitative data

The collected qualitative data through questionnaire administration were analyzed quantitatively using Statistics Package for Social Sciences, version 24 (SPSS 24). The responses were coded and captured onto SPSS. Descriptive calculations were conducted, and the results were summarized in a table. Given the very small sample

size, correlation and regression analysis calculations yielded no significant relationships between variables. For example, when testing for association between variables such as employment status and the number of livestock farmed; age, job occupation and reasons for farming; level of education, farming experience and perception of whether there is overgrazing, all these variables yielded no correlations. Hence, no comparisons were included as part of the results.

3.11.2 Satellite imagery

For the analyses of vegetation cover of the study area, a combination of spectral bands was performed. Vegetation can easily be detected as it reflects more with layer stacking of spectral bands 4,3,2 and 5,4,3 (false-color infrared) on Landsat 5 and 7; and 8 respectively (Table 3.2). The end result from this combination was a composite band.

Table 3.2: TM, ETM+ and OLI band descriptions

Spectral bands of TM and ETM+	Spectral bands of OLI	Wavelength (micrometers)	Use
Band 2 – green	Band 3 – green	0,52-0.61	Emphasizes peak vegetation, which is useful for assessing plant vigor.
Band 3 – red	Band 4 – red	0,63 – 0,69	Emphasizes vegetation slopes
Band 4 – reflected near Infrared	Band 5 – reflected near infrared	0,76 – 0,90	Emphasis biomass content and shoreline

Source: Parece, Campbell and McGee (2015)

The second method of data analysis was Maximum likelihood classification. In this process, the researcher selected imagery pixels that are a representation of land cover types that were identified in the field. By identifying these land features, the computer system was 'trained' to also identify pixels that exhibit identical characteristics. As different land use types are identified, they are then assigned a class number. This classification separates one class from the other, and minimizes chances of duplication of land cover. In this study, land use classes were identified

and classified as: Non-palatable vegetation – 1; palatable grass – 2; water – 3 and bare soil – 4. Thereafter, a supervised Maximum Likelihood classification was performed. This analysis produced the total number of imagery pixels that displayed the characteristics of the four created classes above.

The last type of data analysis was the Normalized Difference Vegetation Index (NDVI). Broadly speaking, a vegetation index is a directory indicating the greenness of vegetation (USGS, 2015). This greenness can be indicative of the health, distribution and composition of vegetation. NDVI measures the reflectance of vegetation between the range of +1.0 and -1.0. Areas of little or no vegetation, rock outcrop, and snow are typically known to indicate very low NDVI values (0.1 and below). Whilst areas of sparse vegetation, water and senescing crops normally reflect moderate values (0.2 to 0.5). In the same token, areas of healthy vegetation, forests and mature crops, reflected NDVI values are high (0.6 to 0.9). The product of the NDVI is the ratio of two electromagnetic wavelengths (Archers, 2014).

Therefore, the resultant thematic maps were examined for corroborative evidence of vegetation pattern change, reflectance and land-use impacts measured on the ground. The change in cover and distribution of vegetation was analyzed in relation to the quantities and distribution of livestock.

The results of the study are presented in three ways: in maps, tables and graphs. Montello and Sutton (2013) describe graphs as photographic representation of information. They primarily use spatial values of a phenomenon to visually display data. Most importantly, graphs communicate large data effectively. Tables on the other hand, are defined as "organized lists, arrays, or matrices of data" (Montello and Sutton, 2013:220). They display data variables simultaneously with numbers, making comparison obvious. Tables are simple, straightforward medium of presenting data.

3.12 Ethical considerations

Montello and Sutton (2013:287) define ethics as "the study of moral or proper action". Ethics are honorable considerations that should be observed during throughout a research project, most especially if human factors are involved. Ethical deliberations are centered around three fundamental basic directives namely; the obligation of

scientists to contribute to existing school of knowledge through innovative methods of inquiry; absolute no harm imposed directly or indirectly onto any participants in a research project; and for a research to serve a greater purpose of benefiting the society at large (Montello and Sutton, 2013).

First and foremost, ethical clearance was obtained from the University of the Free State' ethics committee for the conduction of the project, and collection of data for the study. For the purpose of this research, additional considerations upheld during the conduct of this study as informed by Prathapan (2014) included, scientific honesty - in that the participants were clearly explained to the purpose of this research and no incentives were promised for participation. Carefulness - in that the researcher was already aware of the prevailing working relationship between the management and the local pastoralists and therefore did not insinuate or propagate any future conflicts. Openness, in that the researcher identified herself and institution of association to the respondents. Also, the objectives of the research were indicated for the participants of the study. Therefore, individuals who took part in the research were not misled to do so. Finally, the principle of credit. From the first chapter to the last chapter of this dissertation, acknowledgements were observed and duly indicated on all secondary data information the researcher used.

Moreover, during the data collection process, the following ethical directives were advocated for: Anonymity of the participants was maintained. Administered questionnaires cannot be traced back to the respondents, as participants' completed questionnaires were identified by numbers, not by their names. In instances were respondents' responses had to be quoted in the results chapter, their identities were not revealed and the feedback is not suggestive. Whenever possible, reporting data of participants was in aggregate form. The responses were categories as either livestock owners or the Clarens nature reserve management, instead of individualizing the reactions. No plant or animal species was destroyed or harmed in the reserve during the course of the study. Lastly and most importantly, an informed consent form was explained to and completed by the respondents before they complete the survey.

3.13 Conclusion

Clarens is popularly known for its tourist attraction landscapes and scenic views. The Clarens nature reserve forms part of key destinations explored by visitors, it is a valuable asset for effective ecological functioning and offers a platform for research projects. The nature reserve prides itself in offering magnificent hiking experiences to tourists in the area. It is also home to indigenous, alien and threatened plants species. In its undisturbed form, the reserve is thriving hub of biodiversity.

The research study was structured in a way that will capture and address the farming community of Kgubetswana' perceptions, behavior and attitude towards conservation practices, specifically the Clarens nature reserve as it directly affects their livelihoods. In the same token, the management of the nature reserve were key stakeholders in the designing of the research. Their grazing management strategies and perception of the neighboring community were the main areas of focus.

Research methods used to collect and analyze data were fundamental in achieving the purpose of the study. The use of questionnaires successfully achieved the purpose of assessing the perceptions of both sets of participants towards environmental effects of livestock grazing in the nature reserve and the socio-economic conditions associated with livestock in the area. The use of sophisticated methods of acquiring data and manipulating it on a large spatial scale, enabled the researcher to achieve the objective of identifying vegetation cover associated with livestock grazing in the Clarens nature reserve. Subsequent is chapter four, which will provide the research results.

CHAPTER 4

RESULTS

4.1 Introduction

This chapter presents the results of the vegetation cover change in the CNR and survey findings. These results were obtained from the Landsat images and questionnaires that were administered between the Kgubetswana livestock owners and the Clarens Nature reserve committee members, respectively.

4.2 Vegetation cover change

Vegetation cover data was retrieved from Landsat images of the years 2004, 2008 and 2016.

4.2.1 Landsat data: Maximum likelihood classification and NDVI

The results as presented in Table 4.1 reflects a continuous decrease in water and bare soil from 2004 to 2016, but an increase in non-palatable grass from 2004 to 2016. Palatable grass increased moderately from 2004 to 2008, but experienced a decrease from 2008 to 2016.

Premised on the first objective of this study, vegetation cover over the study area has changed significantly. The Maximum Likelihood classification method of analysis has proved this change. Table 4.1 shows the extent of land cover change after supervised classification for all images was conducted.

Table 4.1: The spatial extent of land cover after classification

	% of the Area			% Change		
Land cover type	**2004**	**2008**	**2016**	**2004 - 2008**	**2004-2016**	**2008-2016**
Non-palatable	38.91	38.95	52.14	+0.04	+13.23	+13.19
Palatable	32.71	40.46	29.78	+7.75	-2.93	-10.68
Water	13.89	10.18	9.48	-3.71	- 4.41	- 0.7
Bare soil	14.49	10.41	8.60	-4.08	- 5.89	-1.81

In 2004, the Clarens nature reserve is observed to be largely covered by (32.71%) of palatable vegetation in the middle of the reserve, where the land surface is characterized by gentle slopes; towards the northern part of the area. Smaller patches of non-palatable vegetation (38.91%), water bodies (13.89%) and bare soil (14.49%) are seen along the southern parts of the reserve. This is according to the results as presented in Figure 4.1 below.

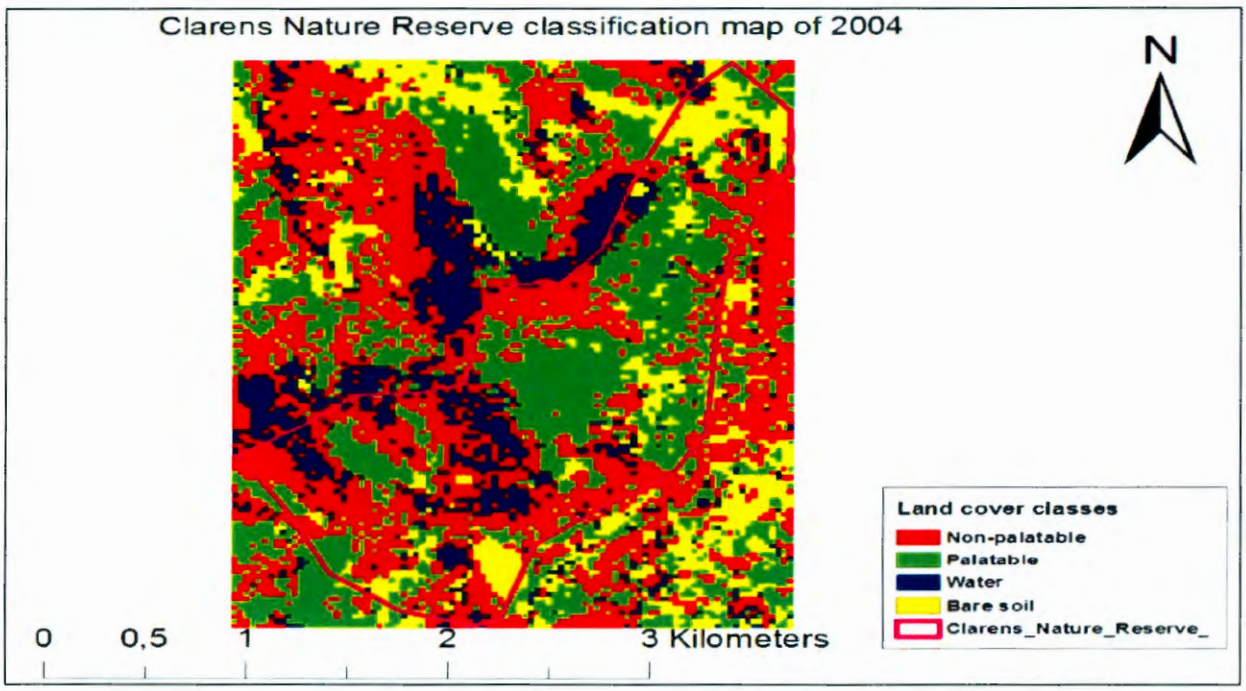

Figure 4.1: Classified map of Clarens nature reserve using Landsat image of 2004

In 2008, the Clarens nature reserve witnessed a further 7.75% increase in palatable vegetation in the south western side of the reserve, even along the proximities of the dam. Non-palatable vegetation encroachment of 0.04% is seen along the south eastern, up to the north eastern boundaries of the reserve. A decrease of 3.71% and an additional 4.08% of water and bare soil respectively is realized (Figure 4.2).

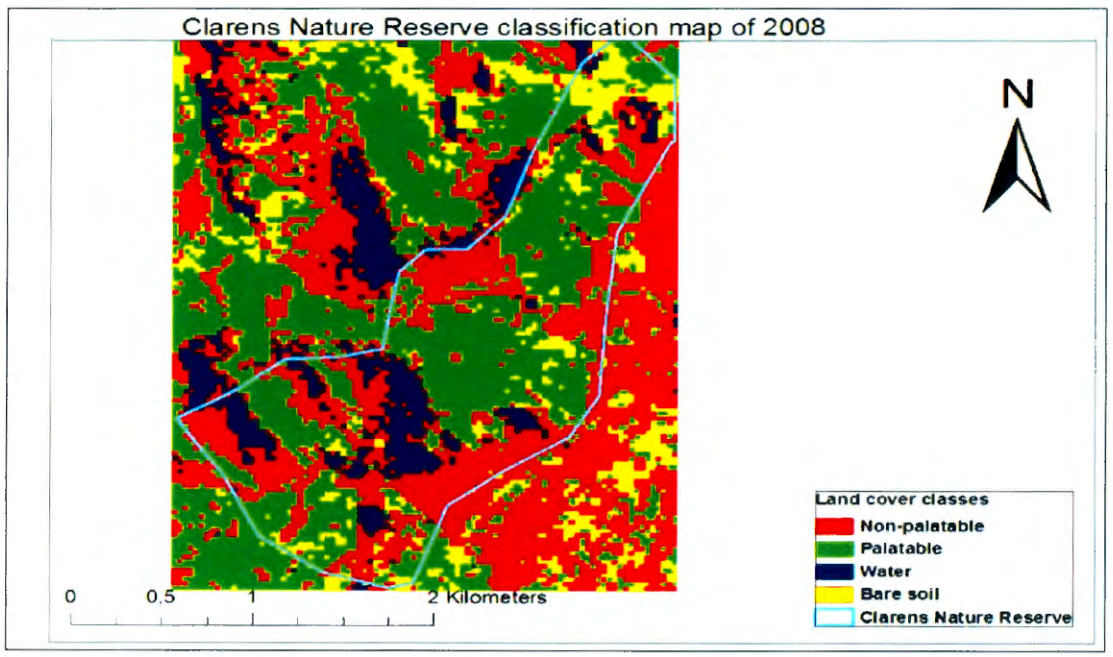

Figure 4.2: Classified map of Clarens nature reserve using Landsat image of 2008

The results as presented in Figure 4.3 illustrates 12 years of history since the official inception of the reserve, and all land cover classes indicate major changes. Non-palatable vegetation evenly overtakes the reserve vegetation cover with coverage of 52.14%, patches of palatable vegetation remains around water sources at 29.78%, while water points over 9.48% of the reserve, and lastly, bare soil continues to decrease to 8.60% coverage, as seen in Figure 4.3.

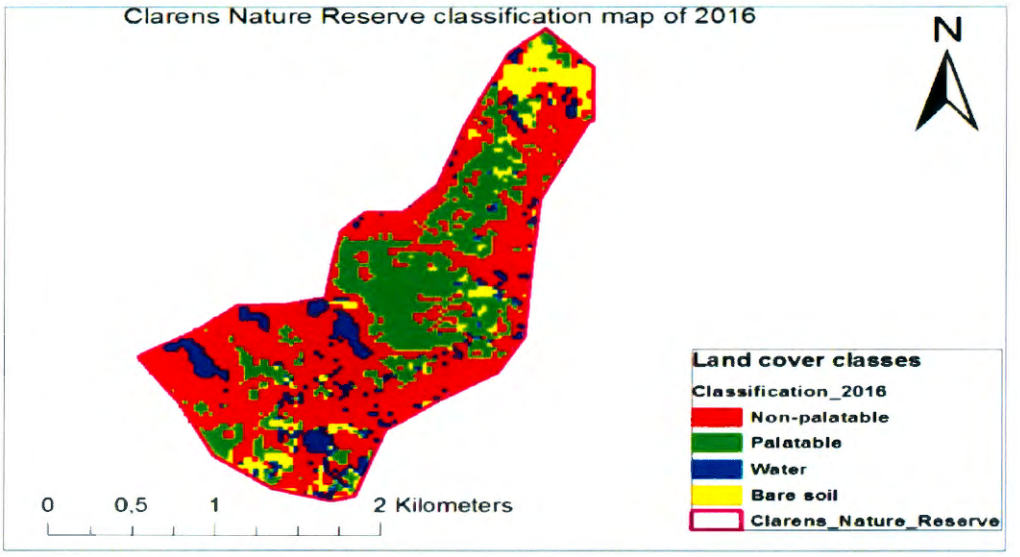

Figure 4.3: Classified map of Clarens nature reserve using Landsat image of 2016

A comparative land cover percentage change between the years 2004, 2008 and 2016 of the three land cover classes is depicted by Figure 4.4. Where land cover class 0 represents non-palatable species, 1 represents palatable species, 2 represents water and 3 represents bare soil. Having said that, what can be observed from the figure is a steady increase of non-palatable vegetation; and a rapid decrease of water and bare soil.

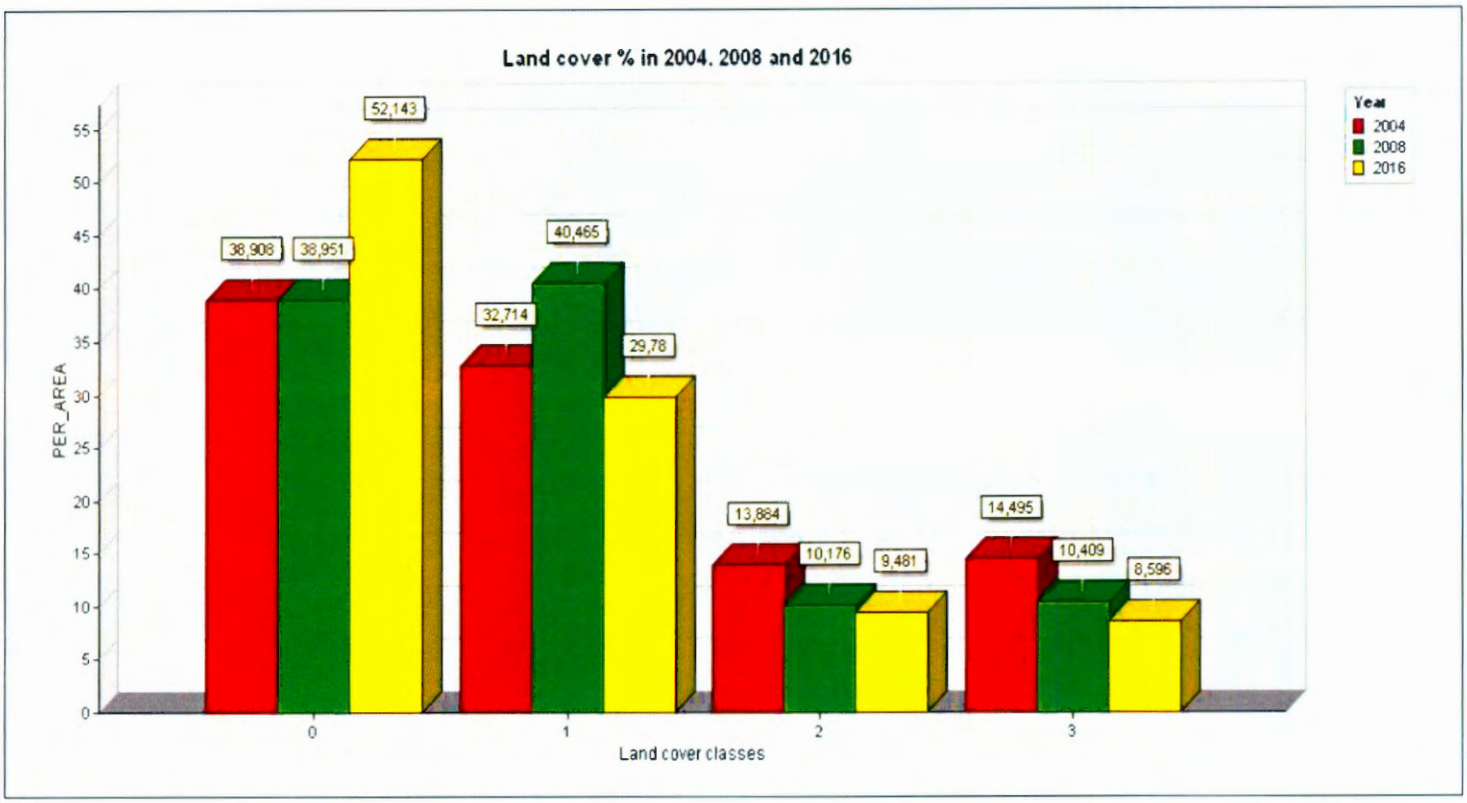

Figure 4.4: Classification graph of Clarens nature reserve for 2004, 2008 and 2016

4.2.2 Normalized Difference Vegetation Index (NDVI)

NDVI is an excellent and widely used method for vegetation growth and condition assessment. For this study NDVI calculation was performed to produce NDVI images for the three years.

Statistical values of the NDVI, from a Landsat image acquired in March 2004 are calculated as follows: minimum value is -0.27, a maximum value of 0.38, mean of 0.07 and standard deviation of 0.10 (see Figure 4.5).

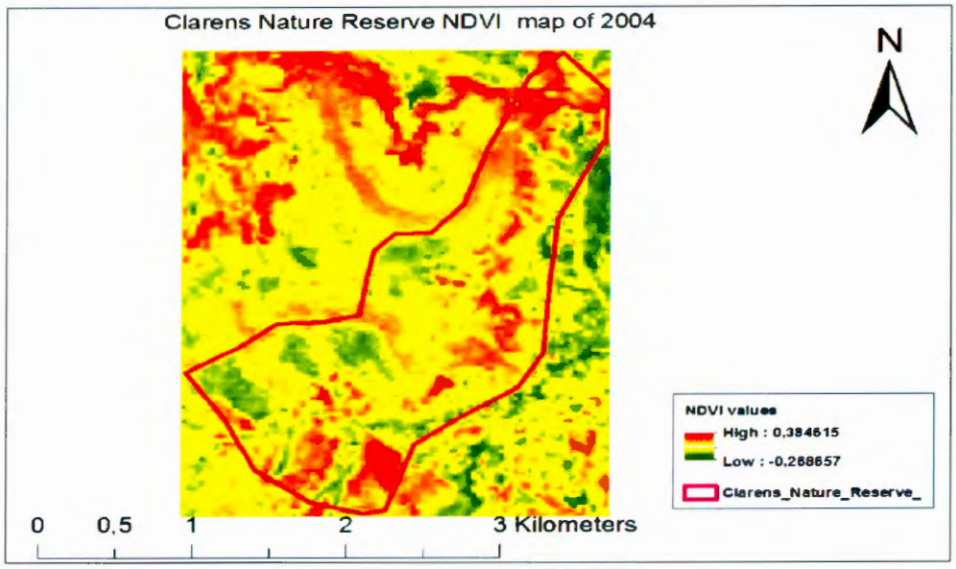

Figure 4.5: NDVI map of Clarens nature reserve using Landsat image of 2004

Statistical values of the NDVI, from a Landsat image processed in March 2008 are sourced as follows: minimum value is -0.28, a maximum value of 0.41, mean of 0.15 and standard deviation of 0.13 (Figure 4.6).

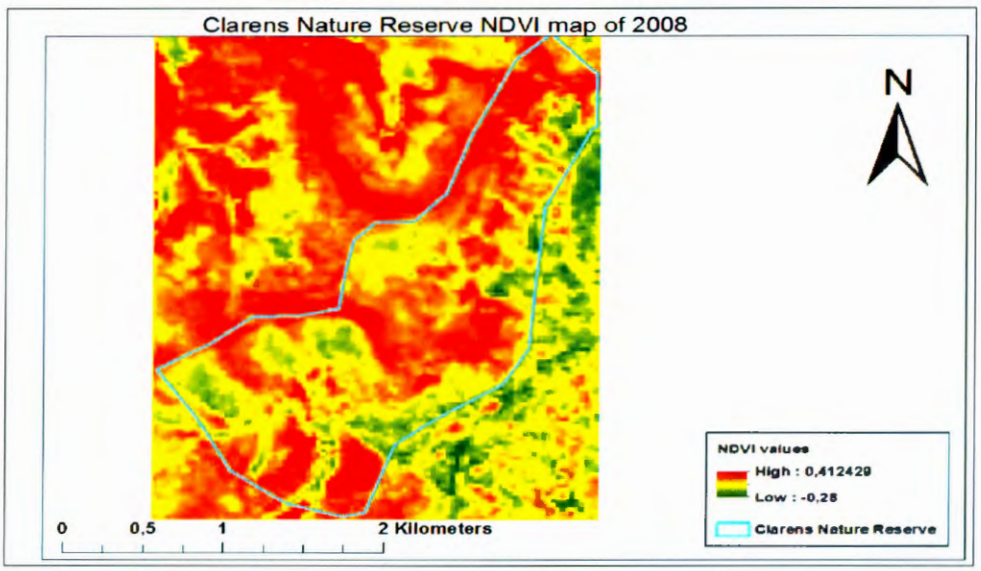

Figure 4.6: NDVI map of Clarens nature reserve using Landsat image of 2008

Statistical values of the NDVI, from a Landsat image attained in February 2016 are as follows: minimum value is -0.42, a maximum value of 0.85, mean of 0.51 and standard deviation of 0.13 (Figure 4.7).

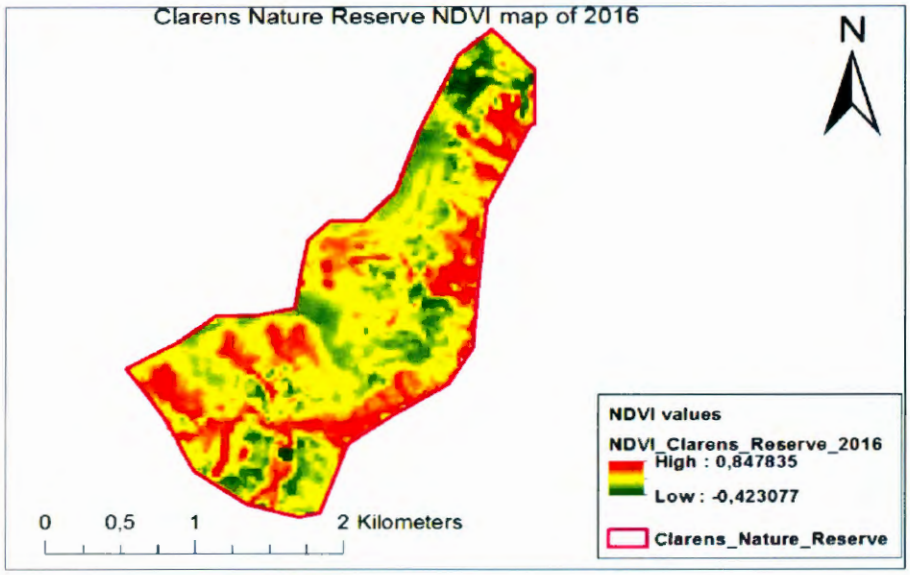

Figure 4.7: NDVI map of Clarens nature reserve using Landsat image of 2016

The results as presented in Table 4.2 provides a comparative display of NDVI values of the three years that are in question. The minimum vegetation reflectance value was observed in March 2004 at -0.27, while the maximum vegetation reflectance was witnessed in February 2016. Variations in the mean and standard deviation over a 12-year period is also seen.

Table 4.2 The NDVI values of Clarens nature reserve for 2004, 2006 and 2016

Year	Minimum value	Maximum value	Mean	Standard deviation
March 2004	-0.27	0.38	0.07	0.10
March 2008	-0.28	0.41	0.15	0.13
February 2016	-0.42	0.85	0.51	0.13

4.3 Survey findings of livestock owners and the CNR management

Livestock owners were interviewed with the purpose of establishing their perception of environmental effects associated with livestock grazing at the Clarens nature reserve; to estimate their understanding of environmental effects associated with livestock grazing at the reserve; and lastly to assess their socio-economic conditions associated with livestock grazing in the CNR. Clarens nature reserve committee members were surveyed with the aim of establishing their perception of environmental effects associated with livestock grazing at the Clarens nature reserve; to estimate their understanding of environmental effects associated with livestock grazing at the reserve; and lastly to assess their awareness of the socio-economic conditions of the Kgubetswana community associated with livestock grazing in the CNR. Both sets of results, from the livestock owners and the management of the reserve were used to validate the responses for similarities and differences.

4.4 Demographic information of study participants

Demographic information of study participants is as presented in Table 4.3.

With reference to table 4.3 below, all livestock owners whose animals graze in the reserve participated in the survey questionnaire. The sample was comprised of males only (100%), with the age average of 40-49 years old (71%). All the participants are married (100%).

The level of education of the respondents is distributed between no formal education (29%); primary education (14%); high school education (29%) and tertiary levels of study (29%). Overall, 71% of the sample have a formal education.

In terms of employment status, 57% of the respondents are employed. In accordance to the table, 43% of the livestock owners occupy low-skilled jobs, while 14% are skilled workers (Statistics South Africa, 2015).

Table 4.3: Demographic information of the participants

Variable	Characteristic	Frequencies	% of sample
Gender	Male	7	100
	Female	-	-
Age	40 – 49	5	71
	50+	2	29
Marital status	Married	7	100
Level of education	No formal education	2	29
	Primary	1	14
	High school	2	29
	Tertiary	2	29
Employment status	Unemployed	3	43
	Employed	4	57
Occupation	Unemployed	3	43
	Public servant	1	14
	Self-employed	1	14
	Other	2	29

4.5 Environmental effects associated with livestock grazing at the CNR

This section presents results of the perceptions of both the livestock owners and the management of the reserve, in terms of their perceived environmental effects associated with livestock grazing at the reserve.

4.5.1 Community's perception of environmental effects associated with livestock grazing at the CNR

Results of community perception of environmental effects associated with livestock grazing at the CNR are as presented in Table 4.4.

Based on the results as indicated in table 4.4, 43% of the respondents strongly agreed that erosion is a negative indicator of grazing. Equal proportions (29%) of livestock owners strongly disagreed, while (29%) strongly agreed with soil

compaction being classified as a negative indicator of grazing. The former's argument was that rotational grazing is practiced, therefore the soil if left to recover.
A majority (71%) of participants strongly agreed that trampling is a negative indicator of grazing. While 57% agreed that the decrease in vegetation is a negative indicator of grazing. On the other hand, 43% disagreed on the basis that there is competition for land by alien species. Therefore, the encroachment of unpalatable grass causes a decrease in vegetation cover. From the results, 57% of the respondents strongly agreed that habitat destruction is a negative indicator of grazing, whereas 43% of livestock owners strongly disagreed.

Increase in unpalatable grass is strongly agreed to be a negative indicator of grazing by 57% of the pastoralists.
Alien plant encroachment control is a positive indicator of grazing. All (100%) of the participants strongly agreed with the statement. Cow dung is said to play a vital role as soil fertilizer, which enriches the productivity of the soil.

There have been noticeable changes in the grazing pattern and vegetation cover in the reserve. This was qualified by 71% of livestock owners. Variety in weather conditions accompanied by changing seasons influence grazing patterns and vegetation cover. More rainfall leads to vegetation growth, thus increasing the carrying capacity of the grazing area. Livestock also has to seasonally rotate grazing camps, to sustain the availability of vegetation – particularly grazing sites that are around water sources. At the moment, there is more cattle than can be provided by vegetation.

Of the livestock owners who participated in the survey questionnaire, 71% believe there is no overgrazing in the CNR. To substantiate this view, some of the reasons given were that new grazing camps have been demarcated, and are alternated in between the seasons. Such strategies are believed to minimise overgrazing and reduce pressure on palatable grass. In contrast, 29% of the respondents are of the opinion that there is overgrazing, which is caused by the presence of more livestock than food sources.

On a rating scale, decrease in vegetation cover was graded the highest indicator of grazing at 40%; followed by erosion, soil compaction and habitat destruction at 13%, respectively. Trampling and a decrease in palatable grass were rated the lowest indicators at 7%. Similarly, 7% of the surveyed livestock owners could not list any environmental indicators of overgrazing.

Table 4.4: Community's perception of livestock grazing in the CNR

Environmental effects associated with livestock grazing		**Strongly Agree (%)**	**Agree (%)**	**Disagree (%)**	**Strongly Disagree (%)**
Erosion is a negative indicator of grazing		43	29		29
Soil compaction is a negative indicator of grazing		29	14	29	29
Trampling is a negative indicator of grazing		71	14	14	
Decrease in vegetation cover is a negative indicator of grazing		43	14	29	14
Habitat destruction is a negative indicator of grazing		57			43
Increase in unpalatable grass is a negative indicator of grazing		57	14		29
Plant encroachment control is a positive indicator of grazing		100			
Have noticed change in grazing pattern/vegetation cover		**Yes (%)**	**No (%)**		
		71	29		
There is overgrazing in the reserve		**Yes (%)**	**No (%)**		
		29	71		
Environmental indicators of overgrazing	Erosion (%)	Soil Compaction (%)	Trampling (%)	Decrease in palatable grass (%)	I don't know (%)
	13	13	7	40	7

4.5.2 CNR committee members' perception of environmental effects associated with livestock grazing at the CNR

Results of the CNR committee members' perception of environmental effects associated with livestock grazing at the CNR are as presented in Table 4.5.

Based on the results as presented in table 4.5 below; all of the respondents (100%) agree that there are challenges with the current stocking rate in the reserve. These challenges include the presence of more cattle than was initially agreed upon, and the inability of livestock owners to sustainably manage grazing camps. A committee member elaborated that:

> "*Cattle are not identifiable [by] branding or tagging, and are therefore perceived to be stolen. As a result, owners cannot be linked or identified through the cattle. This creates the precedent that the nature reserve is harbouring stolen livestock, to the detriment of its own image. Finally, this creates an environment for conflict between cattle owners*".

Above all, at the rate which natural resources are being depleted, it is anticipated that there will be no grazing in the near future.

Regarding prevalent indicators of overgrazing in the reserve, the management highlighted barren patches; increasing outcrop of alien plants; destruction of rehabilitated erosion gullies, hiking trails and related infrastructure on a daily basis by cattle; and erosion – which was indicated as a major consequence of overgrazing. Erosion is said to be caused by trampling of cattle along water seepage points, paths and trails, without sufficient rehabilitation practises by livestock owners and herdsmen.

The committee unanimously (100%) agreed that the matter of overgrazing has been brought to the attention of livestock owners. Moreover, various efforts were made from the municipal and individual level, with continual awareness and environmental education.

Table 4.5: CNR committee members' perceptions of environmental effects associated with livestock grazing at the CNR

Perception		%
	Difficult to manage the cattle number entering the reserve	33
	Cannot dictate to the cattle owners where to graze	33
	Failure to portion land	33
	Poor communication with cattle owners	33
	Rapid decrease of vegetation due to overgrazing	17
	Misuse of natural resources in the reserve by the wealthy	17
	No contribution of effort or resources by livestock owners towards rehabilitation or maintenance of infrastructure	17
	No funding or any material and labour resources provided by the municipality or government institution	17
	Farmers from other areas such as Fourlesburg drive their livestock to the reserve, depriving local community of the resources	17
	Trampling of paths, water seepage points and access routes	17
	Destruction of rehabilitated erosion gullies, hiking trails, and related infrastructure on a daily basis	17
	Cattle are not identifiable through branding or tagging, are therefore perceived to be stolen livestock	17
	Protocol is not upheld by livestock owners	17
	Rehabilitation costs and efforts are expensive and are depleting resources	17
	Allowing access for grazing creates a precedent for other forms of harvesting (sand stone, plant poaching) by herders, shepherds and other individuals	17
Overgrazing indicators prevalent	Soil erosion	100
	Increasing bare patches	50
	Mushrooming of alien plant species	33
	Cattle feed on shrubs	17
	Decrease in palatable grass	17
Matter reported	Yes	100
	Awareness and environmental education	17

4.6 Environmental effects associated with livestock grazing in the CNR

This section will present results of the environmental effects as indicated by the livestock owners and the management of the reserve, in terms of their observed environmental effects associated with livestock grazing at the reserve.

4.6.1 Livestock owners' perceptions of environmental effects associated with livestock grazing in the reserve

Results of the pastoralists' perception of environmental effects associated with livestock grazing at the CNR are as presented in Table 4.6.

Based on the results as presented in table 4.6, on average (43%), the participants in the survey own between 6 to 10 livestock each. According to the livestock owners' agreement, each farmer can only graze up to 10 cattle in the reserve. The aim of this agreement is to maintain the carrying capacity of the reserve, and sustain palatable vegetation.

Further results as presented in table 4.6 show that a majority of 71% of livestock owners indicated that the livestock roam by itself in the reserve. However, 29% of the respondents argued that herdsmen alternate in looking after the cattle, because of theft. The owners also indicated that they regularly check on the livestock health and security in the reserve.

Above all, the grazing strategy practised in the reserve is the seasonal rotation of livestock. This practise was indicated by 29% of the livestock owners. Concerns where however around the influence of seasonal changes. In that during dry periods, livestock has to be moved onto the next camp before the end of a 3 months' term.

The respondents of the survey also indicated that there is an alternative commonage besides the CNR.

Table 4.6: Environmental effects associated with livestock grazing in the CNR

Environmental activities		Response %
Number of livestock owned by farmers	Less than 5 (%)	29
	6-10 (%)	43
	10-15 (%)	29
Does livestock roam or there are herders	Roam (%)	71
	Herdsmen (%)	29
Grazing strategy practised	Weekly rotation (%)	14
	3 months rotation (%)	29
	6 months rotation (%)	14
	No strategy (%)	14
	I do not know (%)	14
	Other (specify) (%)	14
Alternative grazing land	Yes (%)	100

4.6.2 CNR committee members' perception on environmental effects associated with livestock grazing in the reserve

Results of the CNR committee members' perception of environmental effects associated with livestock grazing at the CNR are as presented in Table 4.7.

Based on the results as presented in table 4.7 below, on the question of the initially agreed upon number of livestock allowed to graze per farmer in the reserve, the committee pointed out that the original arrangement was that poverty stricken households that relied on cattle as their sole source of income would be granted permission to graze not more than 5 cattle per owner. In contrast, some committee members stated that currently, there is no agreement between the CVC, CNR and cattle owners.

Accordingly, there is no database of livestock that graze in the reserve. The details of the cattle were once collected from the owners, but the information was fabricated. The main issue is that the cattle is not branded, hence there is no legal compliance by owners with stocking rates regulations. The non-compliance is accelerated by the

fact that the reserve is not fenced, which allows for easy and unregulated access of cattle.

Current management strategies applied to the CNR are that livestock owners should submit an application/motivation to the management, asking for permission to graze an indicated number of cattle before the livestock can be admitted into the reserve. Additionally, attempts to arrange meetings with cattle owners and cattle owners' association have been approaches used by the management, on the issue of livestock in the reserve.

Table 4.7: Environmental effects associated with livestock grazing in the CNR

Environmental activities		Response %
Agreed number of livestock to graze	Not more than 5	50
	For destitute families only	33
	No agreement with livestock owners	17
Database of cattle	None	100
	No branding on cattle	33
	Virtually no legal compliance with stock laws	33
	Incorrect information given by the livestock owners	17
	Reserve not fenced, allows for easy access of livestock	17
Management strategies	Farmers should seek permission to graze from management	50
	Arrange meetings with cattle association, foster participation	33
	Consultations with herders and shepherds	17
	Candid approach of awareness and environmental education	17

4.7 Socio-economic conditions associated with livestock grazing at the CNR

This section will present results on the perception of the socio-economic conditions associated with livestock grazing as indicated by the livestock owners and the committee of the reserve.

4.7.1 Livestock owners' response on the socio-economic conditions associated with livestock

Results of the pastoralists' perception of the socio-economic conditions associated with livestock grazing at the CNR are as presented in Table 4.8.

It can be realized from table 4.8 below that, on average, the respondents in the survey have approximately 25 years of livestock farming experience. Moreover, all (100%) of the participants in the questionnaire indicated that they only farm cattle.

Two major reasons why livestock owners farm cattle are for commercial reasons. That is, to sell for profit and they use farming as their secondary source of income. For the 20% of livestock owners, farming cattle is for subsistence reasons. This includes providing milk for the family and slaughtering during family rituals. It is only 13% of the respondents who farm cattle as a result of inheritance.

Table 4.8: Socio-economic conditions of livestock owners associated with livestock grazing in the CNR

Socio-economic factors		Response %
Farming experience	Response 1	48 years
	Response 2	7 years
	Response 3	More than 50 years
	Response 4	22 years
	Response 5	10 years
	Response 6	More than 25 years
	Response 7	9 years
Livestock farmed	Cattle (%)	100
Reasons for keeping livestock	Commercial (%)	33
	Secondary source of income (%)	33
	Subsistence (%)	20
	Inheritance (%)	13

4.7.2 CNR committee members' perceptions of the socio-economic conditions associated with livestock grazing in the CNR

Results of the CNR committee members' perception of the socio-economic conditions associated with livestock grazing at the CNR are as presented in Table 4.9.

Based on the responses of the committee as indicated in table 4.9, the socio-economic status of the community in Kgubetswana is generally characterised by destitute families and high unemployment rate, where livestock farming is a great source of income. Other committee members do acknowledge that there is a variety

of economic ranking among the community, ranging from desperately poor to wealthy (such as policemen, counsellors, government officials) individuals.

Table 4.9: CNR committee members' perceptions of the socio-economic conditions associated with livestock grazing in the CNR

Socio-economic status of Kgubetswana		%
	Destitute community	50
	Cattle is the main source of income	33
	High unemployment rate	17
	Community depend on each other	17
	Some members are wealthy	17

4.8 Conclusion

There have been changes in vegetation cover in the Clarens nature reserve. Non-palatable grass has been increasing in cover since the 2004 until 2016, and currently occupies an approximated 52% of the nature reserve. On the contrary, palatable grass, water bodies and bare soil has been decreasing in cover from 2004 to 2016. Of the four classes of land cover types, non-palatable vegetation has experienced the most change compared to the other classifications. On the same note, vegetation greenness was higher in 2016, with an NDVI maximum value of 0.85.

Differences in perceptions on the state of overgrazing in the reserve exists between farmers and the management. For the community of Kgubetswana, livestock is farmed for subsistence purposes and it is a source of secondary income. Chapter 5 will then discuss the results, answer research questions, draw recommendations and provide a conclusion.

CHAPTER 5

DISCUSSION, RECOMMENDATIONS AND CONCLUSION

5.1 Introduction

This chapter provides an analysis of the main findings of the study, answers research questions, develop recommendations and open a new line of enquiry as far as assessing the effects of grazing in a nature reserve, and associated socio-economic livelihoods are concerned. The conclusion was drawn from the combination of the primary data with secondary information collected.

5.2 Research synthesis

The discussions that are to follow are drawn from the tables 5.1, 5.2 and 5.3. These deliberations addressed the objectives of the study. The assessment of vegetation cover and socio-economic conditions associated with grazing will be drawn from the literature review in chapter 2 and research findings in chapter 4.

Table 5.1: Objective 1 analysis

Objective 1	Literature Reviewed	Remote Sensing results
To identify vegetation cover associated with livestock grazing at the Clarens Nature reserve	• Preserves distribution and configuration of greenery. • Controls intrusion of weed and wild plants. • Removes old material, to stimulate regrowth • Decrease in cover and compactness on native grass • Unpalatable grass and bush encroachment overtakes grazing land	• Increase in unpalatable grass species • Decrease in palatable grass, water and bare soil. • Increase in greenness reflected

According to the literature reviewed as indicated in table 5.1, the advantages of monitored livestock grazing are that it maintains the structure and composition of vegetation (English Nature, 2015), it facilitates the intrusion of alien species and it

removes dead plant material to rejuvenate regrowth (Van Oudtshoorn, 2012). On the other hand, the disadvantages of excessive grazing concentrated on a specific area are, land degradation (Du Toit et al, 2011), soil erosion (Kgosikoma et al, 2013; Samuels, 2013) which results from a reduction in cover and compactness of indigenous vegetation, encroachment of unpalatable grass and bush species (Hall et al, 2005; Kgosikoma et al, 2013).

Alternatively, remote sensing results from the study (summarised in table 5.1) established an increase in unpalatable grass species (table 4.2), which was concentrated in areas where grazing and cattle numbers were dominant. The land cover percentage of unpalatable grass was at its highest in 2016, at 52% (4.4). This dominance was justified by the NDVI values, which recorded the highest vegetation reflectance of 0.85 in 2016 (figure 4.7). As a result, palatable vegetation, water bodies and bare soil were therefore colonized by unpalatable grass because their spatial cover indicated a significant decrease in 2016 compared to 2004 (table 4.2).

Table 5.2: Objective 2 analysis

Objective 2	Literature Reviewed	Livestock owners' perception	CNR management perception
To assess the community' perception of environmental effects associated with livestock grazing at the Clarens Nature reserve;	• Manure is a source of fertiliser • Trampling enables seedling and germination • Biological, physical and chemical degradation of soils • Sheet and rill erosion	• Decrease in vegetation cover • Soil erosion • Soil compaction • Habitat destruction • Control plant encroachment	• Soil erosion • Increasing bare land • Mounting of invasive plants • Livestock feed on shrubs • Decrease in palatable grass

Numerous studies on ecology and society, as well as nature conservation consistently assess the perceptions of pastoralist communities on the environmental effects of livestock grazing. From the literature reviewed (summed in table 5.2),

environmental benefits of livestock include the soil fertilizer they provide in the form of manure (Van Oudtshoorn, 2012), the trampling which weathers down the soil and allows for seedling (Du Toit *et al*, 2008). On the contrary, the detriments identified which were as a result of livestock were the biological, physical and chemical destruction of soil (DEA, 2007; Sprinkle and Bailey, 2004); sheet and rill erosion which results from exposure of top soil surface as a consequence of overgrazing (Van Oudtshoorn, 2012; Kgosikoma *et al*, 2013).

Similarly, the results obtained from the survey (summarised in table 5.2) indicate that soil erosion is a major environmental indicator of overgrazing in the reserve. Decrease in vegetation cover, increasing patches of bare soil and invasive alien plants, decrease in palatable vegetation cover and livestock resorting to graze shrubs (table 4.4 and table 4.5) are negative environmental effects of livestock grazing in the reserve. The only positive benefit of grazing indicated was grazing' ability to control the encroachment of wild plants and weed (table 4.4).

Table 5.3: Objective 3 analysis

Objective 3	Literature Reviewed	Livestock owners' responses	CNR management responses
To assess the socio-economic conditions associated with livestock grazing at the Clarens Nature reserve	• Secondary source of income • Recreational pleasure • Source of food • Ritual slaughter • Bridal payment • Economic status • Short term insurance, long term investment • Social power and status	• Sell for profit • Secondary source of income avenue • Subsistence • Slaughtering during family rituals	• Indigent community • Main source of survival • High unemployment rate • Social power

Livestock serves multiple roles in rural households' livelihood, thus, it cannot be denied that livestock forms an integral part of society. The literature therefore suggest

socio-economic conditions associated with livestock as being, a source of additional income avenue (Twine, 2013; Kgosikoma *et al*, 2013), recreational pleasure, subsistence farming, bridal payment (DEA, 2007), economic and social prestige (Anderson, 2012; Samuels, 2013; Lesoli, 2013) as well as an investment (Twine, 2013).

In the same token, the results from the survey indicate that livestock farming serves a purpose of providing secondary income for households (table 4.8 and table 4.9), source of food and is helpful in cutting costs during family rituals (table 4.8).

5.3 Discussion of results

5.3.1 Vegetation cover associated with livestock grazing at the Clarens nature reserve

It has been proven beyond reasonable doubt by remote sensing phenology that vegetation cover at the Clarens nature reserve has changed significantly over the past 12-year period. The composition and distribution of unpleasant grass has colonised the nature reserve. The encroaching of this unpalatable vegetation began steadily from 2004 to 2008. It was between the time period of 2008 and 2016 when the intrusion increased rapidly from 38.95% to 52.14% in spatial extent cover. This increase was further confirmed by the NDVI maximum value of 0.85 in 2016. The closer to +1, the higher the vegetation greenness reflected by the near infrared wave band and the denser the vegetation configuration.

During the subtle increasing period (2004 – 2008) of unpalatable grass, palatable vegetation experienced a moderate increase during the same period (2004-2008). However, water and bare soil cover classes were continuously decreasing over this 12-year period. These dynamics in land cover qualify the NDVI values for the years 2004 (0.38) and 2008 (0.41) which are moderate. Therefore, these two average vegetation indices could indicate either sparse vegetation cover, presence of water bodies or deteriorating grass species (Archers, 2014).

Contrary to unpalatable vegetation, the other three land cover types (i.e. palatable, water and bare soil) have been gradually decreasing for over a decade. This

decrease can be attributed to the overtake by unpleasant grass, overgrazing of palatable vegetation since livestock prefer and feed on pleasant grass before it graze on unpleasant grass as its last resort (Bezuidehout, 2015). The ecological footprint that has resulted from grazing is evident in the vegetation cover change of the nature reserve.

This state of non-equilibrium of vegetation cover poses a threat on the future existence of the reserve. A nature reserve that was once boasting with a variety of grass species is currently at risk of being overhauled by a rigorous grass type. Furthermore, the continued increase of unpalatable vegetation has the potential to alter the ecological functioning in the reserve. This mushrooming of unpalatable grass demonstrates that not all the land area available is meant to be exploited by agricultural and subsistence activities.

The visible damage of the vegetation cover as a result of trampling by livestock has resulted in the deterioration of the quality of soil. Grazing is also concentrated in few selected areas, because the topography of the nature reserve is comprised of steep valleys slopes and gullies, which makes most of the land surface inaccessible. As a result, the state of palatable vegetation cover becomes negligible in the eyes of an ordinary person. At a glance, the reserve is vegetated with shrubs and indigenous grass widely spreading across the land area. Outcrops of sedimentary bedrock can be observed on the high lying areas of the reserve.

The variety of land cover types that exists in the reserve, coupled by the grazing activity exacerbates an added pressure on palatable grass grow. Competition for space and water by alien species dominates the presence and occurrence of local grass. Therefore, Remote Sensing results correctly depicts the land cover and vegetation dynamics that are present in the reserve. An immediate intervention that can be introduced to maximise palatable vegetation is to restore the quality of the soil by resting the vegetation through rotational grazing technique. Unpalatable grass absorbs more water than indigenous plants, and since the former has drastically increased over the past 12 years, water courses are drying up because the rate of absorption by non-palatable grass species exceeds the rate of water recharge.

5.3.2 Perceptions of environmental effects associated with livestock grazing in the Clarens nature reserve

Environmental effects associated with livestock grazing can differ between areas. For pastoralists in Kgubetswana and the management of the CNR, soil erosion was the first common negative indicator observed in the nature reserve by the two sets of stakeholders. Soil erosion in the reserve is mostly evident in areas of exposed top soil. The absence of livestock access monitoring system and database of present stock in the reserve means continuously increasing pressure is concentrated onto the natural resources in the area, and this includes the land area. Continued trampling and excessive removal of vegetation wears down the soil until it loses the necessary nutrients which binds the soil.

Gentle terrain and water sources are important determinants of the grazing pattern and spread of grazers (Lesoli, 2013). In the nature reserve is a hydrological spring that is bordered with layers of bricks, which serve as a point of water source for cattle. Because of the increasing demand for water, the spring has since been physically degraded due to excessive trampling by livestock. Pastoralists were able to identify this negative impact of grazing in the reserve. The management asserts that the trampling not only destruct the spring, but extends further to hiking trails, water seepage points, access routes, rehabilitated erosion gullies and related infrastructure. Thus, trampling in the reserve confirms Lesoli' (2013) findings, in that it also occurred on flat slopes in the reserve, more especially at close range to the spring.

Decrease in vegetation cover is quite an obvious and probably the initial indicator of overgrazing of a rangeland. It is also the instigator of soil erosion, trampling, bare soil patches and habitat destruction. A difference in opinion about accelerated causes of decrease in vegetation exists between the participants of the study. The management of the nature reserve maintains that vegetation diminishes as a result of overgrazing by cattle. Whereas pastoralists argue that competition by alien grass species for land reduced the cover extent of vegetation. Monitored grazing can be facilitated through rotation and herding, these are crucial management strategies proposed by Kgosikoma *et al* (2013) to sustain healthy grazing lands. In the case of the reserve,

71% of the pastoralists indicated that livestock herding is not practised. And for the management this poses a problem because the cattle are not identifiable through branding or tagging.

Currently, grazing plots have been demarcated by a partitioning fence, and the practised grazing strategy reported by livestock owners is seasonal rotation. The management dispute the former, in that failure by pastoralists to portion the land has resulted in the mushrooming of alien plant species and grazing of shrubs by cattle. To some extent, the management cannot dictate to the cattle owners where to graze because of poor communication between the stakeholders and unfenced reserve, which enables easy access.

Lastly, alien plant encroachment control was identified as the only environmental benefit of grazing. Furthermore, livestock owners are of the opinion that there is no overgrazing in the reserve. Instead, meteorological abnormalities are said to be responsible for the changing grazing pattern and vegetation cover. They further reiterate that regrowth by vegetation as a result of increased rainfall, subsequently expands the carrying capacity of the rangeland in the reserve. Such differences in the perceptions of environmental degradation between the respondents was expected because according to Archer (2004), the term land degradation is subjected to the end user of the land. For farmers in Kgubetswana the priority is on the agricultural benefits for their cattle, while for the management of the nature reserve the main goal is to maintain the natural integrity of the area. However, regardless of the interest standing, overall, both parties listed more negative environmental effects resulting from grazing in the reserve, than benefits.

The development of a monitoring system such as database of livestock in the reserve should be standard procedure. The list will serve a purpose of regulating, monitoring and enabling effective planning in the reserve. As it stands now, the carrying capacity of the reserve is not known, as a result, the implications of continuously increasing stocking rates will not be fully understood. Furthermore, a mutual understanding of operations, expectations and duties should be communicated by both parties through effective policing. Because at present, there is no sense of accountability from the livestock owners towards the nature reserve.

In light of the recent changes in climate conditions, it is crucial to maintain the integrity of rangelands, particularly in a rural community where there is a great dependence on natural resources. Failure to assess and monitor the quality of a grazing land, while it is being exploited cannot eventually result into a sustainable resource. The influence of significant variables such as the size of stocking rates and carrying capacity remain unknown to the farmers and the management of the reserve, which negatively influences decision making processes of both parties. A sensitive protected area like the Clarens nature reserve, which allows for grazing should at least have a grazing model and policy in place.

For the realisation of the Protected Areas Act regulations, active participation by all stakeholders is important. The Environmental Acts can be customised into grazing policy models of the local area. The farming community should therefore view legislature as a means of ensuring enforcement and standard code of conduct for protected areas instead of punishment. A more active role should also be restored by the local municipality, as the bestowed custodian of local protected areas.

5.3.3 Socio-economic conditions associated with livestock grazing in the Clarens nature reserve

The demographic composition of pastoralists whose cattle graze in the nature reserve is comprised mostly of middle aged (40 – 49 years) males, with some background of formal education. The majority of the participants were skilled workers who were, during the conduction of the study, employed. The history of subsistence farming for the community of Kgubetswana stretches back to an averaged 25 years of livestock keeping. A figure that is unsurprising in the history of South Africa, because grazing is the largest land use activity in the country. The main motivation for keeping livestock is for commercial purposes.

The ability to sell for profit and earn secondary income stream through livestock is an advantage that is experienced and shared by pastoralists in the area. The management of the reserve described the socio-economic status of the community as constituting mostly indigent households, as a result of high unemployment rate in the region, and therefore mainly depend on cattle for their livelihood. This was

acknowledged by the livestock owners who indicated the maintenance function of providing milk and meat; and slaughtering during traditional rituals. Possibilities of land degradation will definitely threaten the living conditions of this rural community.

Literature revealed that rural households, uneducated, unemployed and disadvantaged individuals are commonly the ones who practise farming. Although to some extent this may be correct, this study discovered the opposite of this scenario. Employed and educated individuals are also farmers. These demographic results do not reveal a dire picture of the farming community of Kgubetswana township. Which then means that the socio-economic conditions are not the main factor in the misuse of the natural resources in the reserve. Instead, the main issue evident amongst the community is the conflicts in conservation. This can be explained by the negligence that has been endured by the reserve, the unsustainable grazing management techniques practised by the farmers and a lack of a good working relationships between the livestock owners and the management.

Farmers' priorities of increasing stock productivity and breeding healthy livestock seem to be the main concern to them. In the meantime, the needs of a crucial source of life for their cattle is secondary priority. There is free entry to the reserve, no visible boundaries are set between the community and the sanctuary, therefore the conservation of the reserve should not be smeared by the politics of conflicts in conservation. The preservation of the reserve is ultimately for the benefit of present and future generations.

The Clarens Nature Reserve is categorised under class five of the IUCN listing. This category allows for the integration of the reserve into the society. Therefore, human, social, cultural and economic benefits can only be realised when the reserve is protected and sustained. In essence, the needs of the community and the management should be compatible. This is most important for pastoralists, since cattle is their safety-net and investment. By promoting sustainable grazing, they will in a larger extent be protecting their assurance for a secured future. Simply because, the need for livestock farming by rural communities cannot be disputed.

Pastoralists should understand that they are stakeholders in the maintenance of the reserve and be proactive, instead of being by-standers in the management of the

reserve. As it stands now, the state of the reserve is deteriorating. The management should provide a platform for pastoralists to contribute to the rehabilitation of the reserve.

5.4 Conclusion

The Clarens nature reserve serves three important functions of, contributing to social and human development; tourism and education. Therefore, a disturbance by one will collapse the functioning system of the reserve. Thus, overgrazing in the Clarens nature reserve does not have to be detected at its detrimental stage. Through this research, early interventions can be introduced and implemented to maintain the integrity of this natural sanctuary, to accomplish sustainable consumption of natural resources, and for the overall benefit of the neighbouring community.

There is a great sense of dependency on livestock farming within the community of Kgubetswana, as it is the case in developing countries of Southern Africa. The long history of livestock keeping is realised in the average number of years' pastoralists in the study have indicated. The positive impact of livestock in restoring the dignity of households and providing a source of living for impoverished rural communities have continuously been emphasised by the literature and confirmed by the results of the study.

Conversely, a concern of an unsustainable manner in which grazing lands are being utilised by farming communities has been justified by the results of the study. Grazing lands are left overgrazed, with no rehabilitation efforts by farmers involved. This thus results in land degradation which further stimulates soil erosion, bush and unpalatable vegetation encroachment and plant community' misconfiguration. The nature reserve is neglected and misused by the community, which is exacerbated by the communication break-down between the community and the management of the reserve.

The South African legislature which advocates for the sustainable use of natural resources, the protection of natural resources and biodiversity lays the foundation of protected areas such as nature reserves. This study should therefore be viewed against the present socio-economic conditions that are prevailing in many small towns of the eastern Free State. The scarcity of job opportunities, and alternative of

livelihoods versus the conservation of the natural environment is of critical importance for the future of rural communities in South Africa.

The study was able to show that there are observed vegetation cover changes associated with livestock grazing at the Clarens Nature reserve, those changes where a major overtake by unpalatable grass species. For the community of Kgubetswana, the ability to own livestock for commercial purposes and maintain the livelihood of households are the two major socio-economic conditions associated with livestock keeping at the Clarens Nature reserve.

5.5 Recommendations

5.5.1 Short term recommendations:

These are grazing management strategies that can be developed and implemented over a short period of time, and they are:

i. Establish a formal structure between the livestock owners and the reserve management;
ii. Develop a database of livestock present in the reserve;
iii. Regular consultations and meetings by management with the livestock owners should be introduced;
iv. Enforce sustainable grazing management practises such as rotational grazing, herding, duration of grazing and number of cattle in a grazing camp and resting period;
v. Regular environmental awareness workshops should be provided for farming community; and
vi. Annual veld evaluation.

5.4.2 Long term recommendations:

These are the management strategies that can be planned for the future. They require more extensive planning in their implementation. They recommendations are:

i. Develop local grazing models and policies;

ii. Introduce payment of levies for the number of cattle owned by each pastoralist;

iii. Restore the natural infrastructure of the reserve, including fencing the reserve; and

iv. The adoption of a linear plant succession model and the balance-of-nature succession model.

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Appendix A

LIVESTOCK OWNERS' SURVEY QUESTIONNAIRE

ASSESSING ENVIRONMENTAL AND SOCIO-ECONOMIC EFFECTS OF LIVESTOCK GRAZING IN THE CLARENS NATURE RESERVE

Introduction

The purpose of this survey questionnaire is to assess environmental and socio-economic effects of livestock grazing in the Clarens Nature Reserve. The research study is for academic purposes. The findings from this survey will be documented and used as reference when analysing environmental and socio-economic effects of livestock grazing in the reserve. The information that will be obtained will be treated with absolute confidentiality.

Section A: Demographic information of the respondent (tick in the appropriate box)

1. Gender

Female	
Male	

2. Age

18 – 25	
26 – 33	
34 – 41	
42 – 49	
50 +	

3. Marital status

Single	
Married	
Divorced	

4. Level of education

No formal education	
Primary	
Secondary	
High school	
Tertiary	

5. Employment status

Unemployed	
Employed	

6. Occupation

Unemployed	
Pensioner	
Teacher, nurse, policeman, clerk, etc.	
CEO, director, manager	
Self-employed (barber, shopkeeper, taxi owner, entrepreneur, etc.)	
Other (specify)	

Section B: Community's perception of environmental effects associated with livestock grazing at the Clarens Nature Reserve

This sub-section is on a 5-point Likert scale: The respondent will have to indicate whether he/she **strongly agree (SA); agree (A); neutral (N); disagree (DA) or strongly disagree (SDA)** with the statements provided.

Negative effects of livestock grazing in the Clarens Nature Reserve are:

Indicators	SA	A	N	DA	SDA
7.1 Erosion					
7.2 Soil compaction					
7.3 Trampling					
7.4 Decrease in vegetation cover					
7.5 Habitat destruction					
7.6 Increase in unpalatable grass					

Positive effects of livestock grazing in the Clarens Nature Reserve are:

Indicators	SA	A	N	DA	SDA
7.7 Control plant encroachment					

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8. Have you noticed any change in the grazing pattern or vegetation cover of the reserve? Elaborate

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9. Do you believe there is overgrazing by livestock in the reserve?

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10. Which environmental indicators highlight overgrazing? Tick all applicable answers

Erosion	
Soil compaction	
Trampling	
Decrease in vegetation cover	
Habitat destruction	
Decrease in palatable grass	
I do not know	

Section C: Environmental effects associated with livestock grazing at the Clarens Nature Reserve

11.How many livestock do you own?

<5	
6 – 10	
10 – 15	
15 – 20	
>21	

12. Does livestock roam by itself in the reserve or are there herdsmen employed?

.....

13. What is the grazing strategy practiced?

Weekly rotation	
Monthly rotation	
3 months rotation	
6 months rotation	
Livestock roam freely	
There is no grazing strategy practiced	
I do not know	
Other (specify)	

14. Is there an alternative commonage besides the Clarens Nature reserve?

.....

Section D: Socio-economic conditions associated with livestock grazing at the Clarens Nature Reserve

15. When did you start farming livestock? .....

16. Which livestock do you farm? Tick all applicable answers

Cattle	
Sheep	
Goats	
Horse	
Other (specify)	

17. Why do you farm livestock? Tick all applicable answers

Subsistence farming	
Commercial farming (i.e. to sell)	
Only source of income	
Secondary source of income	
Inheritance	
Status purposes (i.e. to be respected in the community)	
Other (specify)	

Appendix B

CLARENS NATURE RESERVE COMMITTEE MEMBERS' SURVEY QUESTIONNAIRE

ASSESSING ENVIRONMENTAL AND SOCIO-ECONOMIC EFFECTS OF LIVESTOCK GRAZING IN THE CLARENS NATURE RESERVE

Introduction

The purpose of this survey questionnaire is to assess environmental and socio-economic effects of livestock grazing in the Clarens Nature Reserve. The research study is for academic purposes. The findings from this survey will be documented and used as reference when analysing environmental and socio-economic effects of livestock grazing in the reserve. The information that will be obtained will be treated with absolute confidentiality.

Section A: CNR committee members' perception of environmental effects associated with livestock grazing at the Clarens Nature Reserve

1. Are there challenges with the current stocking rate? Please elaborate

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   .....

   .....

   .....

2. Which indicators are prevalent in the reserve to show overgrazing?

   .....

   .....

   .....

   .....

3. Has the matter of overgrazing been brought to the attention of livestock owners?

   .....

Section B: Environmental effects associated with livestock grazing at the Clarens Nature Reserve

2. What was the initially agreed upon number of livestock grazing per farmer?

.....

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3. Is there a database of livestock that graze in the reserve? If yes, how often is it updated?

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4. What is the current management strategy (ies) applied at the CNR?

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Section C: Socio-economic conditions associated with livestock grazing at the Clarens Nature Reserve

5. What is the socio-economic status of the community in Kgubetswana?

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