Multi–criteria livestock assessment for sustainability of smallholder farms in Kwa-Zulu Natal

By

Busie Truetia Mahlobo

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Supervisor: Mrs. A. H. Molotsi

Co–supervisors: Prof. K. Dzama and Prof. T. Seifert

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Declaration

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Abstract

This study was conducted to evaluate the sustainability of smallholder livestock farmers in Kwa-Zulu Natal. The aims of the study was: (i) to evaluate social and economic sustainability, and (ii) to investigate production constraints experienced by smallholder farmers in Umvoti Municipality, KZN Province. A sample of 55 smallholder farmers were interviewed using structured questionnaires in their homestead. The survey was conducted in February and July (2015) for two weeks. Soil samples were collected on 17 farmers' field plot using an auger at a depth of 45 cm from the top soil. The study revealed that livestock was kept for cultural purposes (78%), income (73%) and ceremonies (51%). Only 5% of the respondents had tertiary education, 35% primary and 29% secondary. The lack of education limits the extent to which knowledge can be transferred from researchers to farmers. Livestock ownership was male dominated (53%) and there was an association between gender and ownership. Youth participation was lacking because most of the respondents were old people with mean age group of 57. Livestock were grazed on communal rangelands (94%) and continuous grazing was employed. No breeding plan was in place and 85% used a communal owned bull. About 78% of the respondents did not practice supplementary feeding. Respondents stated that water and feed availability, theft, diseases, and finance are major production constraints that negatively affect their performance. A net loss value of R14 418 per annum was obtained for all households owning livestock. Communal crop producers had a positive net value of R310 per year. Commercial crop farmers obtained a positive net value of R688 800 per year after all deductions. Fixed income (pensions, wages, grants, home industry and gifts) collectively had the highest relative contribution of 55% to household livelihoods. As a result, the alternative hypothesis was accepted at 5% level that farmers employ mixed livelihood strategies to minimise risks against income and food deficits. An asset value was assigned and calculated for 111 calves, 304 cows, 61 heifers, 58 bulls, 19 steers, 206 kids, 336 does, 92 bucks and 34 wethers. Interest was calculated per household and per livestock type. Cattle accumulated the highest asset value (R3 517 821) than goats (R711 131). Statistically the study showed no evidence against the null hypothesis that crop inputs have different effects on potassium (K), calcium (Ca) and manganese (Mg), ($p>0.05$). Cropping patterns showed to have different effects on soil carbon percentage ($p<0.05$) and the null hypothesis was rejected. The veld condition was medium degradation with a condition score of 40–60%. Soil samples were analysed for textual group, pH, exchangeable cation (Na, K, Ca, & Mg), C%, N%, and base saturation (Na%, K%, Ca%, Mg% and T–value cmol/kg). Effects of crop inputs (manure, fertilizer, mixed inputs and none (control) and cropping patterns (mixed, mono cropping, rotational and combination) on soil minerals were also evaluated. The negative net value obtained from livestock and low profit from cropping, suggest that farmers are getting income somewhere else to subsidise farming.

Keywords: Asset value, smallholder, livelihoods, cattle, crops, goats

Opsomming

Hierdie studie is uitgevoer om die volhoubaarheid van vee kleinboere in KwaZulu-Natal te evalueer. Die doelwitte van die studie was: (i) om sosiale en ekonomiese volhoubaarheid te evalueer, en (ii) om die produksie beperkinge wat ervaar word deur kleinboere in Umvoti Munisipaliteit, KZN provinsie te ondersoek. ‘n Groep van 55 kleinboere is ondervra deur gebruik te maak gestruktureerde vraelyste in hul tuiste. Die opname het plaasgevind in Februarie en Julie (2015) vir ‘n periode van twee weke onderskeidelik. Grondmonsters is ingesamel op die landbou grond van 17 boere deur gebruik te maak van 'n awegaar teen ‘n diepte van 45 cm op die bogrond. Die studie het getoon dat diere vir kulturele doeleindes (78%), inkomste (73%) en seremonies (51%) aangehou word. Slegs 5% van die respondente het tersiêre opleiding, 35% primêre en 29% sekondêre. Die gebrek aan opvoeding beperk die mate waarin kennis aan boere oorgedra kan word vanaf navorsers. Vee eienaarskap word deur mans oorheers (53%) en daar was 'n assosiasie tussen geslag en eienaarskap. Landbou deelname van die jeug ontbreek omdat die meeste van die respondente volwassenes was met gemiddelde ouderdomsgroep van 57 en meer. Vee was gewei op kommunale weiveld (94%) en voortdurende weiding was toegepas. Daar is geen teling plan in plek en 85% gebruik 'n kommunale bul vir teling. Ongeveer 78% van die respondente beoefen geen aanvullende voedingspraktyke vir hulle beeste nie. Produksie beperking behels, gebrek aan water en voer beskikbaarheid, diefstal, veesiektes, en finansies. ‘n Netto verlies waarde van R14 418 per jaar is behaal vir alle huishoudings wat vee besit. Opkomende gewas produsente het 'n positiewe netto waarde van R310 per jaar behaal. Kommersiële saaiboere het 'n positiewe netto waarde van R688 800 per jaar na alle aftrekkings. Vaste inkomste (pensioen, lone, toelaes, tuisnywerheid en gawes) het gesamentlik die hoogste relatiewe bydrae van 55% tot huishoudelike lewensbestaan. As gevolg hiervan, is die alternatiewe hipotese teen 5% vlak aanvaar dat boere ‘n gemengde lewensbestaan strategieë toepas om risiko's teen ‘n tekorte aan inkomste en kos te verminder. ‘n Batewaarde is opgedra en bereken vir 111 kalwers, 304 beeste, 61 verse, 58 bulle, 19 osse, 206 boklammers, 336 bokooie, 92 bokramme en 34 hamels. Rente is bereken per huishouding en per tipe vee. Beeste het die grootste bate waarde (R3 517 821) teenoor bokke (R711 131). Die studie het getoon dat daar geen bewyse teen die nulhipotese was dat gewasinsette verskillende effekte op kalium (K), kalsium (Ca) en mangaan (Mg) ($p > 0.05$) het. Gewas patrone toon verskillende effekte op grond koolstof persentasie ($p < 0.05$) en die nulhipotese was verwerp. Die veld kondisie het 'n kondisiepunt van 40-60% wat indikasie is van medium degradasie. Grondmonsters is ontleed vir tekstuele groep, pH, uitruilbare katioon (Na, K, Ca, & Mg), C%, N%) en basisversadiging (Na%, K%, Ca%, Mg% en T-waarde cmol / kg). Effekte van gewasinsette (mis, kunsmis, gemengde insette en kontrole (geen) en die grond minerale in gewas patrone (gemengde, mono teelt, rotasie en kombinasie) was ook geëvalueer. Die negatiewe netto waarde verkry uit vee en die lae wins vanuit gewase produksie, is ‘n indikasie dat boere inkomste vir lewensbestaan iewers anders as slegs vanuit boerdery subsidieer.

Sleutelwoorde: batewaarde, kleinboere, lewensbestaan, vee, bokke, gewasse

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List of abbreviations

3BL: Triple Bottom Line

°C: Degrees Celsius

3Ps: People, Profit and Planet

eNCA: eNews Channel Africa

FAO: Food and Agriculture Organization

GDP: Gross Domestic Product

Ha: Hectares

IDEA: Indicateurs de durabilité des exploitations agricoles or French farm sustainability indicator tool

IDP: Integrated Development Plan

IFAD: International Fund for Agricultural Development

ILRI: International Livestock Research Institute

ILRI: International Livestock Research Institute

Km: Kilometres

KZN: Kwa-Zulu Natal

LSU: Livestock unit

m: Meters

MESMIS: Framework for assessing natural resource management systems

MOTIFS: Monitoring Tool for Integrated Farm Sustainability

SD: Standard deviation

UNEP: United Nations Environment Programme

UNPD: United Nations Population Division

USDA: United States Department of Agriculture

USEPA: United States Environmental Protection Agency

WCED: World Commission on Environment and Development

WWF: World Wildlife Fund

Chapter 1
Introduction

1.1. Background to the research problem

Livestock production in South Africa plays a significant role in economic development and poverty alleviation (Meissner *et al*., 2013) which are primary goals of sustainable development (Schaller, 1993). The livestock industry also contributes a major share to agricultural market, livelihood and employment (Steinfeld *et al*., 2006). Livelihood refers to the means to which one live or make a living, i.e. income, assets and activities (International Federation of Red cross and Red Crescent Societies, 2016). There are approximately 13.9 million cattle, 24.2 million sheep and 6.1 million goats in South Africa (Department of Agriculture, Forestry and Fisheries (DAFF), 2013). This high stock density indicates its significance to society and suggests that it can be used as an instrument for supporting sustainable food production. Sustainable food production can be improved through sustainable rangeland management, biodiversity and wildlife conservation. Soil fertility and nutrient cycling can also be maintained using manure (Mearns, 2005).

Provincially, Kwa-Zulu Natal is the third largest livestock producer in South Africa and account nearly 20% of cattle, 3% sheep and 13% goats (DAFF, 2013). Livestock production in Kwa Zulu–Natal (KZN) province is more concentrated in the Midlands (Ngcobo & Dladla, 2002). Communal farmers of KZN carry 74% of goats, 19% of sheep and 50% cattle (Kwa-Zulu Natal Department of Agriculture & Rural Development, 2016).

Beside food production and economic development, the industry is subject to environmental and social concerns. These concerns involve overgrazing, pollution and erosion contributing to land degradation. Meat, eggs or milk production for example is a social issue because it involves animal welfare, food safety and health concerns (Webster, 2010). Livestock products are essential sources of proteins and amino acids and thus contribute to food security. Excessive consumption of livestock products (i.e. meat) results in health problems like obesity, heart disease, etc. (Rigby & Caceres, 2001; Horrigan *et al*., 2002). Such concerns have resulted in a call for change in consumption patterns (Brooks, 2010). Moreover, these concerns have resulted in a search for practical sound methods alternative to modern methods (Harwood, 1990; Pretty, 2002) to minimise human and environmental risks associated with livestock production.

The call for a change to sustainable farming is likely to affect the most vulnerable groups depending on livestock for livelihood. In South Africa for instance, a majority of people reside in rural areas where livestock is kept as a livelihood strategy (Schwalbach *et al*., 2001). The production systems of communal smallholder are regarded irrelevant especially with regards to formal agricultural output (Beyene *et al*., 2014). Insignificant contribution of communal smallholders is due to the fact that they contribute 5 to 10% of livestock sales compared to 25% from the commercial sector ((Nkhori, 2004; Musemwa *et al*., 2010). As a result, many farmers combine farming with various activities such as urban income transfers in the form of salaries to social grants and remittance (Statistics South Africa, 2012) to decrease vulnerability against unforeseen natural and anthropogenic events. For example, fires, droughts, disease outbreaks or storms can negatively impact on crop yield and animal performance, leaving farmers exposed to hunger and poverty if they have no financial reserves to live on. However, if a farmer employs mixed livelihood strategies, income situation is more resilient to hardships. Although livelihood is diversified, agriculture continues to play an important role to many people (Thamaga–Chitja & Morojele, 2014).

Furthermore, livestock owners in South Africa depend on natural veld to graze their animals under communal ownership. Within this system overgrazing and rainfall are major concern. The rainfall of South Africa is predicted to be more erratic and uneven together with a higher frequency of droughts which forces people to keep livestock as a mitigation strategy against crop failure (Musemwa *et al.*, 2008). For this reason, feed supplementation becomes important especially over the dry or winter period to improve animal performance. Access to land is also a big issue in South Africa, where people access the land only through consultations with a chief (Tribal Authority). Scholtz *et al*. (2013) states that the lack of property rights diminishes the financial value of common grazing because of unlimited stocking densities and lack of responsibility.

Waste management applies to all systems from household farm yard to large commercial production systems (Meissner *et al*., 2013). In extensive systems which, is the case of South African communal smallholder livestock farmers, manure seems not to be a problem. Manure is distributed across the veld thereby contributing to soil fertility (Steinfeld, Wassenaar & Jutzi, 2006). In cases where animal manure is transferred from common property to privately owned land, i.e. field crops, this should serve as a trade–off for environmental impact from livestock (Vetter, 2003; Meissner *et al*., 2013).

Uncertainty of agricultural returns is likely to undermine the farm performance and discourages individuals to sell their animals or to commercialize. Besides, not all individuals keep livestock for income. For that reason, evaluating the performance of smallholder livestock farmers economically is not sufficient, because livestock is multi-functional in that is used for more than one purpose. Thus, to use livestock as an instrument for supporting sustainable farming, it is important to identify the values and roles of livestock and their management. Then again, to meet food demand and contribute to economic growth both communal and commercial production systems need to be social, environmental and economic sustainable (Gwelo, 2012). Analysing smallholder agriculture in a systematic way seems to be a necessity to recognise its intrinsic value and factors affecting its productivity. These may help identify gaps in the current management practices that need improvement to eliminate production constraints, poverty and hunger. Doing so may help researchers to view livestock rearing beyond economic development and in comparing sustenance with commercialization.

With the intention to fit sustainability to South African smallholder farmers, the definition was modified as the ability of the farmer to accumulate profit with local or on–farm generated inputs, to produce enough to feed his/her family and sell surplus to neighbours at low environmental cost.

1.2. Problem statement

Production constraints such as seasonal fluctuation in feed quality and quantity is a common challenge affecting livestock performance. Off–farm income improves the sustainability of smallholder livestock farmers in some rural areas of Umvoti Municipality because it decreases the vulnerability of farmers against unforeseen natural or anthropogenic events. As a result, farmers who don't have off–farm income are exposed to hardships. Feed shortages drives farmers to leave their animals in the bush to scavenger for food partially or throughout the entire dry and/or winter period which contributes to rangeland degradation (Moyo *et al*., 2008). This feeding strategy of not kraaling livestock at night exposes the animals to theft, predation, and death from car accidents and diseases (Munyai, 2012). Poor supervision decreases recovery of infected animals, and results in poor animal performance and economic loss to the farmer and undermines the economic sustainability of the farmer. Moreover, unobserved animals may result to social conflict by grazing on protected land or break into someone's field crops. Theft on the other hand contributes to lack of trust between families and the community and weakens social sustainability of farming. All the above management practices decreases the overall farm performance, which could undermine the productivity of the farm.

1.3. Research question

To contribute to these open questions this study addressed the following:

I. Does off–farm income improve the economic sustainability of smallholder livestock farming in the rural communities of Umvoti Municipality, Kwa-Zulu Natal?
II. Do production constraints experienced by smallholder livestock farmers in Umvoti Municipality decrease overall farm performance, which could undermine farm productivity?
III. Does cropping patterns and fertility inputs have effects soil nutrients affecting soil health?

1.4. Aims and objectives

The study aims were:

i. To evaluate social and economic sustainability of smallholder farmers in Umvoti Municipality of Kwa-Zulu Natal (KZN) Province;
ii. To investigate production constraints experienced by smallholder farmers in Umvoti Municipality, KZN Province; and

In order to achieve the above aims, the following specific objectives have formed the basis of this study:

i. To determine the relative contribution of on–farm and off–farm activities to household livelihoods in Umvoti Municipality in KZN Province;
ii. To analyse the effects of agricultural inputs and cropping patterns on soil minerals in Umvoti;
iii. To assess the effects of rainfall on veld condition in Umvoti Municipality; and
iv. To investigate the management practices employed by smallholder livestock farmers in Umvoti Municipality.

1.5. Hypotheses

The study hypothesized that smallholder livestock production farmers in Umvoti Municipality are socially, economically and environmental sustainable. To validate this claim the following hypotheses were tested in different chapters in an attempt to address the research problem:

I. Null hypothesis$_1$ (Ho_1): (a) Gender is independent of livestock ownership (i.e. no association between gender and ownership). (b) Land degradation is caused by changes in rainfall. (c) Smallholder agricultural producers do not have any production constraints. A 95% confidence interval was used ($\alpha = 0.05$).

II. Null hypothesis$_2$ (Ho_2): (a) Smallholder farmers in Umvoti Municipality do not employ mixed livelihood strategies to minimize vulnerability against unforeseen natural or human–induced events. (b) Agricultural (crop and livestock) production do not make significant contribution to household livelihood of smallholder farmers at Umvoti municipality. (c) There is an association between social grants and livestock farming.

III. Null hypothesis (Ho_3): (a) There are no differences between treatments means or production inputs on soil minerals. (b) There were no changes in rainfall from the year 1997 to 2014.

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Chapter 2
Literature review

2.1. Introduction

Globally, livestock production is an economic enterprise (World Bank, 2005), where approximately 30% of the terrestrial land surface is used for livestock production (Steinfeld *et al*., 2006; Dijkstra *et al*., 2013: 10). Nearly 80% of the world's poor people live in communal areas, and about 680 million of them keep livestock (Steinfeld *et al*., 2006). Livestock production represents nearly 20% of the world population in the tropics (McDermott *et al*., 2010) and contributes to a value of at least US$1.4 trillion in global assets (Reid *et al*., 2008). Roughly 40% of agricultural gross domestic product (GDP) is derived from livestock farming (World Bank, 2009; Moyo &. Swanepoel, 2010). On a global scale, nearly 1.4 billion poor people live on below US$1.25 a day (International Fund for Agricultural Development (IFAD) & United Nations Environment Programme (UNEP), 2013). One billion of these poor people depend on agriculture as their main source of livelihood.

According to the World Wildlife Fund (WWF) (2010) and Meissner *et al*. (2013), nearly 70% of South Africa's land surface is identified to be suitable for grazing by livestock. Communal areas occupy around 17% of the total farming land–base with cattle, goats and sheep occupying approximately 52%, 72% and 17%, respectively (Palmer & Ainslie, 2006). South African communal farmers are the poorest, characterised by high unemployment rate and food insecurities (Livestock development strategy for South Africa, 2006; Info Resources Focus, 2007).

Livestock farming contributes significantly in food production, income, job creation, improvement of soil fertility, and in the maintenance of livelihoods and will be discussed further on Section 2.2. Apart from the significant role livestock plays in human welfare, it is open to public debate, because of the negative effects it has on human health (Thu, 2002; Horrigan *et al*., 2002) and the environment (Dijkstra *et al*., 2013). In South Africa, the sustainability of livestock based livelihood is also threatened by competition for water and land (Ndoro *et al*., 2014). Health concerns from livestock intakes and environmental debates are more prevalent in developed countries, where livestock systems are seen as wasteful, because of the large dependence on grain that would otherwise be fed directly to humans or traded with other countries (Pimentel, 1997). This criticisms are different from developing countries' livestock production systems.

In the developing countries, most of the people depend directly or indirectly on livestock as a major source of livelihood (Kunene & Fossey, 2006; Homewood, 2008; Moyo & Swanepoel, 2010). Within these countries, livestock contribute about 30% to the GDP (World Bank, 2009). In South Africa, about 2.2% of the gross domestic product (GDP) is derived from household or rural agriculture with an employment rate of 5.2% (Census, 2011). At provincial level, Kwa-Zulu Natal has the largest proportion of household agriculture (25%), and the lowest is Northern Cape (2%). Approximately 2.9 million households in South Africa practice some kind of agriculture (Statistics South Africa, 2011) which shows its importance and Section 2.2. focuses on livestock production.

2.2. Functions of livestock production national or international

2.2.1. Food and nutrition

Livestock provides nutrition through direct consumption of animal products i.e. meat or milk (Food and Agriculture Organization (FAO), 1999; Ndlovu, 2010) and contributes up to 30% of protein in human diet (Steinfield *et al*., 2006). On a global scale, livestock provides 17% kilocalories (Kcal) and 33% of consumed protein, but consumption rate differs from one country to another (Rosegrant *et al*., 2009). In order to strengthen the role of livestock, social values also need to be considered together with social acceptable management practices.

2.2.2. Social livestock functions

Social functions ranges from traditional attire (ritual slaughter, lobola or pride price etc.) to ceremonies and funerals (Trench *et al*., 2002; Bayer *et al*., 2003; Stroebel *et al*., 2010). In South Africa, for instance, ritual slaughter occurs if there is a wedding, funeral, or when welcoming a family member that was imprisoned. Traditional attire differs across cultures, i.e. Bayer *et al*. (2003) stated that in Kwa-Zulu Natal (Msinga area), married women by law are required to wear a leather skirt made from cattle hides, but recently this is replaced with goat skin probably because goats are affordable than cattle. The leather skirts are worn as a representation of a wedding ring (Bayer *et al*., 2003). The meat from slaughtered animals at any social events is shared among neighbours, relatives and anyone who attended the event. Meat cuts are consumed by different groups and are often gender limited, i.e. head is usually consumed by males. This occasions across different communities, unite individuals into one united group and enhance community coherence and trust (Hodgson, 2000). Some suggest that livestock contributes to gender balance, where children and women are given a chance to own livestock, especially small stock like goats, sheep and chickens (Waters–

Bayer & Letty, 2010). Andrew *et al*. (2003) and Moyo & Swanepoel (2010) reported that farmers keep livestock for income, job creation, meat or milk production, and ritual or funeral slaughter. Solomon *et al*. (2014) stated that goats are reared mainly for cultural functions, income, meat, and milk production for consumption.

Shackleton *et al*. (2005) found that 97.4% of goat meat is used for home consumption and 84.6% slaughtered during ceremonies (i.e. funeral, rituals) and 82.8% during celebrations (i.e. Christmas, Easter, New Year's Eve, weddings) and each function was rated independently. The authors also reported that nearly 66.7% of goats were traded for cash. Other studies reported goats are used for meat, income, hides and skin (Dovie *et al*., 2006; Katjiua & Ward, 2007). Kagira and Kanyari (2010), reported that farmers in Kenya keep livestock for income (97%), home consumption (59%) and for cultural purposes like funerals and dowry (29%) at Kisumu Municipality. Musemwa *et al*. (2010) indicated that farmers at Amatole (Eastern Cape) keep livestock for sales, ceremonies and milk; Chris Hani (Eastern Cape) for sales, draught power and milk; and Alfred Nzo (Eastern Cape) for sales, milk and wealth status and serve as risk reduction against food security.

2.2.3. Risk reduction

Beyond providing nutrition and enhancement of societal structure, livestock also helps marginal farmers to adapt to harsh environmental conditions and use livestock as an insurance in times of need and disaster (Freeman *et al*., 2008; Moyo &. Swanepoel, 2010). Asset investment assists farmers to cope with uncertainty and finance unforeseen expenditures. This includes sending a child to school or doctor, for buying other household needs and for supporting a family in case of death of a breadwinner (McDermott *et al*., 2010). Moreover, livestock can be used for consumption during drought periods thereby reducing risks associated with poor crop yield due to either climate events or resource scarcity (Freeman *et al*., 2007).

2.2.4. Banking /financing function

It is evident that communal farmers generate income through surplus sale of animals and animal products. They also use livestock as a “living bank” or investment allowing them to secure and accumulate assets (Ainslie, 2002). The function of livestock as an insurance and investment value is well documented in many parts of Africa by Pell *et al*. (2010). According to McDermott *et al*. (2010), livestock contributes to economic growth through fostering forward linkages (marketing and processing) and through backward linkage (increased inputs demands and livestock services). In South Africa, communal farmer use livestock to pay fines and trade for other things they do not own (Bayer *et al*., 2003).

2.2.5. Contribution to soil fertility

Livestock create nutrient cycling through the production of manure and urine as sources of organic fertilizer, and contribute to efficient and sustained resource use. According to Rota & Sperandini (2010), manure improves soil fertility through the supply of nutrients like potassium, phosphorus and nitrogen. Improved soil fertility increases soil structure stability and water absorption. Nearly two–thirds of crops utilized in the developing nations are produced where nutrients are limited and manure is the main fertilizer (Stroebel *et al*., 2010). However, over usage of manure can also result to eutrophication where excessive nutrients leach to underground water sources and negatively affect aquatic life (Horrigan *et al*., 2002). Therefore, it is important to monitor nitrogen content of the soil together with other nutrients needed to improve soil fertility by applying only what the plants and soil can absorb, with no excess (Goulding *et al*., 2008; Moss, 2008).

2.2.6. Other uses of livestock

Cattle, especial oxen and donkeys, are used for ploughing, weeding and as a transport for water and wood collection (Bayer *et al*., 2003). Hides and horns are sometimes used to symbolize the presence of a traditional healer in villages and spiritual aspirations as a way to connect with ancestors (Obi, 2011).

The above discussion emphasizes the importance of livestock in developing countries. Precautions are therefore required to ensure long term sustainable use of natural resources, especially with regard to veld condition, because it is the major source of readily available nutrition for the animals. The sustainability of livestock in developing countries is affected by the following: access to grazing lands (tragedy of the commons); dynamics in rangeland condition; access to market diseases; poor access to resources; poor institutional support and general management (Andrew *et al*., 2003; Gwelo, 2012; Munyai, 2012). Most of the land in rural areas is belongs to the tribal authority and is communally owned, with no regulations in place for controlling stock numbers and grazing by livestock. Communal farming is often viewed as a system that waste resources, destructive and economically inefficient when compared with commercial livestock productive system (Andrew *et al*., 2003). In Kwa-Zulu Natal, only 53% of the rural household have access to land for crop production and the average size was 2 hectares (ha) (Ngcobo & Dladla, 2002).

2.3. Livestock management practices

There are three recognized types of livestock management in South Africa, namely, commercial livestock farming, communal livestock farming and game farming (Smet & Ward, 2005). Commercial and game farming are mainly commercially oriented and privately owned, while communal farming is challenged by the complexity of rangeland resources management (Gwelo, 2012). Mapekula (2009), state that communal farming is characterized by multiple ownership keeping different livestock species on the same grazing land. Whereas the commercial livestock industry is well organised and market oriented (Munyai, 2012). Communal livestock on the other hand is regarded as being subsistence and economically unproductive based with low levels of productivity (Andrew *et al*., 2003). Table 2.1 gives an indication of management differences between livestock farming systems.

Table 2.1 Management differences, product production, species composition and grazing management (Smet & Ward, 2005)

Management system	Management structure	Animal diversity	Grazing management	Products
Communal livestock	Multiple owners	Mixed: several different species (small and large stock)	Continuous grazing, diverse vegetation	High quantity, quality compromised, diverse products, mostly for home consumption
Commercial livestock	Single manager	Mono species	Rotational grazing, diverse vegetation	High quality, single product for domestic and international market
Game	Single manager	Several different species	Continuous grazing, diverse vegetation	High variety, strong, healthy, large animals for trophies or eco–tourism

Management of natural resources (pasture, soil, water and vegetation) is important to ensure long term livestock productivity. However, productivity is not only limited to these factors. It is also determined by linkages between climatic events, plant–herbivore interactions and human management decisions (Vetter, 2009). Moreover, the health status and the genetic potential of the animal are the major factors controlling the prospect of improved productivity and production efficiency (Beede, 2013). All these factors, in fact, can have both positive and negative impacts on the sustainability of livestock farming, especially in this period when livestock systems are rapidly evolving. Reist *et al*. (2007), characterises livestock revolution as follows:

a) Rapidly increase in global livestock production and consumption.
b) Rapidly change in diet due to increase in urban middle class and income, e.g. China and India.
c) Development from multifunctional activity independent market to global integration.
d) Replacement of cereal products with meat products.
e) Livestock supplementary feed is mainly made from cereal grains.
f) Land claims are continually increasing and urban production is intensified.
g) Production and processing are subject to rapid change of technology. As a result, Herrero *et al.* (2009a), states that there is a need to revise livestock farming in order to select appropriate management methods with low environmental impact.

Commercial and game farming in South Africa is managed by people with either secondary or tertiary qualification (Smet & Ward 2005). Communal livestock is mainly managed by old people with low or secondary education and without any formal training in animal husbandry or veld management. Forbes and Trollope (1991), Salomon (2011), and Munyai (2012) found that communal land ownership contributes to veld degradation because of high stocking densities or failure to move animals to consecutive camps which could stimulate bush encroachment. Hoffman and Ashwell (2001), reported evidence of vegetation cover change from palatable to unpalatable plant species or bush encroachment and soil erosion in communal rangelands. Although land degradation in South Africa is recognised on both communal and commercial livestock systems (Lloyd *et al*., 2002), much concerns have been placed on land managed under common property (Palmer & Bennett, 2013). The only difference between these two systems is that commercial farmers may have extra cash to buy supplementary feed to maintain livestock production. However, in communal areas not all farmers can afford to buy extra fodder to compensate land degradation.

Roughly 90% of rangelands in developing countries are communally owned (Du Preez *et al*., 1993) and there is need to improve livestock grazing management practices currently employed. The failure to adjust the stocking rate, grazing management and other related factors will continue to exacerbate veld degradation to an irreversible state. Moreover, the ability of pastoralists to sustain their livelihood may be diminished.

2.4. The South African livestock smallholder farmers

The term “smallholder agriculture” has been described as families or households who practice labour intensive with low levels of external inputs or resource deprived. They also characterized by low income, output and technology, and only owning few hectares of land either for local or exclusive for home use (Statistic South Africa, 2012). Globally, smallholder farmers represent about 85% of all farms (Munyai, 2012), while in Africa, smallholder farmers account for over 80% of the economically active population (Africa Progress Report, 2014).

Nearly 22% of South African households practice agriculture (Statistics South Africa, 2014), where 43.4% of the households produce food and grain, while 30.1% are involved in fruit and vegetable production. Approximately 43.9% and 49.4% are involved with poultry and livestock, respectively. According to FAO (2012), South Africa produces only 85% of local meat and import the rest (15%) from Botswana, Swaziland, Australia, Namibia, New Zealand and Europe.

In South Africa, livestock farming is practiced in all provinces with high concentrations in summer rainfall areas (sour–veld) (Meissner *et al*., 2013). Density and species types are mainly determined by the vegetation and fodder availability. Most rural or communal livestock production systems dominate the following provinces: Limpopo, Kwa-Zulu Natal, Eastern Cape (FAO, 2006). Large commercial livestock systems are located mainly in the Eastern Cape, Northern Cape, and Western Cape (Meissner *et al*., 2013). A summary of livestock distribution across provinces was revised by Meissner *et al*. (2013), and is given in Table 2.2 below.

This livestock densities will help recognise potential target groups to contribute in future food demand and fight against poverty. Research is therefore needed to include livestock kept by communal or rural farmers. Management practices need to be reviewed in order to identify gaps that need improvement so that the communal livestock systems can continue to deliver the multi–functions in section 2.2.2. Communal livestock systems seems to be the largest farming enterprise, primarily farming with indigenous breeds which are known to adapt better to local environments (Scholtz, 1988) and are characterised by the following (Munyai, 2012):

a) They usually own less than 10 hectares (ha) of land.
b) Have limited access to resource inputs (agro–chemicals, knowledge and technology)

c) Most are uneducated with low levels of formal training and often keep their animals on municipal or communal land either because they are landless or forced to do so because of inequity of land tenure.

d) Family is their major source of labour and livestock provide one or more of the following: income, wealth accumulation or biological insurance, drought power (livestock are used to till the soil, especially in marginal areas where the use of tractors is nearly impossible or limited), social stability (lobola) and food security.

e) Management of the livestock is economically inefficient due to poor market access and the knowledge of the price. They commonly trade their produce in informal local markets, usually with neighbours within the community.

f) Their livestock are of poor quality and variable because of variable nutrition, poor supplementation and animals are sold at an old age (class: B and C), thus the age of the animal is a key feature for effective marketing and profit.

The importance of communal livestock systems is shown by the fact that 41% of beef, 12% of sheep, 67% of goats, 28% of pigs, 6% of broilers and 9% of layers are owned by these farmers (Meissner *et al.*, 2013). Apart from being the largest farming enterprise, communal farming has not been included as an economic enterprise because trading occur within informal markets where there are no records kept or captured.

Table 2.2 Projected livestock records in South Africa for 2010 measured in thousand

Provinces	Beef		Dairy	Sheep		Goats		Game
	Large scale	Communal & small scale	Dairy	Large scale	Communal & small scale	Large scale	Communal & small scale	
Western Cape	219	232	323	2 380	336	62	152	34
Northern Cape	603	208	13	5 361	758	144	355	671
Eastern Cape	1 531	1 272	348	6 410	906	643	1588	341
Kwa–Zulu Natal	1 409	1 116	268	676	95	227	561	117
Free Sate	1 232	911	198	4 271	604	67	165	158
Mpumalanga	868	603	60	1 534	217	25	61	273
Limpopo	650	433	12	226	31	349	861	1109
Gauteng	321	245	44	91	13	11	27	90
North West	1 035	713	102	612	86	202	498	198
Total	7 868	5733	1368	13820	3046	1730	4268	2991

Adopted from Meissner *et al.* (2013)

2.5. Production constraints experienced by smallholder livestock farmers

2.5.1. Availability of feed and tragedy of the commons

The rangelands of South Africa provide nutrition to both communal and commercial livestock systems (Gwelo, 2012). Quantity and quality of these rangelands varies between seasons (Ramirez *et al*., 2001). In winter animals perform poorly and lose body condition probably because of seasonal feed shortages and mineral deficiencies (Gizachew *et al*., 2002). In extreme cases (i.e. prolonged drought) animal death may arise if animals are not given supplementary feed. Starvation of animals is common phenomenon in arid and semi–arid areas which can decrease meat and milk yield and increases the animals' susceptibility to diseases (Munyai, 2012). To a large extent feed availability depend on climatic conditions like rainfall and veld type (sweet vs. sour veld) (Tainton, 1999) which need to be considered when drafting grazing plan.

In rural areas rangelands are communally owned and is radically open, and can be better explained as "tragedy of the commons". The term is defined as a problem that occurs when an individual tries to reap the greatest benefit of shared resources to the extent that demand is over the supply and deplete the resource partially or completely before other individuals can access it (Hardin, 1968). Common property is a challenge to many rural farmers of South Africa especially on decision making for sustainable use and management panning of the rangeland leading to violation of the ecological determined carrying capacity (Salomon, 2011). Tragedy of the commons has long existed in rural communities of South Africa which is projected to be the main contributor of overgrazing. Vink (1986), found land degradation to be associated with accessing land through the tribal leadership and power. This action allowed powerful groups to increase stocking density with no enforceable grazing or animal husbandry management measures.

The need to eliminate pollution applies to all systems (Meissner *et al*., 2013) and most food production systems have an environmental impact (Steinfeld *et al*., 2006). However, livestock production has been singled out as a major cause of climate degradation because of the large pollutants from manure and urine causing eutrophication and methane production. The contribution of livestock to global warming is also associated with damage of ecosystem and reduction of biodiversity (WWF, 2010). All the mentioned factors render livestock environmentally unsustainable.

The control of grazing lands and rights is not in the hands of livestock keepers, but in the custody of the chief or government (Reist *et al*., 2007). Due to the lack of land rights rural farmer graze their animals on roadsides, municipal land and distant rangelands where the animals are exposed to theft and death from either diseases or road accidents. Then again urbanization and expansion of agricultural land further decreases this used land and forces animals to intrude community property which may give rise to social conflicts from mixed emotions (Reist *et al*., 2007).

2.5.2. Grazing value

Grazing value is mainly determined by the sweetness of the pasture which determines the carrying capacity of the veld. If the grazing value of the veld is known, it makes it possible to classify the veld into camps (Munyai, 2012). Sweet–veld is defined as the veld that remains palatable and nutritious throughout its growing period and maturity (Tainton, 1999) and provides grazing for 9 to 11 months. Characterising the veld into sweet, mixed and sour, provides information on when should animals be given extra feed to maintain performance and body condition. Sweet–veld is limited to areas with winter rainfall. Sour–veld refers to a veld that is only palatable during the growing season, but becomes unpalatable during autumn and winter with a grazing length of 6 to 8 months. In general, sour–veld occurs in summer rainfall areas where growth is limited to spring and summer and rapidly decline during winter (Huston *et al.,* 1981). It seems that forage quality follows the growth patterns of the plants which only peaks during the growth season. Similarly, livestock performance is likely to follow the same pattern. For instance, livestock performance was found to follow seasonal forage quantity and quality in Ethiopia (Gizachew *et al.* 2002). Carrying capacity is described as the optimum land available to support livestock nutritional needs over a specified period and is expressed in hectares per animal unit (ha/AU).

2.5.3. Stock theft

Rural farmers do not have formal livestock registration or identification which is important for differentiating animals from one owner to another. Khoabane and Black (2009) reported that livestock theft is one of the factors contributing to poverty. Other actors contributing to stock theft are stock negligence, unmarked animals, poor record keeping, unemployment and hunger (Kwa-Zulu Natal Department of Community Safety and Liaison, 2008).

2.5.4. Water availability

Water scarcity is a major problem in Africa which can be linked with expanding agricultural irrigated lands, changes in rainfall and poor land use practices (Amede *et al*., 2009). Livestock and rural people walk several meters (m) to kilometres (Km) to access water and represent a challenge for crop production. According to Kwa-Zulu Natal informal settlements status (2013), only 65% of the rural community have access to pipe/tab water inside their household or on community stand at a distance less than 200 m from their residence. The report also indicated that only 8% have access to higher level of services while 27% have no access to water access at all. Then one can conclude that the 27% of households that do not have access to water, probably share water with livestock either directly from the river or borehole (Census, 2011). Climate change contribute to water scarcity through the increase of temperature and a decline in rainfall with high incidence of drought.

2.5.5. Veld fires and fire as a management tool

Fire has been used for various reasons including the removal of dry and dead plant materials; for initiating new lushes of grass; eradicating ticks; tsetse flies and other insects or pests harmful to livestock; and for harvesting forest honey (Mengistu, 2008). In South Africa, veld burning contributes to land degradation and destroys plant residues that can otherwise be grazed by livestock during winter (Nkomo & Sussi, 2009) and threatens the life of both humans and untargeted wild organisms. In 2014 at least six people, 700 sheep and cows were killed from veld fires and the estimated cost for livestock losses was approximately R3 million, KZN province (eNews Channel Africa (eNCA), 2014).

2.5.6. Animal diseases

Animal performance is decreasing continually because of diseases, poor management and decline in biomass quality and quantity (Devendra *et al*., 2000). Lack of finance and absence or unsuitability of animal health and production inputs exposes the animals of the poor to deadly diseases like foot and mouth disease (FMD), anthrax, black leg, contagious abortion and rabies (Bayer *et al*., 2003; Chawatama *et al*., 2005). Since infected animals cannot be traded this creates a marketing constraint and losses to the farmers. Although, farmers have access to veterinary service, medicines are often not adequately stored which leads to ineffective control. Failure to control diseases may also be linked with education, especially taking note of expiry date and dose quantity (Bayer *et al*., 2003). The movement of livestock and their products in communal areas is difficult to monitor, which presents another way of transferring diseases from one area to another (Musemwa *et al*., 2008). Therefore, it is important to develop community participatory groups, strategies, regulations and policies for controlling livestock movement in order to reduce disease distribution.

It has been said that rural farmers fail to control livestock diseases effectively because of poor knowledge of the disease, inappropriate use of the available control or that the control still needs to be developed and/ or is expensive (FAO, 2002).

2.5.7. Livestock breeds

There is nearly 3 500 livestock breeds from almost 40 types of animals and one third of the breeds are at risk of going extinct (Munyai, 2012). The Info Resources focus report stated that one livestock breed is lost almost every month and the extinction rate was estimated to be 16% for the last 100 years (Reist *et al*., 2007). Approximately 70% of the threatened livestock breeds are found in developing countries (Reist *et al*., 2007). These breeds are hardy and useful to poor farmers from an environmental perspective. However, the importance of indigenous breeds is underutilized and at risk of being lost. This may be because indigenous livestock have poor yield compared to exotic breeds. Farmers prefer indigenous breeds because they are well adapted to local conditions and are able to tolerate heat, drought, diseases, and feed scarcity (Reist *et al*., 2007). The breed type that is widely used by smallholder farmers of South Africa is the Nguni cattle (Musemwa *et al*., 2010) and Afrikander cattle because they adapt well to poor forage quality, hardy to tick–borne diseases and heat (Muchenje *et al*., 2009). Locally developed breeds such as Drakensberger and Bonsmara are also used, mainly by commercial farmers (Palmer & Ainslie, 2006). Farmers have however crossbred the Nguni with other breeds like the Brahman for multiple purposes (Scholtz, 2012).

2.6. Demand factors for livestock products

2.6.1. Changes in livestock production systems

Consumer preferences and lifestyle is one of the driving factors for livestock products (Thornton, 2010). According to Steinfield *et al*. (2006) and Moyo *et al.* (2007), changes in livestock systems are mainly driven by population growth and urbanisation, affluence and economic development, climate change, knowledge and technology.

2.6.2. Population growth and urbanisation

According to the United Nations Population Division (2010), the world population is expected to reach over 9 billion people by 2050 and this increase varies among countries. Tilman *et al*. (2002) reports that the greatest population increase and income will mostly occur in the developing countries (Africa, India and China). The rapid increase of human population will require more food and space.

The world population is expected to consume two–thirds more of animal origin products than the current consumption trends in 2050 (Dijkstra *et al*., 2013). Currently the health status of the world indicates that approximately 864 million people are undernourished (Reist *et al*., 2007). Total meat and milk consumption is expected to increase by 73% and 58%, respectively by 2050 (FAO, 2011). Thus, overall agricultural output is expected to increase by almost 60% (Alexandratos & Bruinsma, 2012). The prospects of increasing animal production suggest increasing pastoral land and intensifying production to ensure abundant protein and other food supply (Dijkstra *et al*., 2013). Meeting this demand will force people to move into areas where agriculture creates erosion and desertification (Sachs, 2008). On the other hand, developments for better living standards will also place enormous pressure on the environment and natural resources like water, minerals and land (FAO, 2011). These activities will also occur at the expense of other land–uses (INEGI, 2007). Urbanization is linked with wealth accumulation and changing in food preferences, with increased consumption of take–away or Kentucky (Delgado *et al.*, 1999) leading to explosive demands of livestock products.

2.6.3. Environment and climate change

Livestock systems occupy the largest land surface on earth, with the pastoral systems occupying 45% of global terrestrial surface (Reid *et al.*, 2008). Both positive and negative impacts of livestock, mainly intensive systems are well–known (Horrigan *et al*., 2002). Most resource–poor farmers are threatened by change in rainfall patterns and erratic weather conditions (Meissner *et al*., 2013). Rural farmers use livestock use livestock as a mitigation strategy against crop failure and for ploughing marginal lands where the use of tractor is impossible especially in mountains and fragmented areas. Livestock also have a potential to be used as an insurance allowing rural farmers to escape bank charges.

2.6.4. Policies and Institutions

As the livestock systems evolve, policies and private sectors and non–governmental organisations (NGO's) emerge, with some supporting while other opposing drivers for change (Moyo &. Swanepoel, 2010). According to Moyo and Swanepoel (2010), private companies in Kenya and India play an important role in the milk supply chain with new marketing strategies. The involvement of public and private sectors, need to pay more attention on how to benefit the poor from the emerging opportunities within the sustainable farming framework. For example, smallholder producers in India have proven that it is possible to be small and produce efficiently, by being the largest milk producer in the world (Cunningham, 2009). The same can be expected in South African communal or rural farmers if they can be supported with technology and knowledge for sustainable farming.

2.7. Agricultural sustainability contexts

2.7.1. Definition of sustainable livestock farming

The term sustainable agriculture emerged 35 years ago describing holistic farming approaches (Bidwell, 1986; Hauptli *et al*., 1990: 143). According to Olesen *et al*. (2000), nearly 800 definitions of sustainable agriculture have been published. None of the given definitions are satisfactory, because of the multiple ways in which it has been defined depending on the perspectives of the analysts, scale and context considered (Webster, 1999; Olesen *et al*., 2000; Pretty *et al.,* 2011). But in literature there seem to be unified themes around what sustainable agriculture should encompass. These themes are as follows: people (social goals), profit (economic goals) and planet (ecological goals) – sometimes called the triple bottom line (3BL) or 3 Ps (Pope *et al*., 2004 & Peterson, 2011).

The World Commission on Environment and Development (WCED) (1987), and Francis and Youngberg (1990), described sustainable agriculture as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" and is among the widely accepted definitions today. To describe sustainable animal agriculture, the study used concepts of USDA (1990) which is based on plant and animal integrated systems that are site–specific and over long term are expected to deliver the following functions:

a) Meet human demands for food, fibre and shelter (Smit & Smithers, 1993) and also be socially, economically and environmental friendly (Crosson, 1992).
b) Reduce harmful emissions to the environment, while improving the natural resource base upon which the agricultural system depends.
c) Make the most efficient use of non–renewable and on–farm generated assets and integrate where appropriate, while promoting natural biological cycles and controls.
d) Improves the economic status of the farm for maintenance requirements.
e) Reduce farmer's risks associated with farming and improve quality of society as a whole (Agronomy News, 1989).

2.7.2. Interpretations of sustainable livestock farming

Similar to the definition, many interpretations have emerged. Most given interpretations are uncertain in that they are not able to exist and perform in harmonious or agreeable combinations of sustainability themes or aspects. Concepts of sustainable agriculture are considered impractical and non–operational because of the many frameworks underlying its concept (Muller, 1998). Efforts of trying to interpret sustainability concepts have resulted in a narrow framework that only captures a snap shot of the whole system. It is so primarily to suite individual objectives. If not too narrow, the interpretation is too broad to grasp its usefulness for practical implementation purposes. In trying to win the debate, concepts of sustainable development have shifted from logical coherence and linguistic to that of holistic and practically sound methods alternative to modern methods (Pretty, 2002; Barker, 2007; Greenpeace International, 2008). In turn this has led to fundamental conceptual errors (Mebratu, 1998). Below we review the multiple ways in which sustainable agriculture has been interpreted.

2.7.2.1. Agriculturist interpretation of livestock sustainability

Sustainable animal agriculture can be regarded as a farming system that seeks to consolidate and build upon the achievements of the green revolution. Food security and animal welfare seem to be the direction towards sustainable farming. Animal welfare is concerned with the animal health, provision of food, water, shelter, freeing animals from pain, minimise illness and injury of animals, and ensuring that that sick animals receive timely and effective care (Tucker *et al*., 2013). Food security is defined as access to abundant food to live a healthy and productive life by all people (Andersen, 2009). Beede (2013: 285) "describe sustainability based on food security that continuously improves agricultural productivity and efficiency to meet the ever–increasing demands for food for a growing population".

2.7.2.2. Environmental interpretation of livestock sustainability

According to the United States Environmental Protection Agency (USEPA) (2010) environmental sustainability means to produce adequately, using few resources. In order for animals to be part of sustainable animal agriculture it must enhance the physical environment (land, water and air) and natural resource base (planet). However, problems inherent in agriculture are more acute when the output is meat because livestock produces large volumes of manure that cannot be absorbed by local croplands. Other concerns are that livestock feed on grain and less on grass (Pimentel, 1997) which increases deforestation rate. Most of the grain is grown intensively under monoculture and erodes the biodiversity of both plants and animals. These production systems exacerbate certain encountered problems by contaminating food products from the use of pesticides and fertilizers which threatens human health (Horrigan *et al*., 2002). Moreover, the use of agro–chemicals also pollutes the soil, water, and air and is unpleasant to both humans and natural ecosystem (Horrigan *et al*., 2002). For example, poor manure storage is suspected to cause *Pfiesteria piscicida* outbreaks and fish death in North Carolina (Silbergeld *et al*., 2000; Horrigan *et al*., 2002).

2.7.2.3. Economic interpretation of livestock sustainability

Economic viability suggests that economists need to identify efficient use of natural resources. The role of economists is therefore to evaluate the profitability of agricultural operations not only in monetary terms, but at all levels of production to the end user (consumer). More importantly, production systems should also be evaluated in terms of output returns so as to facilitate comparisons between alternative systems that are thought to be sustainable or opted for by natural scientists (Blank, 2013: 173). Economic sustainability is also determined by the market structure and product demand which also need to be considered. This view holds on ecological friendly methods notable resource use and yield.

2.7.2.4. Social interpretation of livestock sustainability

This section is concerned with public behaviour and attitude towards certain agricultural practices and products. Behaviour and attitude may be linked with culture, religion, values and other collective forms of social structures that directly or indirectly influence agriculture. These collective forms can be identified by individuals, members of a community or family or as a group at regional or global level. Increasing population together with better living standard continues to place unsustainable pressure on the environment (Horrigan *et al*., 2002). Yet, the quantity and diversity of agricultural products must be met. In meeting these demands, attitudes, motives, beliefs, traditions, new technology, customs (Yunlong & Smit, 1994) and laws will continually constrain the productivity of the industry. Thus, for the livestock industry to be sustainable it needs to adopt one of the following tactics discussed below.

2.8. Tactics of sustainable livestock farming

Since sustainable agriculture is based on a set of strategies it is clear that no single method can solve all agricultural production problems. Below are some of the methods that are used to direct agriculture towards the goal (s) of sustainable farming.

2.8.1. Feed management as a sustainability tool

Feed management is a key element of livestock production, which involves the following: supplementary feeding, grazing plan, storage and nutrient concentration or availability. Different groups of animals have different nutritional requirements and to a large extent are determined by the age and production status of the animal (Moraes & Fadel, 2013). Precise diet is important to better understand the feed nutrient density and the requirements of the animal which can help farmers reduce dietary costs and excessive wastes through manure and urine (Moraes & Fadel, 2013). Giving animals exactly what they need seems to be economically and practically feasible.

2.8.2. Production efficiency as a sustainability tool

Demand for animal food products has the potential to further degrade the environment unless steps are taken to ensure that the natural resource base (land, vegetation, water, air and biodiversity) can be sustained while increasing food production (Dijkstra *et al*., 2013). Godfray *et al*., (2010), argues that the major challenge of livestock production systems is not merely to maintain productivity, but to achieve productivity without damaging the ecosystem. The author further states that advancement in livestock will have to come from the ability of animals to convert natural resources into human–edible food. It has been stated that livestock performance can be improved through increasing feed digestibility and better post–absorptive equivalent of absorbed nutrients which largely depends on the breed type (Dijkstra *et al*., 2013). Therefore, choice of breed is important to ensure efficient and long term animal performance.

2.8.3. Breeding and genetics as a sustainability tool

Animal breeding involves selecting animals carrying a desired trait of interest to become the parents of the next generation (Van Eenennaam, 2013). It is the procedure that human developed to manipulate natural selection. These procedures involved pedigree selection, interspecific hybridization and cross–breeding to domesticate animals that can serve human purposes (Frankenkrug *et al*., 2010). The history of animal breeding reveals that breeding objectives were not necessarily sustainable, because they were mainly based on maximizing productivity and profit. Sustainable animal breeding aims to increase resource use and maintain yield whilst improving animal welfare, environment, and social structures (Olesen 2000). This requires a balance between competing goals as there are often important trade–offs. In the past breeding focused on maximising productivity and profit. These two objectives are not sustainable. For breeders to be sustainable need to incorporate all three aspects of sustainability, namely the people (social goals), profit (economic goals) and planet (environmental goals). This involves: increase resource use efficiency, maintain productivity and returns whilst reducing negative impacts on the environment and animal welfare because consumers are also concerned with the conditions to which animals are grown (Olesen, 2000).

2.8.4. Soil management as a sustainability tool

Soil management involves the preparation of the soil for planting or converting forest to grazing systems. South African soils have been found to susceptible to degradation with limited recovery potential (World Wide Fund (WWF), 2010). Minor errors in soil management can be critical with limited restoration success. Nearly 25% of South African soils are prone to water and wind erosion. Areas with sandy soils like the North West, Free State and maize producing areas in South Africa are likely to experience soil and water erosion (WWF, 2010). According to Horrigan *et al*. (2002), good stewardship must take into account chemical, biological, and physical properties of the soil. A unit area (1 gram) of healthy soil is predicted to contain 4 tons of micro–organisms and is important for ecosystem functioning (Brunetti, 1999). Organic matter and compost are said to be a food source for beneficial bacteria, fungi, nematodes, and protozoa and can only occur on properly managed soils to support plant growth (Intergovernmental Panel on Climate Change, 2001). Therefore, soils need to be properly managed in order to produce healthy plants and pastures that are less prone to pests.

2.8.5. Biodiversity as a sustainability tool

Biodiversity play a vital role in both plants and animal breeding as it facilitates breeding aspects, but is also threatened by genetic erosion (Food and Agriculture Organization (FAO), 2007). If genetic diversity did not exist it would be unnecessary to select and breed animals with specific traits, simply because all animals and plants would be phenotypic and genotypic identical. Biodiversity has been always dynamic as new breeds and crops emerge and others disappear due to change in climate and public interests. According to Convention on Biological Diversity (CBD) (2010) high specialization in livestock and plant breeding contributes to genetic erosion because breeders want to have a controlling power in conserving specific genes. For example, the poultry industry controls and market over 90% of poultry breeding stock globally, is managed only by three companies (Flint & Woolliams, 2008). Biodiversity conservation is also a trade–off that exists between genetic management at farm level for future investment. It also provides buffer zones against economic and environmental challenges.

2.8.6. Nutrient management as a sustainability tool

It is important to monitor nitrogen content of the soil together with other nutrients needed to improve soil health. Farmers can therefore prevent run–off of excessive nutrients into adjacent waters, thereby minimizing aquatic life risks. These practice can save farmers money from buying synthetic fertilizers by providing nutrients needed by the plants and what the soil can absorb, with no surplus (Horrigan *et al*., 2002; Goulding *et al*., 2008; Moss, 2008). Soil tests need to be conducted almost every year in order to avoid over fertilization or use of biological chemicals because they also have some detrimental effects if over dosed. Legumes are important for fixing nitrogen in the soil from the atmosphere.

2.8.7. Rotational grazing as a sustainability tool

Rotational grazing has been defined as a veld management tool where grazing land is separated into camps and one camp is allocated to a group or groups of animals for a period of time (Tainton, 1999). The grazing tool take some form of sequential grazing in rotation so that not all camps are grazed simultaneously and aims to preserve plant biomass to graze during critical times. Rotational grazing accommodate more animals in a given unit area for a given period of time than continuous grazing.

The primary objectives of such rotations are to:

a) Control the frequency at which the plants are grazed at each camp;
b) Control the intensity at which the sward is removed by controlling the number of animals allocated to the camp and the period of accumulation;
c) To reduce the extent to which the veld is selectively grazed by increasing the stocking density in a relative small camp to minimize selective grazing. This grazing approach also tries to eliminate growth rate competition between palatable and invasive (unpalatable) plant species and improves the condition of the veld.

Rotational grazing is therefore characterized by continually moving animals to different grazing camps and prevents soil erosion by maintaining acceptable vegetation cover. Rested camps could be used for winter feeding which can save costs for buying extra feed. However, rotational grazing also have the following disadvantages: it is associated with high fencing cost as more camps are required; is labour intensive; animals are disturbed frequently which might affect the animal's physiological function; and performance may be compromised as animals are not given a chance to select nutritious and palatable plant or grass species (Tainton, 1999).

All the above discussed sustainability strategies are expected to perform the following goals to qualify to be sustainable (US Congress, 1990):

a) Produces high and efficient food and fibre over generations
b) Uses low amounts of inexpensive scarce resources (non–renewable resources), by using organic farming techniques, traditional or indigenous knowledge
c) Food security and self–sufficiency are its priorities
d) It must conserve wildlife and biological diversity
e) Preserves traditional values and support small and family farms
f) Benefit the poorer and disadvantaged farmers
g) High level of participation in the development of decisions by farmers themselves

2.9. Sustainability assessment tools

2.9.1. Empirical evaluation of agricultural sustainability using composite indicators

Gomez–Limon and Sanchez–Fernandez (2010), used composite indicators to develop a practical methodology for evaluating the sustainability of farms. The method is based on 16 indicators covering all three themes of sustainability, namely: social, environment and economic sustainability. This method is more useful for public decision–makers who are tasked with designing and implementing agricultural policies, but not useful for evaluating sustainability at farm level.

2.9.2. Farm Sustainability Assessment using the IDEA Method

IDEA ("Indicateurs de durabilité des exploitations agricoles") is a French farm sustainability indicator tool. The method contains a total of 10 components grouped according to the three themes of sustainability and 41 composite indicators and 16 objectives (Vilain *et al.*, 2008; Zahm *et al.*, 2008). The objectives are as follows: management of non–renewable resources, coherence, biodiversity, animal well–being, food quality, soil conservation, water preservation, atmosphere preservation, ethics, local development, landscape preservation, citizenship, human development, quality of life, employment, and adaptability. Agro–ecological components are: diversity, organisation of space, farming practices. Socio–territorial components ranges from quality of the products and land, employment and services to ethics and human development. The economic aspect of sustainability components are: economic viability, independence, transferability and efficiency. Different indicators represent a specific objective in a matrix form. This method was designed in the context of French or European conditions and references as a self–assessment tool for farmers and policy makers to support sustainable agriculture. The method can also be used for observing sustainability differences between and within production systems of both plants and animals.

Although the IDEA method has shown to be useful in many countries and on evaluating different farming systems, the issue of adaptation still remains. The fact that indicators are not specific to one production system, its use can be largely criticized among users (Parent *et al*., 2010). Nonetheless, the method does not claim to be final as a model of sustainability that must never be changed. In South Africa, sustainability is still a new concept as not many farmers are mindful about it. The calculation of scores requires a lot of data which automatically limit its practical application because not all farmers keep records.

2.9.3. Life–cycle assessment (LCA)

Life–cycle assessment is method that is used to evaluate environmental impacts of a product from production to the consumer (Marie, 2011). The method has shown to be useful on livestock farming systems as it has been applied in several regions. For example, LCA has been applied in Germany (Haas *et al*., 2001), Netherlands (Thomassen *et al*., 2008) and France (van der Werf *et al*., 2009) to evaluate livestock environmental impact.

LCA uses indicators that are related to the environment such as energy use, land use, eutrophication, greenhouse gas emissions and acidification potentials (Marie, 2011). These indicators are used to quantify the product expressed either in millimetres (ml), kilogram (kg) or size (ha). The method does not draw a global image of the system in all its dimensions, although some studies have tried to include supplementary indicators like biodiversity, landscape or animal husbandry (Haas *et al*., 2001). Farmers with no record data i.e. communal systems, cannot be evaluated using life–cycle assessment, simply because they sell or trade their products on informal markets where no data or record is captured.

2.9.4. Sustainability farm tree

Sustainability farm tree was developed by Pervanchon (2006), as a way to help and encourage farmers build a business project towards sustainable development. The method contains 60 questions and four themes or dimensions of sustainable development.

Dimensions are represented as tree branches namely: (i) viability branch (economical aspects) which is further divided into sub–branches (subsidies, dependency and income); (ii) transmissibility branch includes capital transfer from one generation to the next and knowledge; (iii) liveability branch (social aspects) involves time for holidays, presence of neighbourhood, and commitment in associations; and (iv) reproducibility branch is an environmental aspects and is concerned with elimination of air, and water pollution, maintenance of landscape and old buildings) (Pervanchon, 2006).

On answering the questions, each farmer answers each question in their point of view to members of a group. Answers are in the form of yes or no, if a no answer is given, the question is given to peers, if peers fail to advise, indicators are therefore proposed to help farmers find solutions on the question. Each question corresponds to at least one uncoloured leaf of the tree, and leaves are coloured according to the answers provided by the farmers. If the farmer is not satisfied, then the leaf is coloured black.

The farm overall sustainability is therefore obtained through the colour of the tree, which provides information on the contribution of the farmer to sustainable development. The results are divided into three extreme cases:

i. Weak level of sustainability is obtained when most leaves are black;
ii. Medium level of sustainability have many black leaves on every branch and;
iii. High level of sustainability is obtained when the tree is homogeneously coloured with few black leaves.

Rural communities of South Africa are mainly poor living in marginal areas with poor infrastructure and far from urban centres (Jacobs, 2008). This makes it difficult to conduct a participatory study that can be close to their residences. In trying to accommodate everyone, this creates extra expenses on the project with no assurance on the usefulness of the results to the society. Other challenges is that most of South African communal farmers are less educated and some are unable to read and write and some relevant information can be missed from farmers lacking education and some might be discourage to participate actively in a group.

2.9.5. Monitoring Tool for Integrated Farm Sustainability (MOTIFS)

The method was developed by Meul *et al*. (2008, 2009) and is based on 47 weighted indicators with scores that range from 0 to 100. The method contains 10 major principles for sustainable agricultural production. Ecological sustainability is divided into the use of inputs, quality of natural resources, and biodiversity. Productivity and efficiency, profitability, and risks represent the economic aspect. Whereas social aspect is divided into internal social and external social sustainability and further divided to disposable income and entrepreneurship. The method has been applied on 20 Flemish dairy farms. The advantage of using this method is that validation of ecological indicators has been also implemented. MOTIFS requires a lot of information, 47 indicators, which might not be immediately be available especially for poor smallholder farmers. As a result, its use is discouraged by the fact that records and other data might not be available.

2.9.6. Framework for assessing natural resource management systems (MESMIS)

MESMIS is an operative structure of six step cycle. Step (i) is the characterisation of the systems, (ii) identification of critical points and the selection of specific indicators for the environmental, (iii) social and economic dimensions of sustainability. In the last three steps, indicators are used to gather information with integrated mixed (quantitative and qualitative) techniques, and multi–criteria analysis (Lopez–Ridaura *et al.*, 2002). The method originated from Mexico and has been tested in different Latin America countries and is based on five general attributes associated to sustainability: (i) productivity (capability of the system to provide sufficient goods), (ii) stability (reaching and keeping a stable and dynamic balance), (iii) adaptability (finding new balance in changing environmental conditions), (iv) equity (fair intra– and inter–generational distribution of costs and benefits), and (v) autonomy (or self–management). The Framework for assessing natural resource is flexible because it is contextualized and uses indicators relevant to the situation under investigation.

2.10. Summary

To conclude, livestock farming is seen as a potential agricultural enterprise that is more likely to continue improving household food security, alleviating poverty and buffer risks against harsh environmental conditions (Coetzee *et al*., 2004). The livestock sector also plays a significant role in the economy of South Africa. In the communal sector, livestock production is often done under extensive grazing systems where animals rely mainly on natural communally managed rangelands for nutrition. Farmers must be aware of the condition of the rangeland in order to plan feeding strategies to sustain satisfactory growth and reproduction of their animals. Although livestock thrive well in harsh weather conditions, the productivity of smallholder farmers is generally relatively low (Spio, 1997). In South Africa, the overall contribution of smallholder livestock producers is 25% beef and 30% of total agricultural output per year (Musemwa *et al*., 2008). This shows the importance of smallholder or subsistence farming in South Africa. Therefore, there is a need to assess the range of management strategies used by farmers to ensure long term productivity of their animals under changing environment, habits and demand.

Characterizing and assessing smallholder communal systems is of paramount important especially where livestock production provides a major share of agricultural economies, food and enhancing soil fertility and nutrient cycling. Poverty and grazing of the common in many rural areas of South Africa is well recognised (Forbes & Trollope, 1991; Du preez *et al*., 1993; Gcobo & Dladla, 2002) and overgrazing has been the ultimate result of overstocking. This raises questions about the future of smallholder in eradicating poverty and in ensuring sustainable food production. For this reason, it is important to take into account the sustainability of small–scale livestock farming as viable domain while responding to current and future demand for livestock products without overexploiting natural resources (Thompson & Nardone, 1999; Gibon *et al*., 1999). Assessing the sustainability of smallholders is a key step in supporting sustainable development (Sadok *et al*., 2008) and a mean to control the impact that livestock have on the environment. These also provide a way to measure the degree towards meeting the objectives of sustainable development.

Since sustainability cannot be measured directly, assessment can be made operational and practical through the use of composite indicators. Assessment of rural livestock production systems is necessary to understand and identify the strengths and weaknesses associated with resource use and management methods with an attempt to increase food production in a sustainable way. Indicators provide direct or indirect information on other variables that are not easily measured (Gras, 1989; Senanayake, 1991) and may also safeguard in decision making process.

Due to the lack of standardized set of indicators and methods for determining the sustainability of smallholder farming systems (Van Cauwenbergh *et al*., 2007), a group of indicators were selected to assess the sustainability of South African smallholder communal farmers. Indicators were selected in all of the three aspect of sustainability (environment, social and economic dimension). In case where the selected indicator could not provide complete information about the situation, but were useful, indirect indicators were therefore used (Pretty, 1995; Atanga *et al*., 2013). For example, the use rainfall as an environmental indicator to determine forage availability since most of communal rangelands of South Africa are rain fed. Therefore, all effects of water shortages were to be linked directly to decline in rainfall (Glantz, 1987). Thus, the objective of the study was to determine the roles of livestock on smallholders' livelihood characterise their farming practices and determine the impact of livestock on natural vegetation. The objectives will be addressed in different chapters of the thesis.

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Chapter 3

The description and characterisation of livestock production in rural areas of Greytown, South Africa

Abstract

The characteristics of smallholder livestock farmers and present information on production practices and constraints were obtained. Fifty five smallholder farmers were interviewed individually on their homestead. About 87% of the respondents owned cattle while 81% owned goats, multiple answers were possible. The average number of goats per owner was 17 ± 1.9 and 13 ± 2.0 for cattle. Only 5% of the respondents had tertiary education. Most of the farmers were above 40 years and youth participation was lacking. The study also found that most of the households were male headed (53%) while the remaining (47%) were females. Thus, there was an association between gender and ownership meaning that females are probably given a chance to own livestock after death of their husband. Livestock were grazed on communal rangelands (94%). Most farmers indicated to keep livestock for cultural purposes (78%). Food production (meat or milk) accounted 25% of the total interviewed farmers. Farmers reported water access to be a challenge, 51% of the respondents obtained water from the river for household use and farming purposes, which raises quality and health concerns. Livestock were either provided water (17%) or were drinking from the river (89%). Supplementation was not a common practice since the majority did not give their animals extra feed (78%). About 85% of the farmers were using a communal owned bull and there was no specific breeding season as females and males were grazed together throughout the year. Rangeland degradation was caused by livestock because most (52%) said it was overgrazed. In the light of this results presented here, collective work appears to hold great potential for addressing rangeland degradation and water access. External assistance with regards to disease identification and control is required. Farmers also need to be assisted in developing strategies for conserving and harvesting natural resources, specifically water and feed, for feeding their animals during critical periods of feed shortages. In doing so, stock loss through disease infection and feed shortage can be minimized. Similarly, household demand for food, income, accumulation of wealth, can be improved.

Keywords: cattle, goats, smallholder farmers, grazing system, supplementation

3.1. Introduction

Throughout the developing world, livestock is kept for variety of purposes including eradicating poverty, improving household food security and economic development (Coetzee *et al*., 2004; Musemwa *et al*., 2008) and are primary goals of sustainable rural development (World bank, 1986). However, the industry is challenged by the following: land access, human population growth, land use change, grazing of the commons, and climate change (Abule *et al.,* 2005; Musemwa *et al*., 2008; Meissner *et al.*, 2013). In many developing countries, communal livestock production is often practiced extensively where animals rely on natural and communally managed rangelands for nutrition (Bennet, 2008). Quality and quantity of natural rangelands vary across seasons. The nutritional composition, especial protein decline during the dry season while fibre content increases. These variations have significant effects on the growth and reproduction of the animals. Besides fluctuations on biomass production and ownership, these rangelands remain to be a vital aspect of extensive production and provide a livelihood strategy to many people (Mapiye *et al*., 2009; Pell, Stroebel & Kristjanson, 2011).

In a South African context, concepts and the importance of sustainability and sustainable development are strongly recognized, but rarely implemented (Oettle *et al*., 1998; Meissner *et al*., 2013). For smallholder farmers to be able to support their daily needs, they need to improve their farming management practices towards social acceptable methods, environmental friendly and adaptable practices, and economically profitable. In this way, demand for meat and other products can be met without placing pressure on the ecosystem. In the process, malnutrition and unemployment can be minimised in many rural communities of South Africa if take–off for sale can assume equal importance for home consumption or ritual slaughter.

Previous work has not considered objectives governing subsistence, conditions under which smallholder farming systems operates, and factors limiting smallholders to reach maximum production potential (Shackleton *et al*., 2005; Dovie *et al*., 2006; Gwelo, 2012). This study, therefore attempts to address these issues, because implementation cannot be done without assessing current farming practices employed by smallholders of South Africa. Long–term viability of smallholder livestock farmers requires one to find strengths and weaknesses in current management practices that need improvement to enhance farm performance. The objective of the study was to characterise and describe the management practices employed by smallholder livestock farmers in Umvoti Municipality.

3.2. Materials and methods

3.2.1. Description of the study area

This study was conducted in Umvoti Municipality in Kwa-Zulu Natal Province of South Africa. The Municipality is divided into 11 wards and occupies 2 509 km^2 with a population size of 103 092 (Census, 2011). Communities under the tribal authority depend on either crops or livestock for their livelihood where they may sell surplus to neighbours and this farmers are mainly subsistence oriented. The Municipality is characterised by both Moist Midlands Mist belt and Dry Midlands Mist belt ecosystems and is classified as Midlands Mist belt Grassland (Mucina *et al*., 2006; Umvoti Integrated Development Plan (IDP), 2014/2015). It is situated at a latitude of 29° 4’ 0” S and a longitude of 30° 35’ 0” E. The altitude ranges between 1 340 to 1 620 meters with an annual rainfall of 730 mm to 1 280 mm (Mucina *et al*., 2006). Rainfall is associated with summer thunderstorms, strong winds and hail. Winter and spring rainfall is in the form of cold fronts. Temperature ranges from 15 °C to 18.5 °C, with a minimum temperature of –10.8 Celsius over the June month. In general, Umvoti has a temperate climate meaning that it does not experience extreme weather conditions (temperature, excessive rainfall or snow).

The landscape is highly fragmented and associated with the uneven east–facing escarpment, south of Thukela River. The vegetation is classified as sour veld and is prone to Ngongoni grass (*Aristida junciformis*) invasion (Tainton, 1999). Sour veld is a veld type that only supports animal growth during rainy summer months, and losses its quality over winter months (Tainton, 1999). The municipality is forb rich, and dominated by tall, and sour *Themeda triandra* (red grass), which is sensitive to moderate defoliation. Forbs are non woody plants with various colouring flowers that are not a graminoid (Wikipedia, 2015). Other plants were grasses like *Aristida funciformis* (Ngongoni), *Eragrostis curvula* weeping grass, *Sporobolus africanus* (mtshiki) and *Hyperrhenia hirta* (common thatch grass). Poor grazing management give rise to Ngongoni, a degenerative and unpalatable grass species for grazing and decreases the veld productive capacity (Tainton, 1999). Animals are therefore required to search for feed between these grass communities. Ngongoni or mtshiki dominated communities provide little forage for animals, but are useful in protecting forests against veld fires thus creating opportunities for game ranching (Tainton, 1999).

Greytown has excellent arable soils for cropping, mainly maize (IDP, 2014/2015). According to Mucina *et al*. (2006), apedal and plinthic soil types are common throughout the district. These soils are derived from the Ecca Group shale and minor sandstone, and less importantly from Jurassic dolerite dykes and sills and dominated by land type AC, followed by Fa (fulvic acid) (Mucina *et al*., 2006). Acrisols (AC) are soils having only A and C horizon, commonly in new alluvium (sand, silt, or clay) or on steep rocky slopes and are characterized by red and yellow, massive or weakly structured soils with low to medium base status (FAO, 2005). Certain areas between Grey town and Kranskop are characterised with acidic soils and steep slopes, and are prone to erosion, making them unsuitable for agriculture.

3.2.2. Selection of farmers

A simple randomized sampling method was used to randomly select 55 farmers in 19 villages as shown in Table 3.1. Participants were selected given that they own livestock and/ practice crop farming. Fifty four of the respondents owned livestock and one farmer was a crop farmer. Participants in each village were used as a representative of the community. Prior to selection, a meeting was held with the extension officer and the tribal leader in December 2014 for the permission to conduct interviews and also to explain the purpose of the study. This was followed by intensive field investigation and sampling in February 2015 and July 2015.

Table 3.1 Interviewed villages at Umvoti, Kwa-Zulu Natal

Village name	Number of respondents
Kwasenge	5
Nqoleni	4
Etsheni area	2
Dakeni	4
Emavalane	2
Sibuyane	2
Emahlabathini	8
Muden/ Greytown	3
Kwadolo	1
Heinedale	1
Dimane/ Emakhabeleni	5
Dambe/ Nophethu	3
Mbobo	1
Kranskop	1
Mooidraai/ Muden	1

Village name	Number of respondents
Kwabhodlo	1
Ndimakude	1
Kwamanzini	2
Emadekeni/ Ndimakude	8
Total farmers	55

3.2.3. Data collection

All the 55 farmers were interviewed using a pre–tested structured questionnaire. Interviews were conducted individually at the farmer's house by the researcher, extension officer, a student and a community member. The extension officer and the community member helped with directions, introducing the purpose of the study and with interviewing. Ethical clearance was obtained for the study at Stellenbosch University (HS1149/2014). Farmers had to sign a consent form before the interview could be conducted. The consent form served as a proof that farmers were not forced to participate and also to confirm that none of their personal information would be used for any other purposes outside of this study. The questionnaire was originally formulated in English. For the Zulu speaking farmers, the questions were asked in Zulu by a Zulu speaking community member and the researcher.

3.2.4. Questionnaire structure

The questionnaire were divided into seven sections: (1) demographic information, (2) farm and farmer information, (3) type of production system, (4) disease management for livestock, (5) access to electric energy, (6) marketing and (7) breeding and quality of traits perceived by the owner (Appendix 1). The questionnaire was adapted from Rowlands *et al*. (1999) and Girardin *et al*. (2004). Livestock ownership was divided into several categories where the participants had to indicate every person owning livestock in the household. Participants were required to provide information on the type of livestock kept and rank the first 3 primary reasons where the lowest rank i.e. 1 assumes high preference, 2 second and 3 least importance. On the reasons for keeping or functions obtained from livestock, each rank was given a score ranging from 1.0 to 0.33. Where rank 1 had a factor of 1 and assumed the primary importance, the second reason had a factor of 0.5 and the third reason had a factor of 0.33 and assumed the least importance. The level of income was also ranked from 1 to 3. Where ranking was permitted the proportion (%) was over 100 because of the multiple answers from different respondents.

3.2.5. Data analysis

Results were reported using frequency tables, histograms and frequency counts as well as percentages generated SAS Enterprise Guide 5.1 (2012). Graphs and pie charts were generated using Microsoft Excel (2013). The effects of gender on livestock ownership were also investigated using X^2 (chi–square) test statistic as follows:

$$X^2 = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{(f_{ij} - e_{ij})^2}{e_{ij}}$$

Where: f_{ij} the observed cell frequencies; e_{ij} the expected cell frequencies; r is the number of rows and c the number of column in the contingency table. Here the rows were livestock ownership categories and the columns were the gender groups. The test statistics for X^2 was distributed with (r–1)*(c–1) degrees of freedom. However, the chi–square test of independence is only valid for large samples. In case where the expected frequencies were less than five, Fisher's exact test was preferred.

3.2.6. Hypotheses

The following null hypotheses were tested: (a) Gender is independent of livestock ownership (i.e. no association between gender and ownership). (b) Land degradation is caused by changes in rainfall. (c) Smallholder agricultural producers do not have any production constraints. A 95% confidence interval was used ($\alpha = 0.05$).

The above null hypotheses were tested as an attempt to address the following research question: Does production constraints experienced by smallholder livestock farmers in Umvoti municipality decrease overall farm performance, which could undermine farm productivity?

3.3. Results and discussion

3.3.1. Demographic information

Approximately 31% had lower education below primary school as it can be observed in Figure 3.1. Of the 69% that did receive education, 35% had primary education, 29% secondary education, and only 5% had tertiary qualification.

Kunene and Fossey (2006), reported that only 47.4% of farmers at Enseleni District (northern of Kwa-Zulu Natal) had acquired some kind of education. In the Eastern Cape, Musemwa *et al*. (2010) reported 52% of the farmers at Chris Hani, 51% Amatole, and 50% Alfred had primary education. Munyai (2012), reported that 36% of communal livestock farmers at Limpopo did not receive formal education. Gwelo (2013), reported that farmers at Kwezana and Dikidikana had education not beyond primary school. Bidi *et al*. (2015) reported that majority (70%) of farmers in Mangwe district of Zimbabwe have primary education. The other authors together with the present study results shows that education is a major constraint for communal smallholder farmers in South Africa especially in learning new ideas (knowledge transfer) and technology.

The official estimates (Statistics South Africa, 2011) of South Africa indicated that Mpumalanga (31.5%), Limpopo (30.5%) and Kwa-Zulu Natal (27.1%) have the highest proportion of agricultural household heads with no academic qualification, which also supports the findings of the present study. These findings confirm statements of Davenport & Gambiza, (2009) that most communal livestock owners are unemployed, with low levels of education. The implications of education is lack access to information about the market structure and opportunities, consumer demand and preferences. Lack of access to product price and/ or market structure compromises farm productivity and profitability.

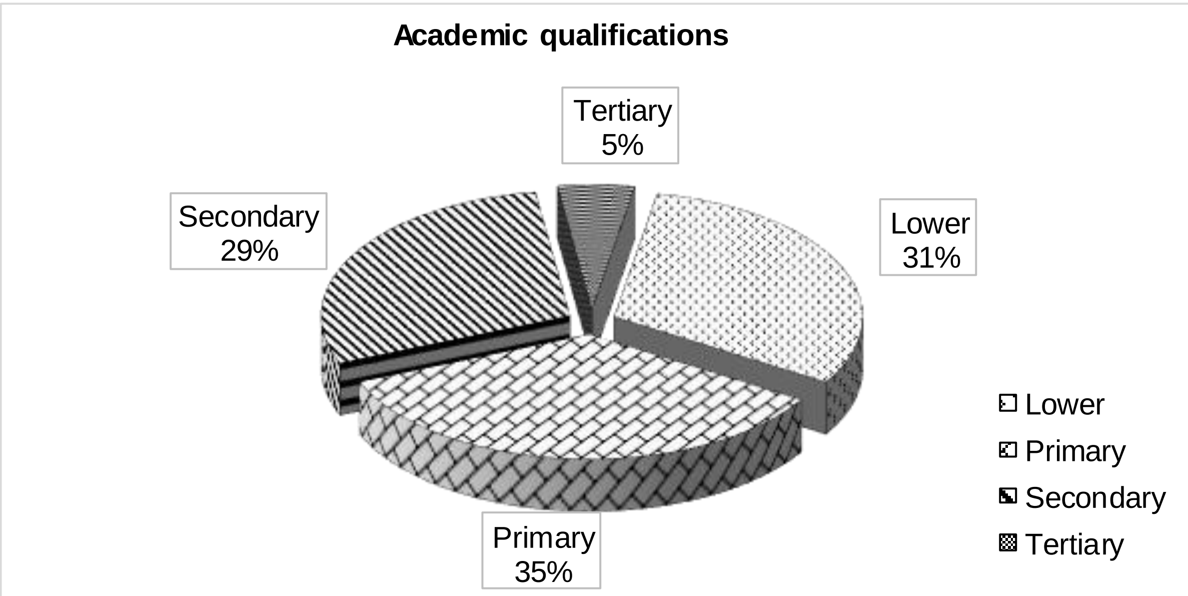

Figure 3.1 Education level of the household head at Umvoti.

Most of the farmers were above 40 years and they relied on livestock for emergency cash and social grants for livelihood (Table 3.2). The age of household heads ranged from a minimum of 18 years of age to a maximum of 87 years. The high age range observed in the current study indicates lack of youth participation.

It has been reported that the number of households engaged in agriculture in Kwa-Zulu Natal are old age people (Statistics South Africa, 2011). The age group reported to be engaged on agriculture in Kwa-Zulu Natal were individuals between 45 and above 65 years (Statistics South Africa, 2011). Poor youth participation entails failure in the transfer of indigenous knowledge from elders to future generations (Lesoli, 2011). This indigenous knowledge is thus at risk of becoming extinct (Lwoga *et al*., 2010). The results of this study also revealed a similar lack of interest and commitment to agriculture among the young generation. This observation is in line with findings of Musemwa *et al*. (2010), who also reported that the agricultural industry is currently dominated by old people, which raises concerns about the future of agricultural industry.

In the present study, farmers were grazing their livestock on communal owned rangeland. The maximum number of males per household were 8, females 7 and children less than 15 years were 17 (Table 3.2).

Communal farmers are considered to be inefficient and subsistence, because they do not contribute to formal agricultural markets (Solomon, Mlisa & Gxasheka, 2014) which may be linked with land access. Inefficient in this context refers wasting or failing to reach maximum productivity. Landownership is major constraint for most rural farmers of South Africa because almost all rural communities in the country are governed by a male chief (Traditional Authority) and people only access the land through consultation with the traditional leader (induna) (Turkson, 2003; Thamaga–Chitja & Morojele, 2014). This constraint is also evident in Kwa–Zula Natal where most farmers relied on communal land to graze their livestock (Table 3.2). It has also been stated that about 60% of the land in Limpopo is occupied by poor people who live on subsistence and about 52% in the Eastern Cape (van Schalkwyk *et al*., 2012; Statistics South Africa, 2012).

The issue associated with land rights is that communal land ownership tends to diminish the commercial value of farming, because of multiple stock ownership and unlimited flock size typically leading to vegetation degradation (Scholtz *et al*., 2013). Thus, 17% of the South African farming land is occupied by communal farmers (FAO, 2007). Although this farming systems cover a small portion of the country's agricultural land, improvements on land access and ownership is required so that individuals have full control on the land.

Table 3.2 Household information of Umvoti communal smallholder farmers

Variables	Mean	Median	SD	Maximum
Age	57.1	58.0	18.3	87.0
Males per household	1.910	2.0	1.567	8.0
Females per household	2.145	2.0	1.353	7.0
Kids (<15 yrs.) per household	3.0	2.0	2.915	17.0
Total private land ownership (ha)	1.0	13.4	52.89	367.0
Total communal land ownership (ha)	300.0	345.8	159.10	700.0

SD: Standard deviation

The results in Table 3.3 indicates that there is sufficient statistical evidence to conclude that gender is independent of ownership – there is no association between gender and the categories of family members owning livestock. The null hypothesis was therefore not rejected at 5% significant level. However, 83% of the cells had expected cell frequencies less than five and X^2 may not be a valid test for this data. In response, Fisher's exact test was used.

Looking at the p–value for Fisher's exact test (p–value = 0.0052), the null hypothesis was therefore rejected. Hence, there is sufficient statistical evidence to conclude that livestock ownership is dependent on gender. The relationship between gender and ownership indicates that livestock is linked with culture where livestock is passed to the first son reducing a chance for women to own livestock. The son therefore uses the livestock for bride price locally called lobola. Moreover, girls are not given livestock because are expected to go marry and in the process livestock is exchanged to her parents. This is also supported by the fact that no daughters owned livestock (Table 3.3). Gender imbalance has implications in decision making where most decisions are made by men (Table 3.8). Although women can buy their own livestock, only few can afford because livestock is expensive. All this factors limit women and favour men ownership through inheritance.

The gender imbalance found in the present study is in agreement with other (Ainslie, 2002; Shackleton *et al*., 2005), especially households with diverse income sources and those owning larger herds. Waters–Beyer and Letty (2010) states that livestock ownership is concerned with social status and contributes to gender balance where women and children are given a chance to own livestock, primarily small stock like goats, chicken and sheep. It also provides opportunities for women to own livestock which may help families to reduce hunger, disease infestation and poverty, consequently contributing to Millennium Development Goals (Waters–Beyer & Letty, 2010).

Table 3.3 A 2 x 6 contingency table of gender and livestock ownership

Livestock ownership								
Gender		HHD	HHD, spouse	HHD, sons	Sons	Spouse	Other	Total
	Female	17	1	1	4	3	1	27
	Male	22	0	0	1	3	0	27
	Total	39	1	1	5	6	1	54
Fisher's Exact Test								
Table probability (p)				0.0052				
Pr< = P				0.49				

HHD: House Hold Head (a family bread winner and/ or one's own home)

The wealth status of farmers was used as an indication of affluence or abundance in biological resources and the ability of the farmer to use their natural assets to meet essential needs, i.e. food and income and the results are shown in Table 3.4. Only 2% of the interviewed farmers indicated to be rich, meaning that they were able to use their natural assets to meet daily needs and generate income to buy other household needs. Forty percent of the farmers were not poor neither rich, while the majority indicated to be resource constrained (56%). From the results it was concluded that smallholder farmers in KZN are not able to meet day to day household needs from selling their livestock or crops and buy other household needs, as most indicated that they are poor. This was probably because livestock were kept for socio–cultural purposes instead of income. The results reveal that communal farmers are rational in reasoning the purpose of keeping livestock.

Shackleton *et al*. (2005), stated that the functions of livestock in rural communities of South Africa are similar, but the relative importance of each function may differ from one place to another. The differences on the reasons for keeping livestock may be linked to several factors, like vegetation type, herd size, access to other income or income combinations (Compell *et al*., 2002). To support the statement above Shackleton *et al*. (2005) conducted a study in semi–arid and arid areas of Limpopo and find that sales assumes greater importance than drought and manure because cropping was less viable and farmers were less dependent on crop production for income and food security.

In this study, livestock was multiple owned by one or more members of family where 71% of the livestock belonged to the household head, 15% by the spouse of the head and 18% by sons (Table 3.4). Of the 71% of the household head, 53% were men and 47% were women.

Other authors accept that women and sons are given a chance to own livestock either through inheritance, gift or by purchasing livestock themselves (Swanepoel & Moyo, 2010). This sequence of ownership is likely to result on skewed asset distribution within family members. Moreover, the livestock industry is noticed to be male dominated. A study in the Eastern Cape reported that adult men dominated all marketing related activities for livestock (Musemwa *et al*., 2010). Mapiye *et al*. (2009) also found 75% of cattle production systems in communal areas of the Eastern Cape to be men dominated, revealing the gender imbalances in the livestock industry.

Table 3.4 Wealth category, family members owning livestock and gender of the household head of livestock owners at Umvoti municipality (Sample size, n=55)

Parameters	Percentage (%)
Wealth category	
Rich	2
Poor	56
Medium	42
Gender of the household head	
Male	53
Female	47
Family members owning livestock	
Household head	71
Spouse of the head	15
Sons	18

Majority of the respondents were black (96%), 2% White and 2% Indian. Majority of the black farmers were residing in the rural areas, while the White and the Indian farmer were living in close proximity to town where market may be easily accessible.

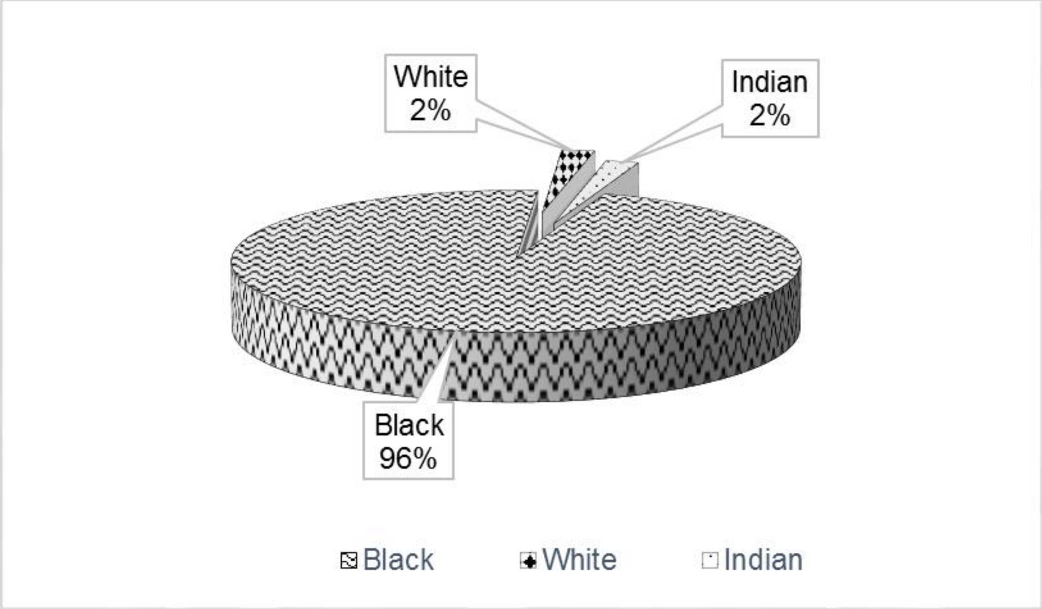

Figure 3.2 The race of respondents in Umvoti municipality.

3.3.2. Energy sources used by smallholders

Farmers seem to have diverse sources of energy ranging from electricity to paraffin and solar as it can be observed in Figure 3.3. Most of the households have access to electricity (28%) and solar energy (28%). Candles were used for lighting and making polish. Paraffin was the second highest energy source used by farmers for lighting and cooking (23%). Only 19% of the respondents owned a generator for various purposes (Figure 3.3). The least preferred energy source was gas, which recorded 2% of the total interviewed farmers.

The statistics South Africa on general household survey (2014) reported that 77.5% of households in Kwa-Zulu Natal Province have access to electricity, 14.4% wood, 4.2% paraffin, 1.5% gas, 0.4% coal and other 2.0% (animal dung, solar and generator) for household uses. Of the 22.5% that don't have access to electricity are probably the communal farmers since only 28% of the sampled communities had electricity in their households.

Wood was also used as an energy source as well as for kraal and house construction and fencing poles, but no formal data was collected. Deforestation is however known to contribute to land degradation by exposing the soil to heavy rains and high light intensity promoting water runoff and evaporation rate. As a result, wood harvesting also give rise to environmental concerns, i.e. carbon dioxide release to the atmosphere. To improve the use of wood, communities need to be encouraged to practice afforestation where the wood can be harvested sustainably by planting back after harvesting the wood and leave the soil vegetative covered.

Social sustainability suggests that human wellbeing should also encompass sanitation (water taps, flushing toilets, and shower bath). Improved living standards however contributes to over–usage of non–renewable resources like coal and results to explosive demands with which industries cannot satisfy. Currently the biggest South African energy supply, Eskom experienced large energy shortages all over South Africa. Thus, these energy sources are mainly obtained from fossil fuel mining (e.g. coal, oil and gas) and their use contribute to global warming through releasing CO_2 to the atmosphere (Nonhebel & Kastner, 2011). This raises concerns about the sustainability of the energy sources available in South Africa and the effects of this energy sources to the environment. At present, improvement of livestock farming and living conditions by technological innovations seems to be limited, since most households have limited access to basic household needs (water, electricity and sanitation). Based on the study results, photovoltaic solar hold a promise on solving some of the energy issues associated with fossil fuel mining by using renewable energy sources like the ultraviolent light from the sun.

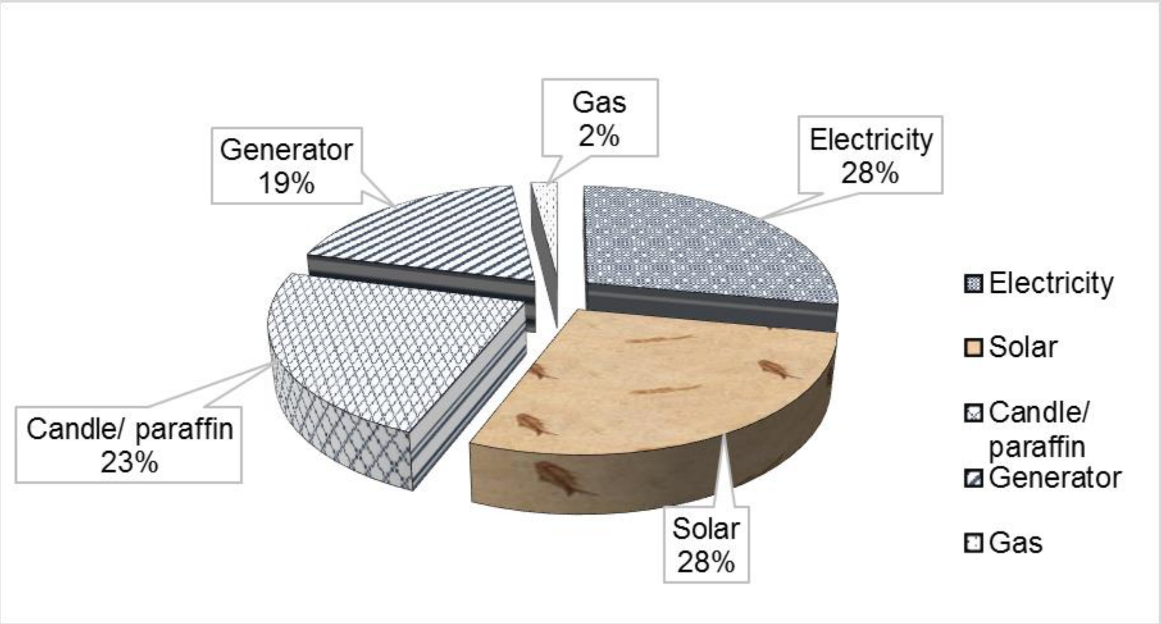

Figure 3.3 Energy sources available to smallholder farmers at Umvoti Municipality

3.3.3. Livestock composition and herd structure

In the present study, majority of the farmers owned cattle (87%), followed by 78% goats and 60% chicken (Figure 3.4). Cattle were owned by 47 of the households while goats were owned by 44 out of the 55 surveyed households. The number of cattle owned by farmers for this study ranged from zero to 85 with a mean of 12. The number of goats owned by farmers ranged from zero to 60 with a mean of 14 (Table 3.6). The average number for chickens (25.7) was higher than that of cattle, goats and donkeys (4.2). Although most of farmers indicated that they have lost their chickens due to Newcastle disease.

The current status of livestock production in South Africa shows that Kwa-Zulu Natal is the second largest beef producer in the country right after the Eastern Cape (DAFF, 2013). These findings also confirm the results obtained from other studies (Mapiye *et al*., 2009; Solomon *et al*., 2014; Musemwa *et al*., 2010) that the livestock industry is more cattle dominated although the density of cattle is lower than that of other domesticated livestock.

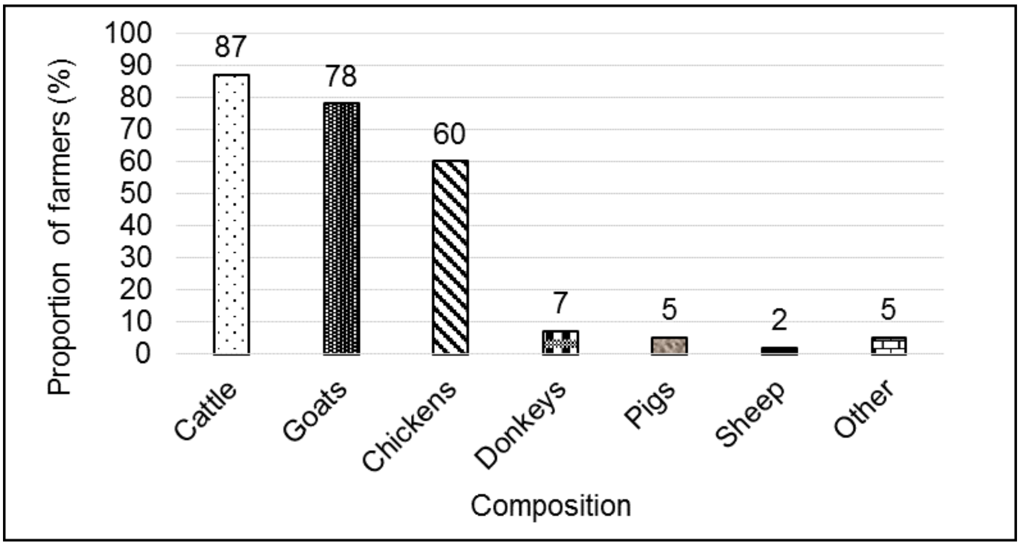

Figure 3.4 Types of livestock owned by communal farmers of Umvoti municipality.

The majority of the respondents (88%) keep a mixture of animal species. Goats and cattle combination represented 24% of the total interviewed farmers while cattle, goats and chicken represented the most frequent species combination (37%). Similar results were also revealed by Solomon *et al*. (2014) where 82.8% of the farmers kept a mixture of livestock species.

Table 3.5 Species combinations of livestock kept by Umvoti Municipality smallholder farmers

Animal Species	Frequency count	Respondents (%)
Cattle only	3	6
Goats only	3	6
Cattle, goats	13	24
Cattle, goats, sheep	1	2
Cattle, goats, donkeys	1	2
Cattle, goats, chickens	20	37
Goats, chickens	5	9
Cattle, goats, chicken, pigs	1	2
Other combinations	7	13
Total	54	100

The present study found that there were more goats (779) than cattle (615) although majority of the respondents owned cattle (87%) shown in Figure 3.4. In both species, females accounted for the largest proportion of the herd (Table 3.6). Cows and does accounted for up to 54% and 43% of the herd size, respectively. The average number for cows was 13.08 ± 2.30 while the mean for goats was 17.4 ± 1.94. The bull to cow ratio for this study was 1 to 5.6. The mean for does was 5. The buck to doe ratio was 1 to 3.5.

Schwalbach *et al*. (2001) reported a herd size of 2291 in the North West Province with a mean of 29 cattle per household. Kunene and Fossey (2006) reported a herd size of 871 and goat flock of 810 in Kwa-Zulu Natal Province. The mean number for cattle was 13.6 and 15.3 for goats (Kunene & Fossey, 2006) per farmer. In Venda a mean of eight head of cattle per farmer was reported by Nthakeni (1996). The herd size of cattle found in the present study is lower than that of Schwalbach *et al*. (2001) and Kunene and Fossey (2006) but higher than that of Nthakeni (1996). Cattle and goats owned per farmer found in the current study is comparable to that of Kunene and Fossey (2006). The differences in animal population may be due to favourable climatic conditions (vegetation, water, soil types) and access to external assistance (i.e. extension offer, veterinary services and equipment).

The bull to cow ratio obtained in this study (1:5.6) is far higher than that reported by Solomon *et al*. (2014) (1:20) and Mapiye *et al*. (2009) (1:30), but lower than that given by Shackleton *et al*. (2005) (1:3). Other researchers have reported a bull to cow ratio of 1 to 3.3 in the North

West (Schwalbach *et al*., 2001) and 1 to 3.7 in Limpopo Province (Stroebel *et al*., 2010). The bull to cow ratio of the present study is far higher than the recommended standard breeding ratio for commercial farmers (1:20) in South Africa (Colvin & Jager, 1989), but is in agreement with the majority of literature. One of the reasons why the bulling ratio is high could be explained by the fact that farmers use bulls for traditional cultural purposes as indicated in Figure 3.5. This also implies that there will be more bulls than females, and bulls will waste time fighting instead of mating leading to low reproductive performance. During fighting bulls can also injure themselves making them unable to mate and this represent a loss to the farmer because an off-spring represent some form of investment and income when they become marketable.

Table 3.6 Herd and flock composition of cattle and goats kept by Umvoti Municipality smallholder farmers

Parameter	Total	Median	Mean	Standard deviation
Cattle herd size	615	8.0	12.0	15.6
Calves	126	2.0	2.27	2.72
Cows	331	6.17	3.0	9.96
Oxen	19	1.0	1.13	1.27
Heifer	78	1.0	1.73	2.97
Bulls	59	1.0	1.07	1.18
Goat flock size	779	14.0	14.47	13.61
Kids	213	3.0	4.17	4.62
Does	336	5.0	7.10	7.39
Whether	36	0.0	0.8	1.68
Bucks	96	1.0	1.78	3.18

3.3.4. Socio–economic importance of keeping livestock

Figure 3.5 indicates the importance of males in Umvoti Municipality. Almost all the interviewed farmers stated that they are keeping male animals for cultural related purposes which accounted for 91% followed by 38% for breeding. Farmers showed little interest in trading their animals for cash (18%). Cultural related purposes involved one of the following: slaughtering of animals for traditional ceremonies, funerals, weddings and ritual sacrifices.

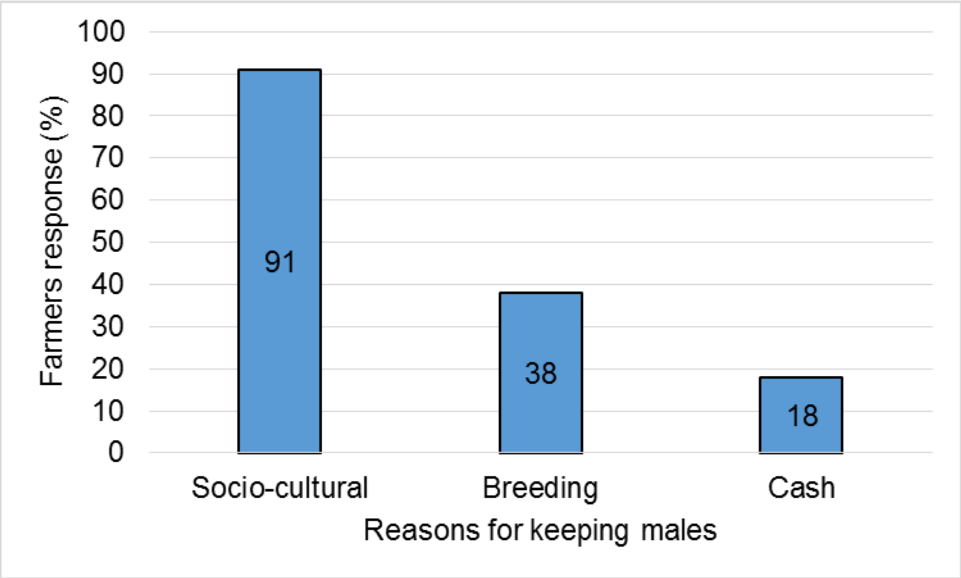

Figure 3.5 The importance of keeping males in Umvoti Municipality.

Smallholder farmers have a wide range of reasons for keeping livestock (Shackleton *et al*., 2000). Figure 3.6 and Table 3.7 illustrates the reasons and the importance of livestock at Umvoti, Kwa-Zulu Natal Province. Of the 54 livestock farmers interviewed, 78% indicated that the main reason for keeping livestock was for cultural purposes. Whilst 73% of the respondents traded their livestock for income, 51% were using it for ceremonies and 25% for food production. These percentages are not adding up to 100% since multiple answers were possible. None of the farmers reported that they were using their livestock for draught power. Other important reasons for keeping livestock indicated by the farmers were insurance or emergency cash sales and social status (13%).

The reasons for keeping livestock is comparable with the findings from literature (Andrew *et al*., 2003; Shackleton *et al*., 2005; Dovie *et al*., 2006; Katjiua & Ward, 2007; Moyo & Swanepoel, 2010; Kagira & Kanyari, 2010; Solomon *et al*., 2014). Farmers seems not to have interest on selling their animals for cash, Chapter 4 will evaluate on how Umvoti farmers obtain income to cover household needs.

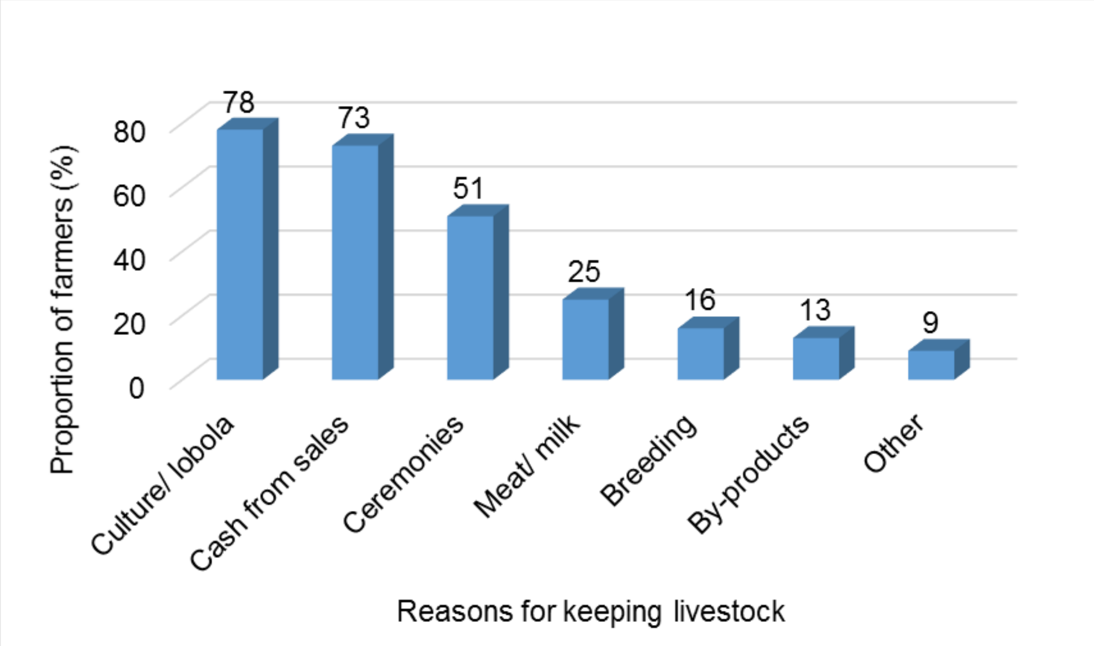

Figure 3.6 Functions of livestock kept by local farmers at Umvoti Municipality.

The present study found culture (32.2), cash (28.3) and ceremonies (12.3) to assume the highest scores and the highest frequency of use as shown in Table 3.7. Culture assumed the highest score because farmers showed least interest in selling their livestock (28.3) and the fact that livestock were also used for ritual slaughter i.e. to remove bad luck and for ancestral celebrations, funerals, parties, and weddings.

Other studies reported cash, savings, ritual slaughter, meat and draught power (ploughing) to assume the highest score and percentage of use (Shackleton *et al*., 2005; Dovie *et al*., 2006).

Table 3.7 Weighted ranking of livestock uses in Umvoti Municipality

Value	Frequency count			Total	Weighted ranking
	1st important (1.0)	2nd important (0.5)	3rd important (0.33)		
Culture	21	19	5	45	32.2
Cash from sales	18	14	10	42	28.3
Breeding	4	0	4	8	5.3

Value	Frequency count			Total	Weighted ranking
	1st important (1.0)	2nd important (0.5)	3rd important (0.33)		
By–product	4	4	3	11	7.0
Ceremonies	2	12	13	27	12.3
Meat/ food	3	3	5	11	6.2
Insurance/ wealth	1	0	1	2	1.3
Milk	1			1	1.0
Emergency	0	1	0	1	0.5

3.3.5. Animal and farm management

Adult men were mainly responsible for all major livestock activities, especially buying and selling or slaughtering (Table 3.8) which also concurs that the industry is male dominated as discussed earlier in this Chapter, Section 3.3.1 under gender and livestock ownership. Girls had the least participation in livestock activities and yet as adult females their participation increases significantly. This could be due to adult females having more influence as married women and the high prevalence of women headed households (47%). Young boys were responsible for feeding or herding the animals. Breeding is mainly uncontrolled and occurs naturally because 73% of the farmers indicated that no one is responsible for breeding decisions. Bulls and cows are kept together throughout the year. The implications of one bull in community is inbreeding (the transfer of unwanted traits to new off-spring). The lack of breeding season makes it difficult to plan for winter feeding because there will be new off-spring born in almost every season. Births during the dry season may result to animal death and poor performance because there will be no enough feed to sustain feed requirements for growth and development in an adult stage of development required for performance.

According to Solomon *et al*. (2007), communal farmers tend to use indigenous knowledge and perceptions to study animal husbandry and management and changes in natural resources. The ability of communal livestock keepers to accumulate knowledge and transfer it from one generation to the next, has allowed them survive many biophysical constraints, like decline in rainfall and in controlling livestock diseases.

Table 3.8 Members of the household responsible for livestock management in Umvoti Municipality (n=54)

Parameters	Adult males (%)	Adult female (%)	Boys (%)	Girls (%)	Hired labour (%)
Buying of animals	69	45	4	2	0
Selling/ slaughtering	71	29	11	4	2
Breeding decisions	24	5	0	0	0
Feeding/ grazing	35	18	36	5	2
Health management	53	27	22	4	2

The majority of the respondents were farming extensively (92%) and continuous grazing was employed (85%). Only 22% of the respondents give their animals extra feed and the rest 78% did not give any supplementary feed. During the dry season, farmers use a wide range of supplements. These supplementary feeds ranged from crop residues (i.e. maize, beans, cabbage and sugarcane) to bought grains and hay. Due to changes in weather pattern brought about by climate change, farmers indicated that they are no longer interested in crop production and they do not have crop residues with which to supplement their livestock during times of feed scarcity. Farmers who provided their livestock with extra feed indicated that they had to buy from suppliers (sugarcane by–products, lucerne, hay and grains). Farmers who did not offer their animals supplementary feed because of no or costly supplements had to let their animals die from hunger during extreme events. This results does not imply that farmers are not able to make decision, but they may internal social factors (i.e. family cooperative decision) or may be lack of opportunist market or buyers.

Timpong–Jone *et al*. (2014) reported that 67% of small–scale farmers in Ghana practiced supplementation. The type of supplementation used by these farmers included cassava peels, wheat bran, dry maize, silage, cut forage, and spent malt. Bidi *et al*. (2015) communal farmers in Mangwe District of Zimbabwe do not practice feed supplementation during the dry season. In the Eastern Cape, Gwelo (2012) reported that only 44% of the farmers provided their livestock with extra feed. Kunene and Fossey (2006) found that communal farmers in KZN use various traditional supplements to enhance reproduction and production performance. The poor productivity of smallholder farmers may be linked due to the fact that supplementation is lacking which directly or indirect affect reproduction and production of milk, meat and profit.

About 79% of the interviewed farmers indicated that they use manure in their field crops as an organic fertilizer. Only 2% of the respondents composted the manure before it was used in the cropping land. About 4% of the respondents discarded their animal waste because they didn't have any use for it while 8% left it in the kraal and 8% for other uses. None of the interviewed farmers sold animal wastes for income, but was donated or given for free if asked by neighbours. The use of manure in field crops serves as a trade-off to the environment in that it minimises wastes that could otherwise end-up in landfills and drinking water. Manure also save money that could be used to buy fertilizer to improve soil fertility.

3.3.6. Farmer perception on the impact of livestock on the rangeland

In the present study (n=41), farmers perceive their rangeland degraded but they believe that livestock is not only the cause of rangeland degradation. Farmers identified drought (44%), bush encroachment (10%), stocking density and poor grazing plan (7%), wildlife and donkeys (39%) to be factors contributing to rangeland degradation. Thirty one percent of the farmers agreed that livestock does contribute in the change of vegetation cover because of overstocking and continuous grazing. Just over half (52%) of the respondents reported that rangelands were overgrazed which directly links livestock to rangeland degradation. Farmers indicated that they are not aware of any kind of regulations governing pasture management. In response, farmers make no effort in adjusting stock density, dividing the rangeland into camps. Continuous grazing does not provide resting period or period of absent to allow plant recovery and/ or regrowth. It has been found that farmers in the Eastern Cape make little effort to control the impacts of livestock on their communally owned pasture (Lesoli, 2011) because of multiple ownership.

3.3.7. Livestock production constraints experienced by smallholder farmers

More than half (54%) of the interviewed farmers indicated that stock theft is a major concern. Farmers claimed that livestock thieves were people from the community. Stolen animals were either used for food or income by selling it to other communities or to local butcheries. Predation especially on young animals was also reported. Farmers also reported to be challenged by predators feeding on their young animals (11%). Some farmers indicated that predation was only a threat if animals were left unattended and are not in the kraal at night. Access to veterinary services posed a challenge to about 19% of the surveyed farmers. Finance was reported to be a major constraint especially when farmers are required to treat sick animals, buy supplementary feed and fencing of rangeland. Due to limited funds farmers lose a lot of animals from feed shortages especially in winter or during drought periods. Farmers find it difficult to control external parasites because there was no dipping facility close by. Farmers that were above 50 years stated that they were unable to walk long distances to dip their animals. Moreover, farmers also indicated that dips were old and ineffective in controlling ticks. Only 11% of the farmers had fenced grazing camps while 83% indicated that their rangeland had no fencing. Lack of animal health care facilities results in disease distribution and contamination of meat, milk and eggs. These bring concerns on human and animal, health and food safety that may be from consuming contaminated or diseased animals.

The value of stock theft in the current study was not quantified, but majority indicated that stock theft is a major challenge in Umvoti Municipality. In the Eastern Cape stock theft cost about R 600 million per year which present about 20% of the province's GDP from agriculture (Scholtz & Bester, 2010b; Anthrobus, 2002).The South African Police Services (SAPS) indicated that there are approximately 45 000 cases of stock theft reported per year, of which only about 8 000 of the cases go to court. The Agricultural Research Council (ARC) newsletter of South Africa reported that stock theft is estimated to cause losses of R750 million annually, of which only, R250 million were recovered (ARC, 2013).

3.4. Conclusion

In conclusion, the study showed that livestock is not used for economic purposes, but for culture and ceremonies. Chapter 4 would explore different ways employed by Umvoti communal smallholder farmers to cover household and farming expenses. Majority of the respondents had primary education. Livestock ownership was male dominated. Youth participation to agriculture in Umvoti Municipality was lacking as most of the farmers were above 50 years of age. The bull to cow ratio found in the present study was low than the standard recommended bulling ratio. The study also showed that Umvoti smallholder farmers have limited access to grazing facilities, resources, equipment for fencing grazing facilities, and ways to control theft and disease infestations. Due to the above production constraints farmers were not able to reach their full production potential and this undermines overall farm performance, in all three themes of sustainability. Based on these results farmers need to be assisted in addressing the identified challenges (education, gender inequality, fencing equipment and rangeland degradation).

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Chapter 4

The livelihood of smallholder farmers in Umvoti Municipality, South Africa

Abstract

The roles and contributions of livestock to household livelihood were evaluated in Umvoti Municipality of Kwa-Zulu Natal Province. Monetary and net values associated with the cost of production for livestock and cropping are presented in this chapter. Costs associated with livestock production were higher than profit obtained with an annual net loss value of –R14418 for all households owning livestock. A positive net value of R310 per household was estimated for subsistence oriented crop farmers. The positive net value obtained from communal cropping systems were related to low input costs as most respondents indicated the use of animal manure in their field plots as a replacement for chemical fertilizer. A total of four smallholder commercial crop producers made R688 800 per year which is equivalent to R172 220 per farmer. Fixed income (pension, wages, grants, home industry and gifts) proved to be the major livelihood strategies with an annual value of R23 694 per household. These income sources were used to subsidise livestock production costs. An off–take rate (i.e. Deaths, exchanged, used for lobola as a gift, stolen, slaughtered and traded) of 44% for cattle and 62% for goats were estimated for smallholder farmers. Kidding rate contributed 88% to goat flock increase and calving represented 85% of cattle herd increase. Based on these results, livestock seems to have other values than income since farmers showed no interest in selling their livestock. Accordingly, assumptions were made that respondents used livestock as some kind of investment by assigning a financial value to each animal type per household. Cattle accumulated the highest cash savings (R3 517 821) in comparison to goats (R711 131). From both livestock types dams contributed the highest cash investment. It is clear from the results presented above that mixed livelihood strategies does improve economic and social sustainability against unforeseen income and food shortages by using off-farm income to cover household and farming expenses.

Keywords: Investment, livelihood, goats, cattle, off–take rate

4.1. Introduction

Several studies have contributed significantly to the pool of knowledge on the livelihoods of farmers in communal areas in South Africa (Shackleton *et al*., 2001; Dovie *et al*., 2006; Munyai, 2012; Gwelo, 2012). These studies have recognized the importance and the contribution of arable land, livestock and natural resources harvesting (i.e. wild fruits and animals) to livelihoods (Shackleton *et al*., 2001). It has been stated that cattle and small stock like goats or sheep are multi–purpose in nature providing various goods and services (Ainslie, 2002). As a result, this multiple use system may potentially contribute to social cohesion between families and neighbours. Shackleton *et al*. (2005), argue that communal farmers can yield higher values if all livestock functions can be valued, rather than just comparing off–take rate and carrying capacity of smallholder farmers against that of conventional farmers. It has been stated that low returns from livestock production in communal areas are caused by the use of conventional and inappropriate economic models to quantify production costs and profit (Cousins, 1999). Dahlberg (1995) states that there are inadequate experimental case studies for communal smallholder farming. Failure to consider all goods and services obtained from livestock also undermines livestock farming (Beinart, 1992). Barret (1992) and Scoones (1992) showed that communal livestock values are higher than those of commercial farmers. Input costs associated with livestock production in communal areas are reported to be lower than production cost of commercial farmers (Hatch, 1996). Commercial farmers rely on the producing livestock for income purposes while communal farmers take into account the value of livestock or other products that do not have formal market value (Swanepoel *et al*., 2010; Dovie *et al*., 2006). These products could include one of the following: manure, ploughing (draught power), hides, horns, biological bank or insurance, etc. However, communal systems experience large capital losses through natural disasters such as drought, disease outbreaks, floods and other natural factors (Campbell *et al*., 2000).

The value of asset investment helps to protect farmers against unforeseen events, are known to improve social prestige and the economic balance (Scoones, 1992; Bosman *et al*., 1997). Barret (1992) and Ainslie (2002), stated that communal livestock owners are consistent in the ways they use and manage their animals, and that social-economic benefits have been the main objective. Goods and services obtained from livestock are similar in most communities of South Africa, but the relative importance differs between individuals (Shackleton *et al*., 2005). The variation in the relative importance of the goods and services has led to contrasting conclusions about the role and value of livestock in communal production systems. Several studies conducted in South Africa (Cousins, 1996; Ainslie, 2002; Shackleton *et al.*, 2005; Dovie *et al*., 2006) and Zimbabwe (Barrett, 1992) reviewed the importance and the economic value of livestock in communal areas. All the studies showed that livestock ownership in communal areas have a significant contribution to communal livelihood with a net positive benefit. For example, Shackleton *et al*. (2005), reported a net value of over R400 from livestock per hectare at Sand River catchment in Limpopo Province, which was equivalent to R64.52 per household (with a mean of 6.2 people per household). The authors also found cattle and goats had an annual savings value (herd growth) of R2 487.30 and R425.76 per household.

Several studies have attempted to place monetary values on non–marketed livestock goods and services (Adams et al., 2000; Shackleton et al., 2005; Dovie et al., 2006). All these studies demonstrated that livestock production in communal areas contribute significantly to livelihoods with positive net values. For instance, Dovie et al. (2006) reported a net monetary value of R6000 in direct benefits from livestock. The role of livestock as a form of investment and insurance or as a safety–net is often ignored, and yet is as important as cash from sales to most smallholder livestock owners, especially animals sold for emergency cash flow (Ainslie, 2005, Shackleton et al., 2005; Twine, 2013). Livestock owned by the poorer population not only provide food and by–products, but also have a banking related function (Info Resources Focus, 2007). To date, only a few studies have attempted to measure the value of livestock as a tool of asset investment or insurance. Bosman et al. (1997) find that the role of livestock keeping, from a financial point of view, was visible in both entries (herd growth) and off–take (sales). Herd growth (entries) indicate income accumulation while off–take indicate the spending of the accumulated capital to meet household requirements. Instead of measuring inflows (births) as a form of investment only, the present study assigned a monetary value to all animals because the whole herd represent some form of invested capital and have the potential to meet future expenses. In an attempt of addressing economic and food insecurity, the study examined annual monetary values of major livelihoods of smallholder farmers and the relative contribution of these incomes to the household gross value.

4.2. Materials and methods

4.2.1. Description of the study area

The study area is described in Chapter 3.2.1.

4.2.2. Data collection

Information on (i) annual livestock records, (ii) income sources and their values, (iii) types of crop production inputs were collected in Umvoti Municipality. All data were collected through semi–structured interviews using questionnaires. Data were collected at two different stages; February 2015 and June to July 2015. Forty two farmers were interviewed in their homesteads. In cases where it was difficult to obtain all the relevant information from the breadwinner (household head), a collective household interview was conducted. Livestock income values were expressed in annual terms because a majority of the households indicated that they only sell their animals when there is a need for cash. Crops were seasonal (summer and winter) and production costs were calculated from money spent on buying seeds, fertilizer, labour and pesticides per year. Livestock production costs were calculated as money spent on veterinary medicines, transport, supplementary feed, additional animals and labour.

Monthly income (pension, salaries/wages and grants) were converted to annual income by multiplying these incomes from each household by 12 months. Income generated from home services and home industry were multiplied by a factor of 0.5 to standardise the variability between months (Liaw *et al*., 2008). After the income were standardised it was then converted to annual income by multiplying the total income from each household home services by 12. Livestock and crop production costs and benefits were reported using mean values.

4.2.3. Data analysis

Income patterns

Income patterns were determined using categorical variables from SAS Enterprise Guide 5.1 software. The effect of pension was examined using contingency tables calculating the expected frequencies for pension versus livestock income.

Model information

$$eij = \frac{fi \times f \cdot j}{f \cdots}$$

Where *fi* = observed i[th] row total, *fj* = observed j[th] column total and *f* is the observed grand total. This is then used to calculate chi-square test statistics (X^2).

$$X^2 = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{(fij - eij)^2}{eij}$$

Where f_{ij} is the observed cell frequencies, e_{ij} the expected cell frequencies, *r* the number of rows, and *c* represent the number of columns. Each farmer was asked to rank each income source from 1 to 3. Score 1 being the most important income source, 0.5 second and 0.33 the least income source. From this a weighted score was calculated by adding the values obtained from multiplying the counts by the given score.

Model assumptions

H_0: There is no association between social grant and livestock farming

H_1: There is an association between social grant and livestock farming; $\alpha = 0.05$

Monetary values

Incomes obtained from various sources were analysed using descriptive statistics from SAS EG 5.1. The means calculated ($\bar{x} = \frac{\sum xi}{n}$), median (middle value), sum ($\sum xi$), count (n), probability of absolute t values (prob.>|t|) and the standard deviation ($s = \sqrt{s^2}$). The relative contribution per income type was obtained follows:

$\frac{\sum income\ type\ (xi)}{\sum all\ income\ types\ (xij)}$, e.g. $\frac{\sum home\ industry}{\sum\ all\ income\ sources}$

Monetary values were calculated in South African Rand using the mean of all households benefited from crop and/ or livestock goods and services and costs. An exchange of US$1 = 12.59 was used (South African Rand exchange rates and currency conversion, 2015).

Analysis of livestock entry and exit mechanisms

Generalized linear models (GLM) using SAS Enterprise Guide 5.1 software (2012) were performed to investigate factors contributing to herd growth (entries) and replacements (exits) on cattle and goats.

Model information

The link function fitted were, link function, log, η = g (E (Yi)) = E (Y) because it is a direct

mean model. The mathematical model was: $Yi = \beta_0 + \beta_i X_i + \varepsilon_i$. Where Y$i$ = the i^{th} value of the dependent variable; β_0 is the intercept of the best fitting line; β_1 the slope of the best fitting line; Xi the i^{th} value of the independent variable and ε_i (scale) which is not explained by the

regression line (residual error). βc = *cattle slope*, and βg = *goat slope*. There were 188 cattle entry observations and 172 for goats. The number of observations in the data set used for cattle and goats exits was 288 and 258, respectively.

$$g\ (i) = \beta 0 + \beta 1x1 + \beta 2x2 + \cdots + \beta kxk$$

Where *gi* the response; and the expected count of is *gi = E (G) = g (μ)* the distribution; *β0* is the intercept; X = ($X_1, X_2 \ldots X_k$) categorical explanatory variables and i = 1……= n and β is the slope.

Cattle and goat rates

The following equations were used to calculate entry (herd growth) and exit (off–take) rate:

$$\text{Entry} = \frac{\text{Total entries}}{\text{Flock size}} \times 100 \qquad (1)$$

$$\text{Exits} = \frac{\text{Total exists}}{\text{Flock size}} \times 100 \qquad (2)$$

The relative contribution per either entry or off-take mechanism was calculated as:

$$A_i \text{ or } B_i = \frac{Ai \text{ or } Bi}{At \text{ or } Bt} \times 100 \qquad (3)$$

Where A is the entry of i mechanism; B represent exit of i mechanism, A (total) is the total number of animal entries and B (total) is the total number of exits.

Entries

Goats = G, cattle = C, counts specifies the response of G and C, and predictor = entry or outflow mechanisms (Ai). Explanatory variables or parameter information (Ai) for cattle and goats entries were: the number of animals bought (A1), bred (A2), donated/ gift (A3) and exchanged (A4).

Exists

Explanatory variables or parameter information (B1) for cattle and goats removals or exits were: died (*B1*), donated (B2), exchanged (B3), slaughtered (B4), sold (B5), and stolen (B6). The number of observations in the data set used for cattle and goats exits was 288 and 258, respectively.

Asset investment

Asset investment value of each livestock type (goats and cattle) was calculated per household basis using compounded interest rates from Standard Bank South Africa. Compound interest is interest added on the principal amount after a certain period of time, from the date the money is invested and its investment grows exponentially (Business Dictionary, 2015). However, the compounding period and the interest rate are components determining profit and compound interest calculation (Standard Bank, 2015). Compound period was defined as the period (daily, monthly, quarterly, and half yearly or yearly basis) from when the compounding interest take place (Standard Bank Pure Save, 2015).

A sample of 54 households was interviewed about their livestock numbers and its composition on February 2015 at Umvoti Municipality in KZN. The reason of having different sample size is that on the second sampling stage (July, 2015) not all participants were available for interviews. Households that had an unknown herd size were excluded from the analysis of asset investment. There was only one household that owned sheep and the sheep price was the same as the goats' price. The sheep was not included in the analysis of biological bank investment as there was no data for comparison. One respondent who was specializing in beef cattle production and was selling his cattle for R7 000 each was also not included in the analysis of asset investment because the animals were sold once they reached market size.

After removing all households with missing values, the data set was reduced to 45 households with appropriate cattle records and 39 for goats. The selling livestock prices were obtained from the farmers. In cases where there was a big difference between the highest and lowest price for a particular animal species, an average was used.

Livestock sales in communal areas are skewed with most sales occurring during the festive season and the Easter holidays. For that reason, a half–annual compounded interest formula was used for all livestock types.

$$\text{Amount} = p\,(1+\frac{(R/2)}{100})^{2n}$$

Where:

P = the principal amount, R = percentage of the interest and n = the time in years or months.

Indigenous goats are said to have longer kidding intervals: 200 to 300 days (Webb *et al.*, 2010). Generally, they have a maximum fertility period of 4.5 years compared to Boer goat (3.5 years) and longer for Angora goats. Therefore, the compound period for kids was assumed to be 5 years with a 50% chance of survival, reducing the compound period to 2.5 years. The assigned compound period for does and bucks were assumed to be 2 years because they can be bought and sold at any time when there is a need for cash and when they ready for marketing.

The average weaning age for calves is 7 to 8 months (Mpayipheli & Scholtz, 2014). Age, weight and life expectancy differ according to the breed and management i.e. nutrition (Bidi *et al*., 2015). Garoma (2014) reported a mean reproductive lifespan of 13.2 years for Kereyu breeding females in Fentalle District, Ethiopia. According to ADI (Animal Defenders International), the average natural lifespan for cattle could be as long as 25 years (ADI, 2015). If we assume that communal cattle have a productive lifespan of 15 years the assigned compound period for calves was 15 years with a 50% chance of survival which reduces the compound period to 8 years. The study made assumptions on the lifespan of the animals because no lifespan data was collected and farmers were expected to sell their animals to get cash to over households needs. A compound period of 4 years was assigned for heifers, cows, bulls, and steer or oxen because they can be marketed any time after they have reached market size. Interest rates were calculated using pure save balance bands from Standard Bank. The Standard Bank initial investment values are illustrated in Table 4.1. In the absence of empirical studies on informal insurance providing data on premiums, we took the proportions of Standard Bank rates. We also assumed that capital embodied in livestock is protected against inflation. Standard Bank was chosen amongst other banks because savings rates are determined by inflation (the sustained increase in goods and service's price) not the bank. In this most of the banks are more likely to have the same interest rate. In that way the choice of bank seems not to have any effect on the results.

Table 4.1 Standard Bank pure savings rates

Initial investment value	Nominal	Effective
R0 – R999	1.85%	1.87%
R1 000 – R9 999	1.85%	1.87%
R10 000 – R19 999	2.35%	2.38%
R20 000 and more	2.60%	2.63%

Interest rates were quoted as per annum rates.

4.2.4. Hypotheses

The following null hypotheses were tested to find out if mixed livelihood strategies do improve the economic sustainability of smallholder livestock farmers. The relative contribution of livestock and crop farming was tested to indicate the importance of agriculture to smallholder farmers. Moreover, the effects of social grants on livestock farming were also tested using a chi-square test and Exact P Test.

I. Null hypothesis ($H0_1$): Smallholder farmers in Umvoti Municipality do not employ mixed livelihood strategies to minimize vulnerability against unforeseen natural or human–induced events
II. Null hypothesis ($H0_2$): Agricultural (crop and livestock) production do not make significant contribution to household livelihood of smallholder farmers at Umvoti municipality. A 95% confidence interval was used
III. Null hypothesis: there is an association between social grants and livestock farming ($\alpha = 0.05$).

Therefore, the research question was: Does off–farm income improve the economic sustainability of smallholder livestock farming in Umvoti Municipality, Kwa-Zulu Natal?

4.3. Results and discussion

4.3.1. Income patterns

The effect of pension on livestock farming income

Umvoti Municipality smallholders farmers make use of different strategies to generate income such as crop and livestock production, pension and salaries as shown in Figure 4.1. Pension were the common source of income for most of the respondents (60%) while 75% of the farmers obtained income from selling crops, livestock and salary, and each source accounted for 25% respectively. The results revealed that smallholder farmers in Umvoti Municipality are not commercially oriented, because pension and salaries assumed a greater importance (Table 4.2).

Nationally, 65.4% of households have been found to rely on salaries and 42.3% on social grants (Statistics South Africa, 2014). Grants were more prevalent in less developed provinces, like the Eastern Cape (56.6%) and Limpopo (56.1%). These income patterns prove that provinces dominated by communal areas continue to rely on income from the government. Kunene and Fossey (2006) found that famers in Enseleni District (KZN) depend on non–agricultural activities for income. The following proportions of income sources were reported for Enseleni district municipality in KZN: pension (22.8%), livestock (20.2%), crops and vegetables (0.8), work (55.9%) and home industries (0.3%) (Kunene & Fossey, 2006).

Reliance on pension may be related to the fact that most of the respondents were over 50 years age (Table 3.2 of Chapter 3) and were not able to work, and in certain instances jobs were difficult to find. Comparable results were reported by Fossey and Kunene (2006) where 79% of farmers at Enseleni District traded their livestock only when there was a need for cash. Hence, they rely on government grants because they are reliable and fixed, and may be the only exposable income available.

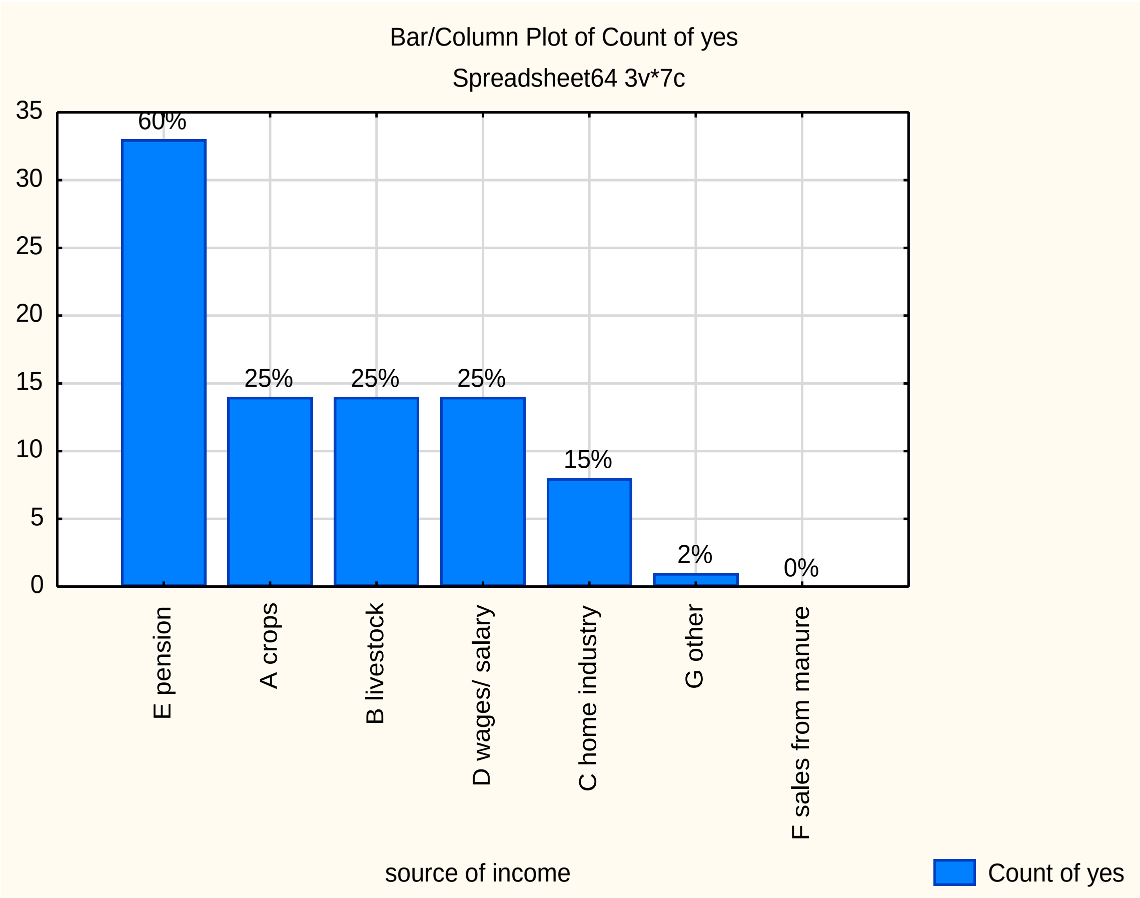

Figure 4.1 Sources of income for Umvoti Municipality smallholder livestock farmers.

There was no significant (p>0.05) association between pension and livestock farming income (Table 4.4). Although pension was ranked the highest, respondents were possibly getting income from other sources which were used to cover livestock and household expenses.

According to Montshwe (2005), Delali *et al*. (2006) and Mapiye *et al*. (2009) smallholder farmers keep livestock for income and as source of investment.

The importance of different income sources to smallholder farmers in Umvoti municipality

Table 4.2 shows that pension is an important source of income for Umvoti communal smallholder farmers. Pension had a weighted score of 36. This was then followed by 10.3 for salary and 9.3 for livestock. Livestock was ranked third which may be associated with the fact that sales in Umvoti Municipality were seasonal reaching their highest peak during the Festive Season and the Easter holidays. Low livestock sales in other seasons could be seen as the reason why livestock income was regarded as less reliable source of income.

Similar results were also reported by Musemwa *et al*. (2010), were pension assumed the greatest source of income. Moreover, the authors also reported that most communal farmers have no access to credit and livestock is only sold for emergency cash, i.e. school fees. In addition, the South African general household survey (2014) also reported that majority of households ranked salaries/ wages/ commission (57.5%) as the main source of income followed by 21.5% grants, 8.4% remittances and 9.7% other income sources.

Table 4.2 Ranking of important sources of income

Item	**Ranking score**			**Total counts**	**Total weighted**
	1st important (1.0)	**2nd important (0.5)**	**3rd important (0.33)**		
Pension	34	4	0	38	36.0
Salary or wages	8	4	1	13	10.3
Livestock	4	8	4	16	9.3
Crops	3	3	3	9	5.5
Home industry	5	2	1	8	6.3
Other	1	1	0	2	1.5
Total	55	22	9	86	68.9

Actual income values from different sources

The relative contribution of various income sources to household livelihood is shown below (Table 4.3). The results shows that home industry, crop production, gifts and chicken sales made no significant contribution to total household income ($p>0.05$). The relative contribution was less than 6% while pension (36%), livestock (18%) and wages (10.5%) made a significant input to households major livelihood ($p<0.05$). These results presented in Table 4.3 concur with the results from income rankings reported in Table 4.2.

Formal income (pension, wages and child grants) made a relative contribution of 46.9% all together and were equivalent to a value of R54 700.2 per household. Smallholder subsistence farmers obtained an annual income of R1 161.0 per household. Smallholder commercial crop farmers made a relative contribution of 26.6% to major livelihoods, but its contribution was statistically insignificant ($p>0.05$). The annual income obtained from crop production by smallholder commercial crop farmers was R122 700.0 per household. The annual income obtained from livestock R212 84.4 per household.

Dovie *et al*. (2006) reported that formal income (wages, pension, grants and remittances) make a relative contribution of 26.9% to total household income while crops contributed only 15.4% to household income. The value of formal income and crops was R4 770.8 and R2 720.0, respectively. These results are comparable with that of the present study where formal revenues anticipated the greatest contributions to household livelihoods.

The findings of the current study (subsistence crop producers) are less than that of Kinsey (1998) who reported income contributions of US $102 crop income per household, per year and Shackleton *et al*. (2000) who reported 7 to 24% of crop income contributions worth US $188 to US $753 per household, per year. A study in Kwa-Zulu Natal found that agriculture contribute approximately 6.8% to household income with a value of R2 628 (US $ 208.7) per household, per year (Shackleton *et al*., 2001). The differences in crop income contributions may be linked with production objectives and access to improved seeds, fertilizer and irrigation. For this study, respondents said they were using their crops for home consumption which can explain the low contribution of income from crop production. According to Ardington & Lund (1996) smallholder commercial crop producers contribute 16 to 20% of total household income and are comparable with that of the present study where smallholder commercial famers contributed 26% to household income. Other authors have reported an annual crop income of R1 225 smallholder farmers in Limpompo (Sartorius Von Bach & Nuppenau, 1996), R3 038 (Ogg, 1995) for KwaJobe (Kwa-Zulu Natal), 50% of cropping income in communal areas in Zimbabwe (Bradley & Dewees, 1993) and an annual cropping gross value of R2 750 by Dovie (2001).

Dovie *et al*. (2006), reported that cattle (live animal sales) had a gross value of R2 300 for all household and a value of R621 per household. The authors determined income from cattle and goat combination to be R3 432.3, representing 22.7% of total incomes to the household. The authors also reported a 58% of animal live sales. These findings are not comparable with that of the present study where 18% live sales were reported. This is because the study combined the income (R21 284.40) generated from both cattle and goats instead of separating them. From the study findings, it can be concluded that communal farmers at Umvoti Municipality have lower income from livestock and smaller herd sizes than Thorndale village (Limpopo province) which is the reason why income from livestock was lower. As a result of diverse income sources, Umvoti communal farmers were not bound to depend on livestock as a main source of livelihood.

Table 4.3 Comparing monetary values (Rands) from various livelihood strategies in Umvoti communal areas, sample (N=46)

Variable	N	Mean	Median	Sum	Pr>|t|	Relative input (%)
Home industry (12*0.5)	10	10772.0	1800.0	107720.0	0.3	5.7
Pension	31	21925.2	16920.0	679680.0	<.0001	36.0
Grant	1	7920.0	7920.0	7920.0		0.4
Wages	8	24855.0	24000.0	198840.0	0.003	10.5
Communal crop	10	1161.0	95.0	11610.0	0.2	0.6
Smallholder commercial	4	122700.0	6000.0	490800.0	0.4	26.0
Livestock	16	21284.4	10000.0	340550.0	0.04	18.0
Gift	5	10200.0	6000.0	51000.0	0.07	2.7
Chicken	6	311.7	185.0	1870.0	0.05	0.1

Variable	N	Mean	Median	Sum	Pr>|t|	Relative input (%)
Total		134372.7	72920	895830		100.0

4.3.2. Livestock and crop production costs

Livestock production costs

Additional animals and lobola (bride price) contributed the highest cost of production, 46.3% and 37.1%, respectively. Approximately 30 animals were bought, 9 were goats and 21 were cattle. The cost associated with purchasing additional livestock per farmer was R12 284.6 per year. After all costs associated with cattle and goat production were included, the costs increased to R35 703.00 per household (Table 4.4).

These numbers are larger than those of Shackleton *et al*. (2005), who reported that Bushbuckridge (Limpopo Province) farmers use R319.70 for purchasing extra animals per year. When including stock losses due to illness, injury and theft, the production costs increased to R790.72. These findings contradict with that of the current study due to differences in duration of the study (the present study was a month versus 20 years). Herd size was less than that of Shackleton *et al*. (2005) who recorded 25 000 to over 73 000 cattle and 23 000 to 47 000 goats and type of inputs measured (Hiring herders, taxes/fees, dipping costs kraal construction and maintenance, equipment (plough and yoke) and supplementary feed versus additional animals, lobola, fines, supplementary feed, vet and medicine, and hiring of herders). Moreover, Shackleton *et al*. (2005) did not include purchased animals as a true cost because they were productive and present a form of investment to the owner. In the present study, costs associated with stock losses (predation, death and sickness) were not included, which was going to increase the production cost even further.

Table 4.4 indicates that veterinary drugs were commonly used by many households (83.7%) and contributed 4.7% to the total annual cost of livestock production per household. Scoones (1992), reported that Mazvihwa communal farmers (Zimbabwe) used roughly Z$3.7 (Zimbabwean dollar) for vet services and medicine per livestock unit. The author also stated that veterinary services added 50.7% to the livestock costs per livestock unit, and the overall cost depend on the number of the animals the farmers had.

Hiring of herders had the lowest input cost (1.8% of the production costs) as most households herded their own animals or assigned other family members to be herders. Such herding strategies had no direct cost to the owners as the herder is part of the family.

Similar findings were reported by Dovie *et al*. (2006) who found that 89% of households in Thorndale village herded their own goats or appointed a family member to herd them. A hiring rate of Z$30 to Z$60 per month was reported by Scoones (1992) for herd boys. In South Africa, a hiring rate of R317.30 per month was found by Shackleton *et al*. (2005). The rates paid for livestock herders in communal areas of South Africa are lower than the minimum payment rate which should be R105 per day in the agricultural sector (South African Department of Labour, 2015). The current study found a herding rate of R3 075.00 per household, per year which is equivalent to R256.3 per month (Table 4.4). This hiring rate is less than the recommended R2 273.52 per month for an employee who works 9 hours per day (South African Department of Labour, 2015)

Table 4.4 Costs (Rands) associated with cattle and goat production per household in Umvoti Municipality (N=45)

Item	N	Mean	Median	Sum	Pr>|t|	Relative input cost (%)
Additional animals	13	12284.6	6000.0	159700.0	0.01	46.3
Lobola	9	14211.1	10000.0	127900.0	0.005	37.1
Fines	6	4933.3	800.0	29600.0	0.1	8.6
Supplementary feed	7	781.4	130.0	5470.0	0.3	1.6
Vet and medicine	39	417.6	230.0	16286.0	<.0001	4.7
Herders	2	3075.0	3075.0	6150.0	0.5	1.8
Total				345106		100.0

Crop production costs and inputs used to enhance crop yield

Farmers were asked about the types of inputs they use to improve soil fertility and improve crop yield as shown in Table 4.5. Manure was a form of organic fertilizer among households (44%) to improve crop yield while 14% of the households indicated no chemical fertilizers used. About 9% of the respondents were not practicing crop production. Some of the farmers used multiple input combinations to improve soil fertility (31%).

The use of manure saves money because farmers can easily access manure from their homestead (kraal) and it has a positive effect on nutrient balances. Although manure alone is not sufficient to restore nutrient deficiencies after harvests, it does make significant contributions. The value of one metric tonne of manure, as a fertilizer, was estimated in 1987 to be equivalent to 200 kg of fertilizer with a worth of Z$60 according to ARDA (Agricultural and rural Development Authority, 1987).

Table 4.5 Types of production inputs used by Umvoti smallholder farmers

Input type	Frequency Count	Percent of Total Frequency
Manure	24	44
None	8	14
Fertilizer & manure	7	13
No plants	5	9
Fertilizer	3	5
Fertilizer & compost	3	5
Fertilizer, manure & compost	2	4
Fertilizer	1	2
Fertilizer & manure	1	2
Manure & compost	1	2

Cost associated with crop production of communal farmers are presented in Table 4.6. None of the respondents were buying water from the municipality. Communal farmers purchased less production inputs than commercial crop farmers. Machinery and equipment, modern seeds and pesticides accounted for the highest cost of crop production and their relative input cost was 47.3%, 21.1% and 19.1%, respectively. Thus, a 95% confidence interval for the machinery mean was (-117.9 ± 1024.5). Nevertheless, the cost inputs of machinery and equipment, fertilizer and traditional seeds were not significant ($p>0.05$). Pesticides, improved seeds and household expenses (electricity and loan) made a significant contribution to the total production costs ($p<0.05$).

Smallholder commercial crop producers had high production costs than subsistence crop producers. The highest input was labour (24.3%), fertilizer (23.9%), modern seeds (16.1%), electricity (14.8%), and water (10.7%). Machinery and equipment, transport, pesticides and loan contributed 10.2% to the total crop production costs. The mean value for commercial crop production was R900 245 with a sample size of 4 farmers. Labour had a mean confidence limit of (-R235 109.6 ± R673 109.6) at 95%.

Table 4.6 Costs (Rands) associated with crop production in communal areas in Umvoti Municipality and household expenses (N=42)

Rural expenses	N	Mean	Median	Lower 95% CL for mean	Upper 95% CL for mean	Pr > |t|	Relative input cost
Machinery & equipment	6	453.3	200.0	-117.9	1024.5	0.1	47.3
Fertilizer (chemical)	3	126.7	60.0	-249.5	502.9	0.3	6.6
Pesticides	11	99.7	96.0	57.7	141.7	0.0004	19.1
Traditional seeds	3	113.3	100.0	-87.5	314.1	0.14	5.9
Modern seeds	21	57.8	50.0	42.0	73.6	<.0001	21.1
Total	44	850.8	506			0.5405	100.0
Household expenses							
Electricity	9	133.3	100.0	82.5	184.2	0.0003	38.8
Loan	4	210.0	840.0	156.4	263.6	0.001	61.2
Total		343.3	940				100

CL: confidence limit of the mean

4.3.3. Agricultural and household net income

Smallholder farmers in communal areas of Kwa-Zulu Natal use between R15 to R650 per year for crop production. Crop and livestock production made a significant contribution to input costs (expenses) ($p<0.05$) and can be observed in Table 4.4 and Table 4.6. The net loss for livestock production was –R14 418.60 including all costs associated with livestock production (Table 4.4). The results indicate that communal farmers are operating under economic losses. In this study a net value of R310.2 per household per year was found in subsistence oriented farmers. Three of the commercial farmers were farming together and they made a profit of R18 000 per month after all deductions associated with crop production. Annually, the co-operative farmers were making approximately R216 000 which they shared among themselves. While the other commercial crop farmer generated R472 800 per year. Therefore, the gross value was calculated by summing up profit generated from the trust and the one independent farmer (Table 4.7). Household net (home industry, gift and chicken live sales) income was R23 694.30 per household per annum.

Adams *et al*. (2000), reported that crop and livestock production in communal areas contribute R1 543 and R1 200 per household per year, respectively. Duvel and Afful (1996), found that the use of livestock together with the ranking priorities which may be the case of this study where a net loss (–R14 418.60) was found. Livestock sales were farmers' ways of generating income to take care of emergency expenses (Fossey &Kunene, 2006). Small stocks like goats were probably used to cover household income shortages and emergencies, and they are less expensive than cattle. These kinds of sale patterns might have contributed to production costs and low returns. Dovie *et al*. (2006) stated that farmers at Thorndale village (Limpopo) used goats to cover emergency costs while in the present study goats were mainly used for cultural purposes which contribute to food production and strengthen social relationships.

In summary, the present study found that livestock and household income (home industry, gifts and chicken live sales) were statistical significant. Although livestock net income was negative, this was because livestock sales were not common and rearing objectives were subsistence than income. From the findings, we can conclude that income from other sources, not from livestock or crop sales were used to cover livestock production expense.

Table 4.7 Annual gross values from livestock and crop production per household in Umvoti municipality (N=42)

Item	**Livestock**	**Crops**		**Household**
		Communal	Commercial	
Gross value (R)	21284.4	1161.0	1589045	23742.9
Production cost (R) (Including extra animals)	–35703	–850.8	–900245.0	–48.6
Net value (R)	–14418.6	310.2	688800	23694.3
Pr |t|	0.03	0.1	—	<.0001

4.3.4. Regression Model for livestock annual records

Goat entries

The number of observation in the data set used was 172 and all of the data sets were used in the analysis. There were no missing values neither for the response counts nor the predictor entry mechanisms. Given the value of deviance statistics of 331.7 with 168 degrees of freedom (DF) and the value/DF is bigger than 1 (Table 4.8), hence the model does not fit the data well. The lack of fit may be associated with covariates or over dispersion as no data was missing. The estimated model was:

$$\boldsymbol{Log\ (Yg)\ = -2.37\ + 1.75 bought\ + 4.04 bred - 1.39 donated}$$

A total of 779 live goats were recorded across all the sampled households (Table 3.6, Chapter 3). Entry rate was estimated using Equation 1, but the relative contribution per entry (i) was calculated using Equation 3. For example, kidding rate was calculated as follows:

Entry (bred) = $\frac{No.\ bred}{total\ entries} \times 100$

Using the above equation, kidding represented approximately 88.4% of goat entries per year for all respondents. However, entry rate (31.1%) was less than the exit rate (62.4%). This was probably associated with a high death and theft rate. Overall, there were approximately 214 kids born per year with a mean of 5.0 per farm. Moreover, low entry rate would mean that herd/ flock sizes are decreasing as indicated in Chapter 3.3.7. Although majority (37%) said goat flock size was increasing. Therefore, stolen goats were integrated in the heard/ flock of the thief because it was not so obvious whether stolen animals were sold or used for meat (home consumption).

Table 4.8 Criteria for assessing goodness of fit, goat entries

Criterion	DF	Value	Value/DF
Deviance	168	331.65	1.97
Scaled Deviance	168	331.65	1.97
Pearson Chi–Square	168	523.53	3.12
Scaled Pearson X^2	168	523.53	3.12

Log Likelihood	96.68

Algorithm converged.

The chi–square statistics for bought (10.4) and reared (64.3) with 1 degrees of freedom for both predictors, p–value for bought (0.001) and 0.0001 for reared animals counts resulted in the rejection of the null hypothesis that $\beta_0 = 0$ (Table 4.9). It was therefore concluded that the number of goats bought and reproduced (bred) are significant predictors for goat herd growth or asset accumulation. Donated or animals received as gifts was significant at 5% level, p–value was 0.2 and the null hypothesis was not rejected. Therefore, donated or goats received as gifts were insignificant predictors for increasing goat population.

Table 4.9 Analysis of Maximum Likelihood Parameter Estimates

Parameter	**DF**	**Estimate**	**Standard Error**	**Likelihood Ratio 95% Confidence Limits**		**Wald Chi–Square**	**Pr> Chi–Square**
Intercept	1	–2.3749	0.50	–3.54	–1.53	22.56	<.0001
Bought	1	1.7492	0.54	0.79	2.97	10.43	0.0012
Bred	1	4.0431	0.50	3.19	5.22	64.26	<.0001
Donated/ gifted	1	–1.3863	1.12	–4.36	0.52	1.54	0.215
Exchanged/ Lent	0	0.0000	0.00	0.00	0.00	.	.
Scale	0	1.0000	0.00	1.00	1.00		

Note: The scale parameter was held fixed.

<u>Adjusting for over dispersion</u>

In the above model we detected a potential problem with over dispersion as the scale factor (*Value/ DF* = 1.97) and is greater than 1. To test and adjust for over dispersion we need to add a scale parameter in SAS code from scale = none to “scale = Pearson”. The output results from SAS EG are shown in Table 4.10.

Here we consider the Scale deviance and Scaled Pearson chi–square statistics instead of the deviance. The overall model seems to fit better when we account for possible over dispersion with p–value about 0.20 for deviance (G^2) = 106.43, with *DF* = 168. The p–value was obtained by scaled deviance/ Pearson chi–square.

Table 4.10 New assessment of Goodness of fit

Criterion	DF	Value	Value/DF
Deviance	168	331.66	1.97
Scaled Deviance	168	106.43	0.63
Pearson Chi–Square	168	523.53	3.12
Scaled Pearson X^2	168	168.00	1.00
Log Likelihood		31.03	

Algorithm converged.

In the modified model (Table 4.11), the random component does not have Pearson distribution anymore because the response has the same mean and variance. From the given estimate (e.g., Pearson X^2 = 3.12), the variance of random component (response, the number of goats entering the herd) is roughly three times the size of the mean. The standard errors in model 2 (Table 4.11) in comparison to model 1 (Table 4.9) where scale = 1 are larger, e.g., X (bought) in model 2 is 0.96 = Scale (1.77)*0.54 which comes from the following equation:

Scale standard error (SE) $=\sqrt{value/df} * originalSE$. The Wald X^2 statistics is now smaller,

e.g. bought X^2 changed from 10.43 to 3.35, 3.35 = *10.43/ 3.116*. Note that square root of 3.116 (X^2) is equals to 1.765. The estimated model was as follows:

$Yg = -2.37 + 1.75X_1 + 4.04X_2 - 1.39X_3$, note exchanged was not included in the model because it was 0.

Other authors have reported similar results that the number of animals born per breeding season to have a significant contribution in livestock growth (Mapiye *et al*., 2009). It was therefore concluded that rearing is a good predictor for goat population increase (p<0.0001) which showed a strong evidence against the null hypothesis (β = 0). Moreover, buying of goats does not have a significant effect on asset accumulation or population increase, therefore, the null hypothesis was significant (p>0.05).

Table 4.11 Analysis of Maximum Likelihood Parameter Estimates (goats)

Parameter	DF	Estimate	Std Error	Likelihood Ratio 95% Confidence Limits		Wald chi–square	Pr> chi–square
Intercept	1	–2.37	0.88	–4.78	–1.03	7.24	0.007
Bought	1	1.75	0.96	0.16	4.23	3.35	0.067
Bred	1	4.04	0.89	2.67	6.46	20.62	<.0001
Donated/ gifted	1	–1.39	1.97	–8.49	1.9566	0.49	0.482
Scale	0	1.77	0.00	1.77	1.7653		

Note: The scale parameter was estimated by the square root of Pearson's Chi–Square/DOF.

Cattle influx

The fitted model seems to fit the data well with a deviance statistics of 949.8 with 184 degrees of freedom (DF) and p-value of 0.20. Thus the Value/ DF is close to 1 (Table 4.12).

Table 4.12 Criteria for Assessing Goodness of Fit

Criterion	DF	Value	Value/DF
Deviance	184	949.83	5.16
Scaled Deviance	184	188.00	1.02
Pearson Chi–Square	184	949.83	5.16
Scaled Pearson X^2	184	188.00	1.02
Log Likelihood		–419.03	

The analysis of parameter estimates for all cattle entry mechanisms were significant (p>0.05) and the null hypothesis was not rejected (β = 0) as shown in Table 4.13. Therefore, none of the explanatory variables were insignificant predictor for cattle population growth (p>0.05) and this accepts the null hypothesis that $\beta_i = 0$.The estimated model was:

$$Yc = -2.24 + 0.18X1 + 3.33X2 + 1.10X3 + X4$$

A cattle herd size of 615 was recorded across all sampled households (Chapter 3) which we used to calculate off-take and entry rate. An entry rate of 27.5% was estimated. Only 4 cattle were exchanged for items like bricks or for either a reproductive or non-reproductive animal or injured for non-injured animal to households that want to slaughter. Purchasing of cattle was not a common practice because only six cattle were bought during the study period across all sampled households.

The findings of the current study are comparable to that reported by Mapiye *et al*. (2009), who found 88% of entries from births and 12% from purchases. The authors also found that only 4% of farmers in the Eastern Cape Province of South Africa purchased animals as a way to increase the flock size. Shackleton *et al*. (2005) and Mapiye *et al*. (2009) tested the effect of herd size in selling animals and they found that the more livestock a household owns the more they likely to sell or slaughter for home consumption.

Table 4.13 Analysis of Maximum Likelihood Parameter Estimates (cattle)

Parameter	**DF**	**Estimate**	**Standard Error**	**Wald 95% Confidence Limits**		**Wald Chi–Square**	Pr>**Chi–Square**
Intercept	1	–2.24	3.08	–8.28	3.80	0.53	0.47
Bought	1	0.18	4.01	–7.68	8.05	0.00	0.96
Bred	1	3.33	3.08	–2.72	9.37	1.16	0.28
Donated/ gifted	1	1.10	3.25	–5.27	7.47	0.11	0.74
Exchanged/ Lent	0	0.00	0.00	0.00	0.00		
Scale	1	2.25	0.12	2.03	2.49		

Note: The scale parameter was estimated by maximum likelihood.

There seem to be differences in the contribution of cattle entry mechanisms (Table 4.13).The type 3 analysis indicates that all entry mechanisms are statistically significant predictor if we group the different entry mechanisms as one independent variable ($p<0.0001$). Although individually they seems to not to be significant predictors for cattle increase.

Goat outflow

The number of observations in the data set used was 258 and that's all of them were used in the analysis, that is there were no missing values neither for the response variable nor the predictor goat outflow. Given the value of deviance statistics of 3994.14 with 252 DF, the p–value of 0.064.The Value/DF is slightly higher than 1, so the model fit the data well as shown in Table 4.14.

Table 4.14 Goat criteria for Assessing Goodness of Fit

Criterion	DF	Value	Value/DF
Deviance	252	3994.14	15.85
Scaled Deviance	252	258.00	1.02
Pearson Chi–Square	252	3994.14	15.86
Scaled Pearson X^2	252	258.00	1.02
Log Likelihood		–719.50	

Algorithm converged.

From the analysis of parameter estimates: slaughter, donated, slaughtered, and sold were insignificant predictors of goat population outflow (p>0.05) and the null hypothesis was not rejected that their effect is zero (β = 0) shown in the Table 4.15 below. The number of animals that died and stolen were significant predictors for goat population decrease (p<0.05). Hence, β ≠ 0 and the null hypothesis were rejected for these independent variables. The estimated model for goat exits:

$$Yg = 0.98 + 0.88X1 - 4.74X2 - 11.50X3 - 0.89X4 - 1.08X5 + X6$$

The present study revealed that a communal farmer in Umvoti loses approximately 7 goats per year through death and 3 from theft. There were more goats slaughtered (47) than cattle (33). Goat removal rates was estimated at 62.4% per annum with large losses from death at a rate of 57.4% per household per year.

Dovie *et al*. (2005) and Shackleton *et al*. (2005) found that goats are used and meat replacing cattle for ritual slaughter in communal areas of South Africa which contribute to food security.

Table 4.15 Analysis of Maximum Likelihood Parameter Estimates for goat removal

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi–Square	Pr> Chi–Square
Intercept	1	0.98	0.22	0.54	1.42	19.23	<.0001
Died	1	0.88	0.24	0.40	1.35	12.97	<.0003
Donated	1	–4.74	25.80	–55.32	45.83	0.03	0.85
Exchanged	1	–11.50	1530.01	-30645.80	30622.76	0.00	0.99
Slaughtered	1	–0.89	0.59	–2.06	0.27	2.28	0.13
Sold	1	–1.08	0.70	–2.45	0.29	2.40	0.12
Stolen	0	0.00	0.00	0.00	0.00	.	.
Scale	1	3.93	0.17	3.61	4.29		

Note: The scale parameter was estimated by maximum likelihood.

There seems to be differences in the number of goats leaving the flock between the exit mechanisms according to the chi-squared statistics for each row in Table 4.15, with a reference level stolen. Furthermore, Wald type 3 analysis output indicates that the goat exit mechanisms are statistically significant predictor of goat population decline.

Cattle outflow

The number of observations used in the data set was 288 and all of the data set were used for the analysis. Given the value of deviance statistics of 4475.27 with 282 DF and a p-value of 0.064 and the Value/DF is slightly above 1, therefore the model fit well (Table 4.16).

Table 4.16 Criteria for Assessing Goodness of Fit

Criterion	DF	Value	Value/DF
Deviance	282	4475.27	15.87
Scaled Deviance	282	288.00	1.02
Pearson Chi-Square	282	4475.27	15.87
Scaled Pearson X^2	282	288.00	1.02
Log Likelihood		-803.69	

Algorithm converged.

Table 4.17 reveals that none of the explanatory variables were statistically insignificant predictor of cattle replacement (p>0.05) except for stolen and the null hypothesis was not rejected (β_c = 0). Therefore, stolen cattle counts were statistically significant predictors of flock decline (p<0.05). Moreover, the standard errors are larger which also confirms that stolen (std. error = 0) is the only significant independent variable for predicting cattle replacement or removal.

Table 4.17 Analysis of Maximum Likelihood Parameter Estimates

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr> Chi-Square
Intercept	1	-0.83	1.30	–3.38	1.72	0.40	0.53
Died	1	0.39	1.57	–2.69	3.47	0.06	0.80
Donated	1	-0.48	2.47	–5.32	4.36	0.04	0.85
Exchanged	1	0.29	1.63	–2.90	3.47	0.03	0.86
Slaughtered	1	1.60	1.33	–1.00	4.20	1.45	0.23
Sold	1	1.11	1.37	–1.57	3.80	0.66	0.42
Stolen	0	0.00	0.00	0.00	0.00	.	.
Scale	1	3.94	0.16	3.63	4.28		

Note: The scale parameter was estimated by maximum likelihood.

The above results (Table 4.17) are also confirmed by Wald Type 3 analysis that the chosen cattle removal mechanisms are not statistical sufficient estimates for cattle population decline.

The estimated model for cattle exits:

$$Y_c = -0.83 + 0.39X1 - 0.48X2 + 0.29X3 + 1.60X4 + 1.11X5 + X6$$

A cattle removal rate of 44.4% (Equation 2) was estimated (17.2% died, 15.9% sold, 5.4% slaughtered, 0.8% donated and 5.0% stolen) for all cattle owners. The cattle exit rate (44.4%) was higher than its entry rate (27.5%) with the largest exit contribution from death and sales (33.2%). For the present study, calving and purchases contributed 84.6% and 3.6% to the total entries for all households, respectively.

The findings of the current study differs from that of Shackleton *et al*. (2005), who found a 12.1% (6.6% died, 4.2% theft and 1.3% other) removal rate based on 1998 secondary data. Additional, the authors also evaluated the correlation of cattle off-take mechanisms through sales for financing household needs, school fees, hospital bills, village taxes and emergencies and they found no correlation between offtake and herd size. Groenewald & du Toit, (1985) reported that off-take increase with increased herd size.

4.3.5. Biological property investment

Cattle investment

Oxen or steer and bull were selling at R5 500 to R11 000, a mid–point of R8 250 was used. Heifer were selling at R5 000, while mature cows were selling for R7 000. Bucks were sold for R1 000, while prices ranged from R1 000 to R1 800 (average = R1 400) and wether were sold for R1 000 to R2 000 (mid–point = R1 500). Young animals are not usually sold, therefore an estimated price of R1 000 for calves and R100 for kids were assigned. The investment rate was determined by the principal value (Table 4.1) obtained from the number of animals a household owns multiplied by the financial value assigned to that animal type. All livestock investments were calculated on half yearly basis. There were approximately 111 calves, 304 cows, 61 heifers, 58 bulls and 19 oxen or steer after removing owners with unknown livestock numbers. Respondents indicated to sell their livestock if there is urgently needed cash or as a form of insurance, which provide cash for the family when they have lost a breadwinner.

The investment amount per animal type was as follows: R1 158.72 for calve, R5 382.20 for a heifer, R7 535.08 for a cow, while bull or oxen had an investment value of R8 880.63. Cows had higher investment values than bulls and calves, and the relative contribution for cows was 67.0% followed by bulls (14.8%). The results are displayed in the table below (Table 4.18).

Bosman *et al*. (1997) stated that rural communities in Southwestern Nigeria did not have access to credit and banking facilities in the past. Hence, they use livestock as an alternative method for saving and as a way to avoid inflation (Randolph *et al*., 2007). Shackleton *et al*. (2001) and Sikhweni & Hassan (2013) stated that the more livestock a household owned, the greater the investment portfolio for cash savings and security, which was solely determined by the interest value of the principal amount of the total animals in a given category per farm. Many studies have recognized the use of livestock as a form of live bank savings (Ainslie, 2002; Campbell *et al*., 2002; Shackleton *et al*., 2005; Dovie *et al*., 2006), but the lack of empirical studies on actual accumulated income from livestock savings and differences in modelling and evaluation methods makes it difficult to compare our results with other studies. Shackleton *et al*. (2005) reported a cattle savings of R2 487.30 for all sampled cattle owning households in Bushbuckridge region of the Limpopo Lowveld. Mhinga Traditional Authority (TA) in the Vhembe District of Limpopo Province, South Africa (Chaminuka *et al*., 2014) reported a financing value of R1 189 and an insurance value of R137.

Table 4.18 Cattle half yearly asset values (rand = R) per household in different areas of Umvoti Municipality (N = 45)

Variable	N	Mean	Min	Max	Sum	Relative contribution (%)
Calves	37	3511.6 ± 495.3	1158.7	15671.7	129928.5	3.69
Cows	40	58962.6 ± 12834.8	7535.1	457957.9	2358505.4	67.04
Heifers	25	13421.7 ± 1645.9	5382.2	33265.7	335542.4	9.54
Bulls	33	15804.5 ± 1690.5	8880.6	54888.4	521549.1	14.83
Steer/ Oxen	9	19144.0 ± 4726.5	8880.6	45740.4	172296.3	4.90
Total cattle investment	45	78173.8 ± 12852.1	10039.4	491745.9	3517821.6	100

Means are given together with the standard error; N is the number of households or respondents owning livestock (sample size).

Goat investment

The present study calculated asset values of 39 goats. Each goat owning household was saving at least R209.40 for every kid born per breeding season, R1452.50 for every doe, R1556.30 for a buck and R1556.30 for a castrated buck (wether), Table 4.19. Productive males and females had the highest investment, 20.2% and 69.3%, respectively. The asset value of goats was less than of that cattle, because goats are smaller, and the unit price of goat products was less than that of cattle.

Shackleton *et al*. (2005) reported a net asset value of R415.44 per household per year from goats (including savings and mortality). Bosman *et al*. (1997) studied the benefits of keeping goats in Nigeria and they reported a financing value of 23 and 116 Naira. These results are not comparable with our current findings, due to differences in methodology. Bosman *et al*. (1997) used biological parameters i.e. body weight to calculate the goat asset investment. Mtati (2014) reported that households in Nkonkobe local municipality (Eastern Cape Province) had a mean net value of R11165 from consumptive goods and services excluding savings and herd growth. These results are difficult to compare with that of the present study as savings was not included.

Table 4.19 Half yearly goat investment values (R) per household in communal areas of Umvoti municipality (N = 39)

Variable	N	Mean	Min	Max	Sum	Relative contribution (%)
Kids	30	716.3 ± 73.4	209.4	1675.4	21490.5	3.02
Does	38	12968.2 ± 1711.8	1452.5	50123.9	492791.1	69.30
Bucks	36	3994.8 ± 959.2	1556.3	34749.8	143812.8	20.22
Wether	10	5303.7 ± 1052.2	1556.3	12574.0	53037.2	7.46
Total goat investment	39	18234.1 ±2535.1	1452.5	75077.6	711131.5	100.00

The mean is given together with the standard error; N is the number of households or respondents owning livestock (sample size).

4.4. Conclusions

In conclusion, smallholder farmers in Umvoti Municipality employ mixed livelihood strategies to minimize vulnerability against unforeseen natural or human–induced events. Fixed incomes were seemingly ranked the most important source of income than income from agricultural practices. Low livestock returns came with no surprise as most respondents were older (over 50 years) and were already on pension which might have discouraged them from selling their animals for cash. Manure was the common organic fertilizer used by Umvoti smallholder farmers to enhance soil fertility. Pesticides and modern seeds had a significant effect on communal cost of production. All input costs associated with commercial crop production had no significant effect on the farm profitability because of the small sample size. The parameter estimate for goat entries showed that the number of kids is a good predictor for goat population growth. The analysis of parameter estimates for cattle bought and donated animals were the only significant predictors for cattle increase. In both cattle and goats, off-take rate was higher than the entry rate. The study also found that dams (females) accumulates more cash savings than sires (males). The relative contribution of cows was higher than that of the sires for cattle investment. A similar pattern was observed for goats where does accumulated more cash savings that bucks. The use of livestock as a form of investment, holds a greater promise of accumulating income notable in communal areas where banks are not easily accessible, and helps this households avoid inflation.

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Chapter 5

Soil and rangeland condition of smallholder farmers at Umvoti Municipality, Kwa-Zulu Natal

Abstract

Decline in rainfall affects the availability of fodder by limiting plant growth through water availability from the soil and contributes to rangeland degradation. An investigation was carried out to study the impact of production inputs (fertilizer, manure, combination and none) on soil chemical concentration. Soil samples were randomly collected from the top soil (0–45 cm) using a soil auger and sent to Bemlab for analysis. Interviews were also used to validate lab results. Historical rainfall data was used to establish if there were changes over the past years that could contribute to fodder availability and rangeland degradation. The results showed that there was no change in rainfall with a negative p–value ($p = -0.098$). However, there have been seasonal fluctuations over the past years. Treatment inputs (fertilizer, manure, mixed and none) had equal effects on soil chemical properties ($p>0.05$), but had different effects on sodium concentration and T–value (cmol/kg) percentage ($p<0.05$). Cropping patterns (mono; mixed; mono and rotational; and mixed and rotational) had different effects on soil carbon percentage ($p<0.05$). Rangeland condition of the surveyed communities was severe to medium degraded with a condition score ranging from 40 to 60 percent and a carrying capacity of 4 to 23 ha/LSU. From the study findings, it was concluded that the effects of cropping patterns on soil carbon need to be further evaluated to identify which of the cropping patterns holds a promise in carbon sequestration. The identified cropping pattern could be used as a management tool for storing carbon in the soil where micro–organisms and soil biological processes can effectively use it to improve soil fertility and health.

Keywords: rangeland condition, cropping patterns, production inputs

5.1. Introduction

Soil quality and health are analogous terms used to describe the condition of the soil (Idowu *et al*., 2008) which may be induced by agricultural management practices (Wienhold *et al*., 2004). These management practices include tillage, minimum till, crop rotation, continuous cropping, and production inputs (fertilizer, manure, and compost). According to Doran and

Parkin (1994) soil quality is the ability of the soil to function to its maximum capacity and stimulate plant growth and ensure adequate fodder for animal consumption and health. Dynamic soil quality refers to changes occurring in the soil due to human interference through field management practices (Wienhold *et al*. 2004). Soil provide a growth medium for all vegetation growth and plays a key role in nutrient and carbon cycling, and water purification (Lesoli, 2008). There are 13 well known minerals in the soil that are essential for plant growth and reproduction (Gwelo, 2012) and are classified into micro – and macro minerals (Karr, 2003). In South Africa, there seven trace minerals considered most important and are as follows: cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), lead (Pb), nickel (Ni) and zinc (Zn) (Herselman, 2007). Soil quality assessment is divided into three categories: biological, chemical and physical properties. Biological properties includes organic matter content, microbial activity, root health and growth, bacterial and fungal proliferation, while chemical processes have to do with cation exchange (Amezketa, 1999). According to Dexter (2004) soil physical factors such as texture, stone content and aggregate stability plays an essential role in controlling biological and chemical processes in the soil.

Francis and Kemp (1990) argue that agricultural management practices like tillage, crop rotations, cover crops and organic matter additions can negative or positive affect soil quality and crop yield. Cover crops decrease water and wind erosion, increase water infiltration and retention, and improve nutrient cycling, while tillage exposes the soil to frost, high temperatures and rain which my result into limited plant growth. Consequently, soils exposed to different management practices and agricultural inputs are likely to have different mineral composition.

Factors like soil texture, pH, organic matter content and cation exchange capacity (CEC) are known to affect the availability of soil nutrients (Jones, 2001). Soil pH plays an integral role in the availability and solubility of nutrients. For instance, at pH 6.5– 8, calcium (Ca) and magnesium (Mg) is absorbed in large amounts (Gwelo, 2012). At pH 7– 7.5, minerals like iron (Fe), manganese (Mn), copper (Co) and Zinc (Zn) are limited, while boron (Bo) is available in adequate amounts for plant absorption (Matlhoahela *et al*., 2006). Phosphorus (P) and nitrogen (N) uptake are favoured at pH 3– 6.

South Africa is regarded as semi–arid because it receives a mean annual rainfall less than 500mm (Meissner *et al*., 2013) and livestock production is preferred than crop because of limited water for irrigation. There is, however, a wide range in annual rainfall in South Africa, namely: winter rainfall areas (Western Cape); bimodal rainfall areas (Eastern Cape) and summer rainfall areas (central Highveld and Kwa-Zulu Natal) (Palmer & Ainslie, 2006). Summer rainfall areas support cattle and sheep production. The western regions encourages C3 grasses and shrubs and favours sheep and goat production. Because of the varying rainfall seasonality and plant growing periods this implies that it is farmers' responsibility to manage their rangelands sustainably and techniques to provide water to their animals. Kwa-Zulu Natal belongs to the grassland biome and is classified as a sour–veld.

A good understanding on feed availability, soil health status, dynamics in rainfall, and livestock feed and water requirements are required. Therefore it is important to evaluate changes in rainfall to enable arid livestock producers to plan accordingly and manage risks imposed by environmental variability and general production constraints. According to Malherbe *et al*. (2013), more dry spells and heavy storms with more run–off would be expected in the near future. In Chapter 3 (3.4.6) respondents indicated that their rangelands is overgrazed, but the driving factor behind vegetation dynamics and deterioration was drought (44%). To verify this claim, the study evaluated changes in rainfall from 1997 to 2014 and this can be regarded as one of the production constraints that may be experienced by rural farmers of Umvoti Municipality. In response, hypotheses (III) and (V) of Chapter 1 was tested as an attempt to address the following research question: does cropping patterns and fertility inputs have effects soil nutrients affecting soil health?

5.2. Methods and materials

5.2.1. Description of the study area

The study was conducted in Umvoti local Municipality under UMzinyathi District Municipality in Kwa-Zulu Natal Province of South Africa (Figure 5.5.1). The municipality has a latitude of 290 4' 0" S and a longitude of 300 35' 0" E. The altitude ranges between 1 340 to 1 620 meters with an annual rainfall of 730–1 280 mm (Mucina *et al*., 2006). According to Mucina *et al*. (2006) and the Integrated Development Plan (IDP) (2014/2015), the municipality is characterised by both the Moist Midlands Mist belt and Dry Midlands Mist belt and is classified as Midlands Mist belt Grassland. Rainfall is associated with summer thunderstorms, strong winds and hail. Winter and spring rainfalls are in the form of cold fronts. The Moist Midlands Mist belt is characterized with low temperatures ranging from 15 ^{0}C–18.5 ^{0}C while the Dry Midlands Mist belt has annual mean temperature of 16.2 ^{0}C–17.6 ^{0}C, with an absolute minimum temperature of –10.8 ^{0}C recorded over June month.

The landscape is highly fragmented and associated with an uneven east–facing escarpment, south of Thukela River. The vegetation is classified as sour veld and is prone to Ngongoni grass (Aristida junciformis) invasion. Apedal and plinthic are the common soils of the district (Mucina *et al*., 2006). These soils are derived from Ecca Group shale and minor sandstone, and less importantly from Jurassic dolerite dykes and sills and dominated by land type Acrisols (CA), followed by fulvic acid (Mucina *et al*., 2006). Acrisols are soils with only A and C horizons, commonly in new alluvium (sand, silt, or clay) or on steep rocky slopes (http://nesoil.com/gloss.htm, 2015). According to Palmer and Ainslie (2006) sour–veld is associated with acid soils of quartzite and andesitic origin, and occurs in areas receiving a rainfall above 600 mm per year and at an elevation greater than 1 400 m. The figure below (Figure 5.5.1) shows where the study was conducted.

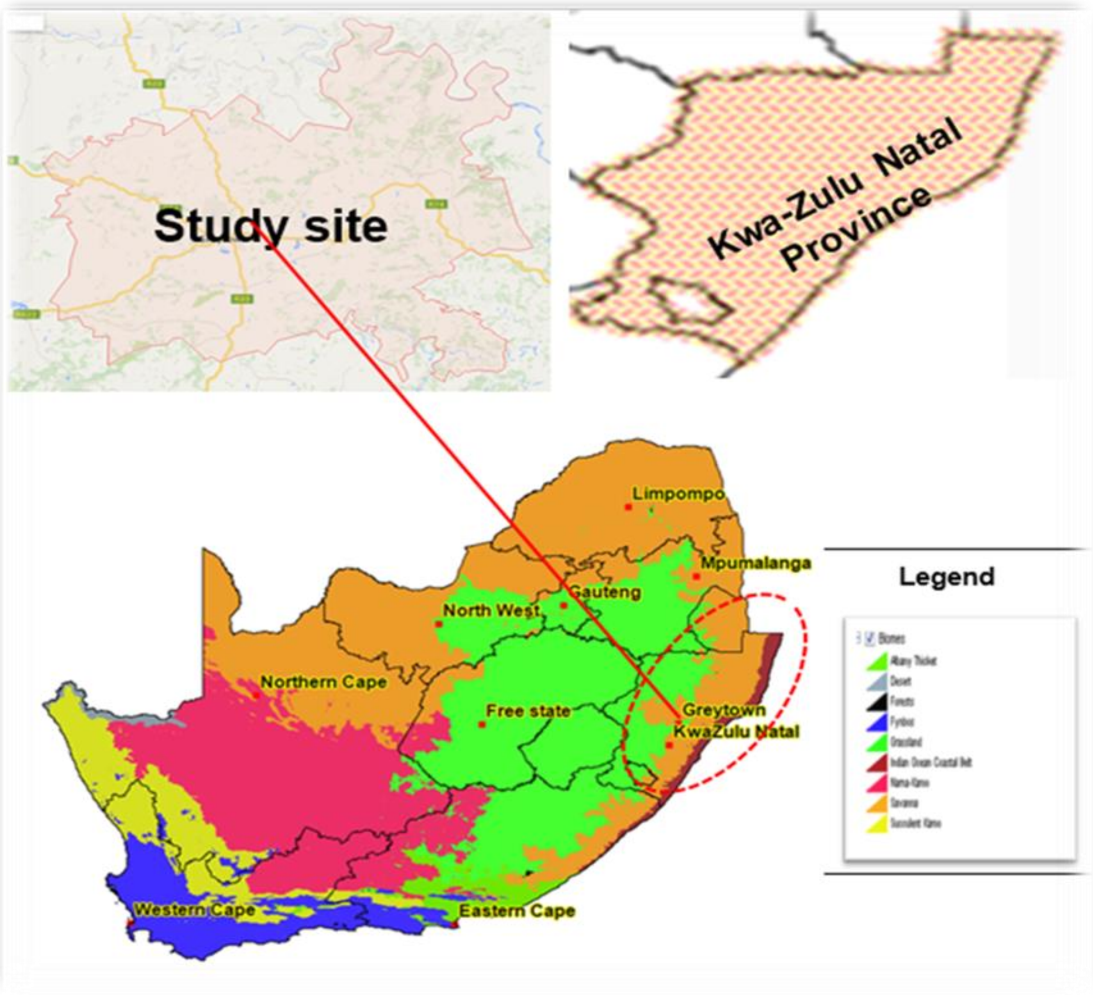


Figure 5.5.1 Indicates the map of South Africa and the study area (Internet source).

5.2.2. Data collection

Farmers were interviewed about the condition of the soil using a questionnaire (n=49). Each respondent was required to mark one of the given options about the soil condition. The options were as follows: the soil is very poor, poor, medium, good and excellent. A total of 17 soil samples were randomly taken from cultivated farm yard or field plot. Soil samples were taken from farmers that had crops during the study period within a walkable distance. Soils were collected using a soil auger at a depth of 45 cm from the topsoil between the crops. If there were prominent crop rows soils were taken inside the row. In uncultivated fields no soils were taken because it was not going to give fair results on the soil fertility status and the minerals available in the soil for comparison. Samples from each household or farm field plot was mixed thoroughly and a composite sample was placed in a plastic bag. Samples were then air dried and send to Bemlab for analysis. The analysis included the pH, stone percentage, exchangeable cation, carbon percentage, nitrogen (N), phosphorus (P) and potassium (K).

Rainfall changes was measured using rainfall data from 1997 to 2014 obtained from South Africa Weather Services (SAWS) (www.weathersa.co.za, 2015; personal communication, Joe.Matsapola@weathersa.co.za).

Secondary data on the condition of veld for various rural communities that participated in the study was attained from Botha (2013) through (personal communication, Botha, 2015) from the Department of Agriculture, Forestry & Fisheries. The dataset was represented using maps that emanated from bio–resource program.

5.2.3. Data analysis

Cropping pattern were grouped into mixed, mono, mono rotational, and mixed rotational. The soil samples were uneven among the different cropping pattern groups and too small and made it difficult to make comparisons between the groups. In response, mono and mono rotational was pooled together to make a better comparison between the cropping patterns and the soil chemical concentrations. The new subdivision was called mono and rotational as displayed in Figure 5.2. Statistical 12 was therefore used to examine the effects of cropping patterns and production inputs on soil mineral concentration. Kruskal–Wallis (a non–parametric) statistical test was used to test the effects of cropping patterns and production inputs on soil mineral concentration. Kruskal–Wallis Test was used to test the significant differences between treatment means. Inspections of the normal probability plots indicated no severe outliers that could influence the results. Hence, we assumed that samples from the different populations were independent random samples and have the same general distribution shape.

If the null hypothesis of equal treatment effects gets rejected, this meant that not all the treatments means (production inputs) have equal effects on the soil and the difference between the treatments were unknown. To know exactly which of the treatments (production inputs or cropping patterns) differ significantly from each other, multiple comparisons was performed using Fisher's LSD (Least Significant Difference).

An area chart was used to illustrate rainfall trends from 1997 to 2014. The significant changes in rainfall was reported by using Pearson correlation (r). A statistical software (SAS Enterprise Guide 5.1) was used to analyse farmers' perceptions on soil condition. Percentage of total frequency was generated using descriptive statistics of categorical variables.

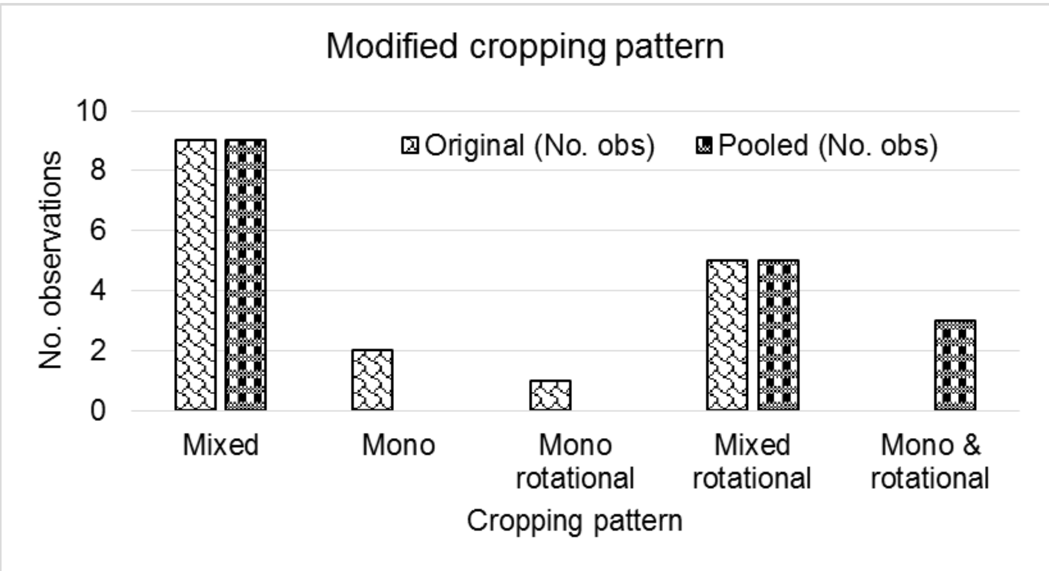


Figure 5.2 Communal cropping patterns of Umvoti Municipality.

A similar approach was applied to production inputs, where input combinations were pooled together to better compare the different treatments. Manure and compost, fertilizer and manure, and fertilizer, manure and compost were pooled together, and the new category was called "combination". Figure 5.3 indicates the number of observations before and after pooling production inputs into sizeable samples for better comparison.

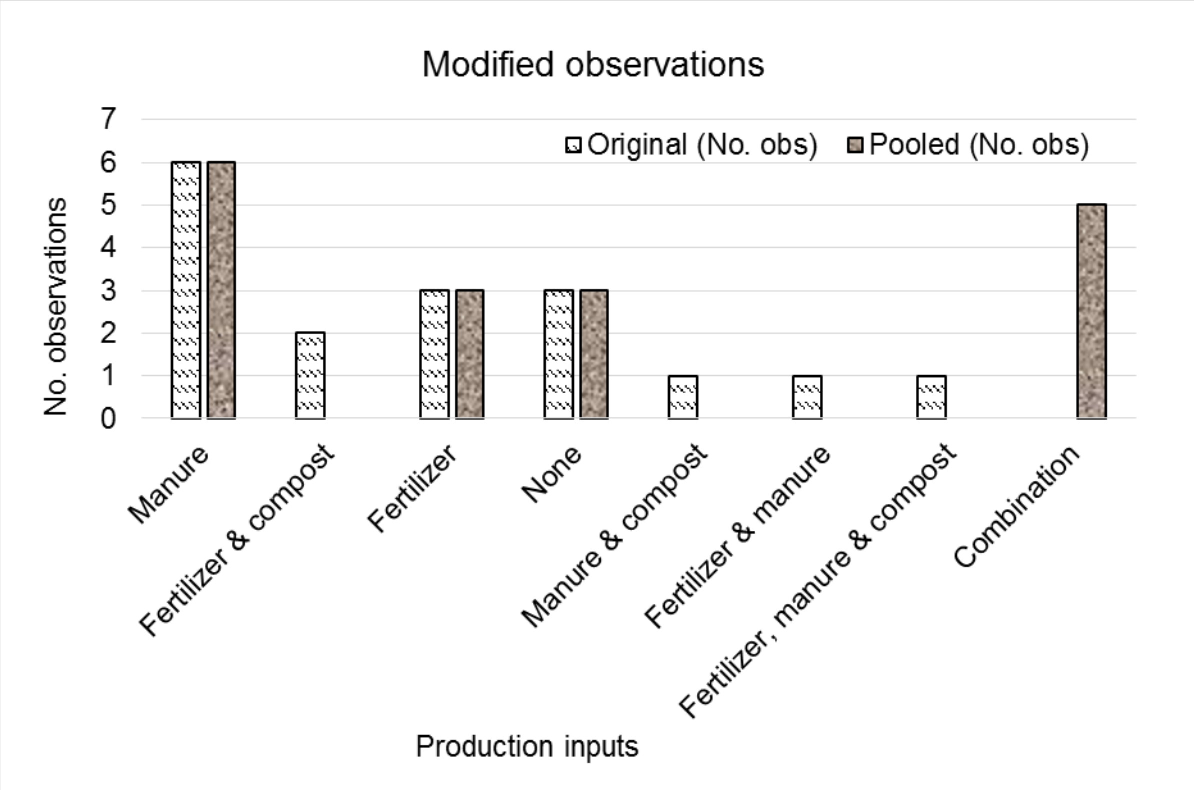


Figure 5.3 Types of production inputs used by subsistence farmers at Umvoti Municipality.

5.2.4. Hypotheses

(a) Hypothesis (III) of Chapter 1 was tested which states that there are no differences between treatments means or production inputs on soil minerals and was formulated as:

I. H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$

II. H_1: $\mu_1, \mu_2, \mu_3, \mu_4$ are all not equal

Where μ_i is the mean of the i^{th} treatments (production inputs or cropping patterns)

$\alpha = 0.05$

(b)There were no changes in rainfall from the year 1997 to 2014.

5.3. Results and discussion

5.3.1. Changes in rainfall

Figure 5.4 displays rainfall trend from 1997 to 2014. The data indicate no significant change in the amount of annual rainfall ($p>0.05$). The graph also indicates that as the number of years increase, rainfall may decline with small amounts. This can be observed from the graph (Figure 5.4) that there is no decline in rainfall but fluctuations.

The rainfall of South Africa is erratic and uneven with high incidence of drought which favours rural people to keep livestock as a mitigation strategy against crop failure (Musemwa *et al.*, 2008). Thus, changes in rainfall have been noticed worldwide. In South Africa, a decline in rainfall has been observed in different provinces (Christensen *et al*., 2007; Engelbrecht *et al*., 2009; Meissner *et al*., 2013). A decline of 40 mm in rainfall and an increase in day temperature in Mpumalanga, Northern Cape and Limpopo Province has been reported. This raises two considerable concerns that can worsen the environment (Lange *et al*., 1998): (I) an increase in soil erosion which can induce changes in vegetation cover and (II) water access and availability.

Farmers in Chapter 3 section 3.4.9 stated that their animals have little if any effects on the change of the rangeland and this claim was insufficient because there was no change in rainfall. Based on these results, it was concluded that other factors other than rainfall are main causes of feed shortages and rangeland degradation. These factors includes overstocking density, poor vegetation (unpalatable grass species), and poor soil condition i.e. poor moisture retention, etc.

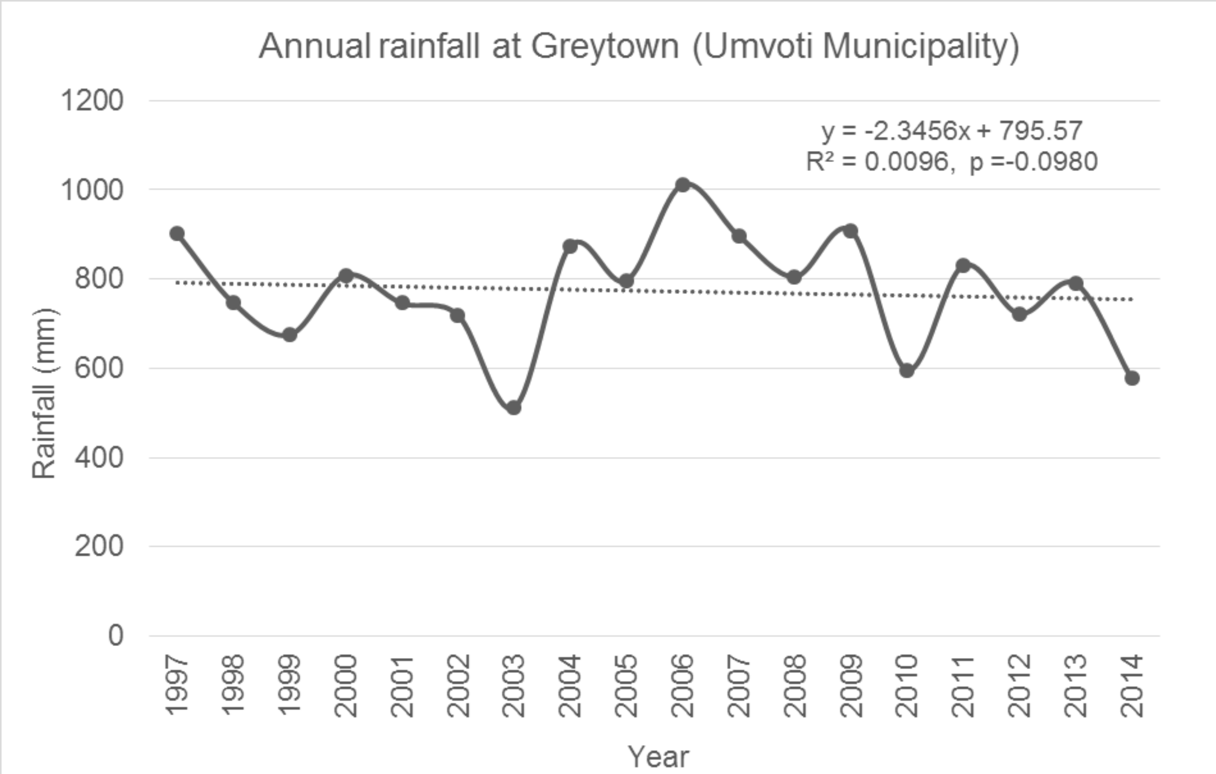


Figure 5.4 Annual rainfall at Grey town (Umvoti Municipality, Kwa-Zulu Natal).

5.3.2. Soil chemical concentration

From the interviews the majority of the respondents indicated that their soil were in good condition (34.7%) and 26.5% had poor soils. Only 8.1% of the respondents perceived their soils to be very poor and that it might negatively affect crop yield if no fertility improvements are made. Excellent soil conditions were reported by at least 16.3% of the respondents and (14.3%) ranked their soil as medium.

The soils were classified into three textural groups, namely clay, loam and sand. Textural grouping is important because it is known to affect its chemistry. Table 5.1 indicates the soil textual group; pH; stone percentage; Carbon percentage; Cu; Zn; Mn; B; and Fe. Most of the samples were acidic (Table 5.1) with a minimum pH of 4.3 to a maximum pH of 7.1.

According to Vangheluwe *et al*. (2005) pH is a primary property that controls soil chemistry and biological processes. For example, at pH 6.5–7.5, sodium (Na), potassium (K), copper (Cu), boron (B) and zinc (Zn) is optimized adapted from Gakwerere (2012). Hydrogen ions are mainly used as a standard measure for pH (Herselman, 2007). Cataldo and Wildung (1978) states that soil pH is mainly affected by changes in redox potential, soil properties, decomposition of organic matter and weathering during soil development. Herselman (2007) states that clay content and soil pH affects the concentration of trace elements in the soils. The author further states that soils with low clay content or low pH have lower concentration of trace elements than soils high in clay content or high pH. Kwa-Zulu Natal (KZN) vegetation is sour and it was expected for the soil to be acidic because acidic soils are associated with high rainfall (>600 mm) and high altitude (>1 400 m) (Palmer & Ainslie, 2006). Trace elements are elements derived from both soil parent and agricultural production inputs, like fertilizer, that are needed by plants for growth, development and reproduction, and are commonly called micronutrients (adapted from Zhenli *et al*., 2005; Gakwerere, 2012).

Stronkhorst *et al*. (2010) evaluated the chemical composition of soils from commercial crop production and grazing lands (rain fed and irrigated) at Okhahlamba municipality, KZN, and they reported that most of the soils were acidic and relatively acceptable for maize (pH 5.5–6). The study also found similar results to that of Stronkhorst *et al*. (2010) where a minimum pH of 4.3 was recorded.

Based on the results, nutrient mining does not seem to be an issue since respondents indicated to employ some kind of soil fertility management. Based on these assumptions, it was concluded that poor soils might be associated with soil acidity as some farmers indicated to have poor soils from the interviews. However, soil acidity can be addressed through liming. According Haynes and Naidu (1998) liming improves soil physical structure and biological activities, but its mechanism is unclear. It is also a common method used to increase the pH of acidic soils (Viade *et al*., 2011). The trade–off of liming involves reduction of N leaching into fresh water that would otherwise increase greenhouse gas emissions (Gibbons *et al*., 2014). However, the use of lime in agricultural fields is a bit sceptical because is costly, thus the benefits to avoid eutrophication to water bodies is yet to be investigated. Grieve (1990) stated that liming may raise the concentration of dissolved organic matter released from the soil to freshwater. The author also stated that the removal of dissolved organic matter from water before human consumption may increase greenhouse gas emissions. Therefore, it is better to consider benefits against the effects.

Table 5.1 Summary of soil chemical analyses, (N=17)

Soil textual group	PH (KCl)	pH group	Stone V%	C%	Cu	Zn	Mn	B	Fe
Clay	4,6	Acidic	44	2.48	8,2	12,3	166	0,27	286
Clay	4,8		44	1.89	10,2	2,9	332,8	0,40	283
Clay	4,6		23	0.88	15,4	13,6	452,9	0,59	264
Clay	5		35	1.64	7,1	2,4	172	0,17	188
Clay	5,5		64	1.41	21,6	1,8	248,2	0,45	145
Clay	6,2		64	2.0	20,1	19,1	278	0,30	122
Clay	6,2		29	1.43	34,3	1,7	385,1	0,85	84
Clay	5,5		61	0.93	16,7	3,2	305,6	0,31	84
Loam	4,5		29	2.06	9,2	5,1	231,1	0,57	219
Loam	4,8		50	1.19	3,6	2	68,5	0,44	120
Loam	4,3		21	2.51	9,7	10,9	64,7	0,35	115
Clay	6,5	Neutral	59	0.77	10,2	6,7	255	0,18	77
Clay	6,8		32	1.36	2	3,4	10,6	0,26	6
Clay	7,1		29	1.37	5,9	4,1	9	0,24	6
Loam	6,9		29	2.16	5,2	48,1	61,9	3,61	46
Loam	7,1		18	2.62	4,7	15,3	14,2	0,63	17
Sand	7,1		8	0.55	3	0,4	14,9	0,4	5

Figure 5.5 Depict the impact of production inputs on soil carbon percentage. Shows that there was no differences between production inputs namely: manure, fertilizer, control (none) and input combinations on carbon percentage ($p>0.05$). Therefore, the null hypothesis is not rejected at 5% level.

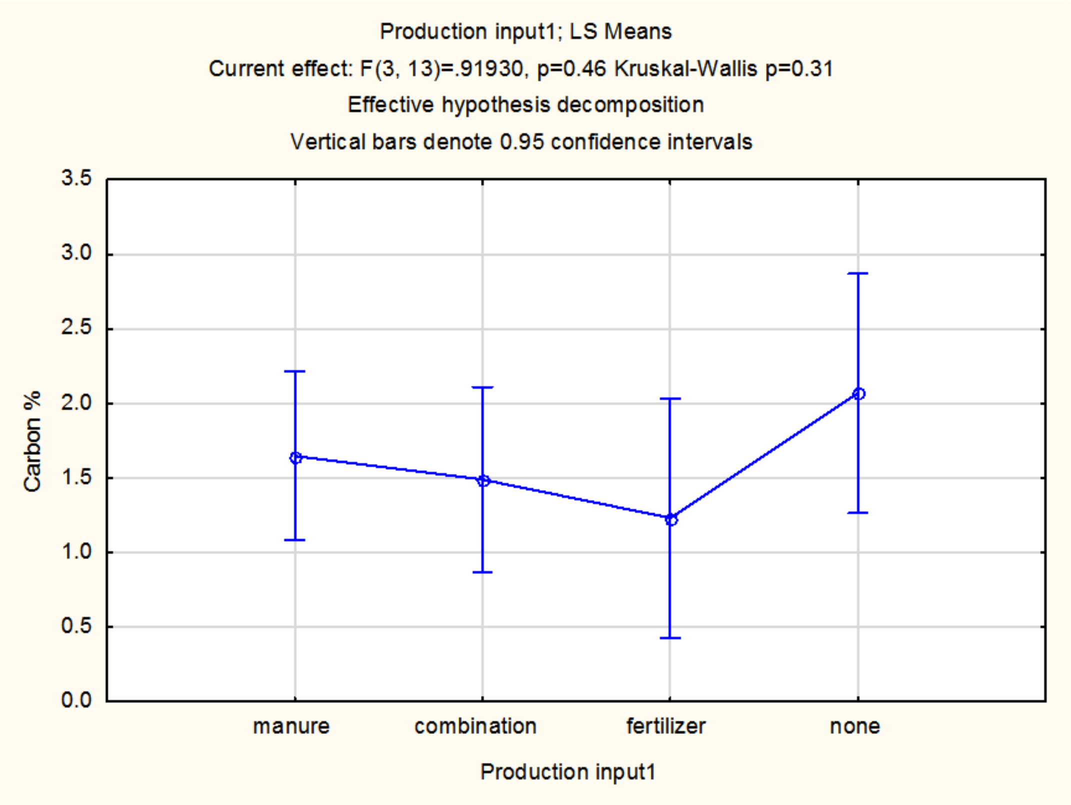


Figure 5.5 Depict the impact of production inputs on soil carbon percentage.

Table 5.2 indicates that there was no evidence against the null hypothesis at 5% significant level (p> 0.05) that production inputs have different impact on carbon (C) percentage, pH (KCl), stone percentage, Copper (Cu), Zinc (Zn), Manganese (Mn), Boron (B) and Iron (Fe) of the sampled soils. Since there were no differences on the treatment inputs, this means that the treatment inputs have equal effects on the soil minerals that are shown in Table 5.2. The fertilizer or manure used by farmers in Umvoti is most likely to equal effects on crop yield because there were no differences in mineral quantity. Fertiliser seem to decrease the carbon content a little bit more than the manure and combination, even though it is not significant, but since the quantity and the types of fertilizers used by the farmers were unknown, it is makes it difficult to make recommendations. On input management point of view, the use of manure is encouraged because it does not decrease carbon higher than the use of fertilizer. The study therefore, favours the use of farm generated inputs as a way to minimise waste and improve nutrient cycling. Hence, allowing farmers to save money from buying fertilizers and likely to be become financial stable.

Hati *et al*. (2007) investigated the effects of long term application of fertilizer and manure on soil organic carbon in central India, and they found that soil organic carbon (SOC) was significantly influenced by the type of the inputs they used in the field. Similar results were reported by Yanai *et al*. (2001) who studied the effects of agricultural inputs on SOC over a two year period. However, in both studies, experiments were conducted which was followed by intense soil sample collection, while in the recent study samples were randomly collected from households with cultivated land. The differences in methodology and experiment design makes it difficult to compare the study findings.

Moritsuka *et al*. (2015) evaluated the influence of past and present field management on soil properties and these authors reported that the distribution of field attributes was influenced by past management i.e. passage of machinery and application of external inputs (fertilizer, manure, compost etc.). Based on the above of information, it was concluded that agricultural cropping inputs does influence, to a certain extent soil chemical and also soil physical properties (Hati *et al*., 2007; Moritsuka *et al*., 2015). Further, the authors reported no changes on many of the measured soil properties over a period of 10 years. Another study (Celik *et al*., 2004) evaluated long term organic fertilization and mycorrhiza at the Agricultural Experimental Station of Çukurova University, Adana, in southern Turkey, and these authors reported that soil porosity, bulk density, soil aggregation and water retention capacity was significantly affected by the treatment inputs (compost and manure). Generally, additions of organic or inorganic amendments can greatly affect soil properties (Celik *et al*., 2004).

The results of the present study differs from that of Celik *et al*. (2004), Hati *et al*. (2007), and Moritsuka *et al*. (2015) because of differences on experimental design, duration of the experiment, past and present soil management practices, methodology, location and input types. In this study soils were collected randomly in cultivated field under different management and agricultural inputs, while Celik *et al*. (2004), Hati *et al*. (2007) and Moritsuka *et al*. (2015) collected samples where inputs were physical administered for a specific time interval. The results obtained from this study indicates that other factors like pH, soil physical properties, texture, etc. may be affecting soil minerals which the study did not evaluate.

Table 5.2 Descriptive statistics for production inputs

Input type	N	Mean	Std. Dev	Std. Error	P value	F test
Total Carbon%	17	1.602	0.638	0.154	0.46	0.92
Manure	6	1.648	0.6760	0.310		
Combination	5	1.490	0.637	0.285		
Fertilizer	3	1.233	0.264	0.152		
None	3	2.070	0.600	0.346		
Total pH (KCl)	17	5.73	1.05	0.255	0.25	1.53
Manure	6	5.25	1.13	0.462		
Combination	5	5.60	1.12	0.502		
Fertilizer	3	5.93	0.750	0.433		
None	3	6.73	0.472	0.272		
Total Cu (mg/ kg)	17	11.01	8.36	2.03	0.61	0.62
Manure	6	11.27	5.85	2.39		
Combination	5	7.00	2.47	1.10		
Fertilizer	3	13.43	10.20	5.89		
None	3	14.73	16.94	9.78		
Total Zn (mg/ kg)	17	9.00	11.52	2.79	0.170	1.96
Manure	6	8.67	7.11	2.90		
Combination	5	5.50	4.23	1.89		
Fertilizer	3	2.80	0.87	0.52		
None	3	21.70	23.85	13.77		
Total Mn (mg/kg)	17	180.61	143.78	34.87	0.76	0.39
Manure	6	229.07	165.01	67.37		
Combination	5	134.10	96.21	43.03		
Fertilizer	3	188.13	156.4	90.30		
None	3	153.73	201.78	116.50		
Total Fe (mg/kg)	17	121.58	96.71	23.45	0.30	1.34
Manure	6	168.00	106.34	43.41		
Combination	5	135.40	107.05	47.87		
Fertilizer	3	78.33	69.67	40.22		
None	3	49.00	33.60	19.40		

Error bars with the same alphabet do not differ from each other significantly. Production inputs were found to have different effects on sodium (Na) indicated by different alphabets in Figure 5.6. Thus, the null hypothesis was rejected at 5% level ($p<0.05$). Then we concluded that at least one production input differ from the others. To find exactly which of the inputs differ significantly from each other, we used Fisher LSD and the results are reported in Table 5.3 Least Significant Difference (LSD) test for sodium (Na)

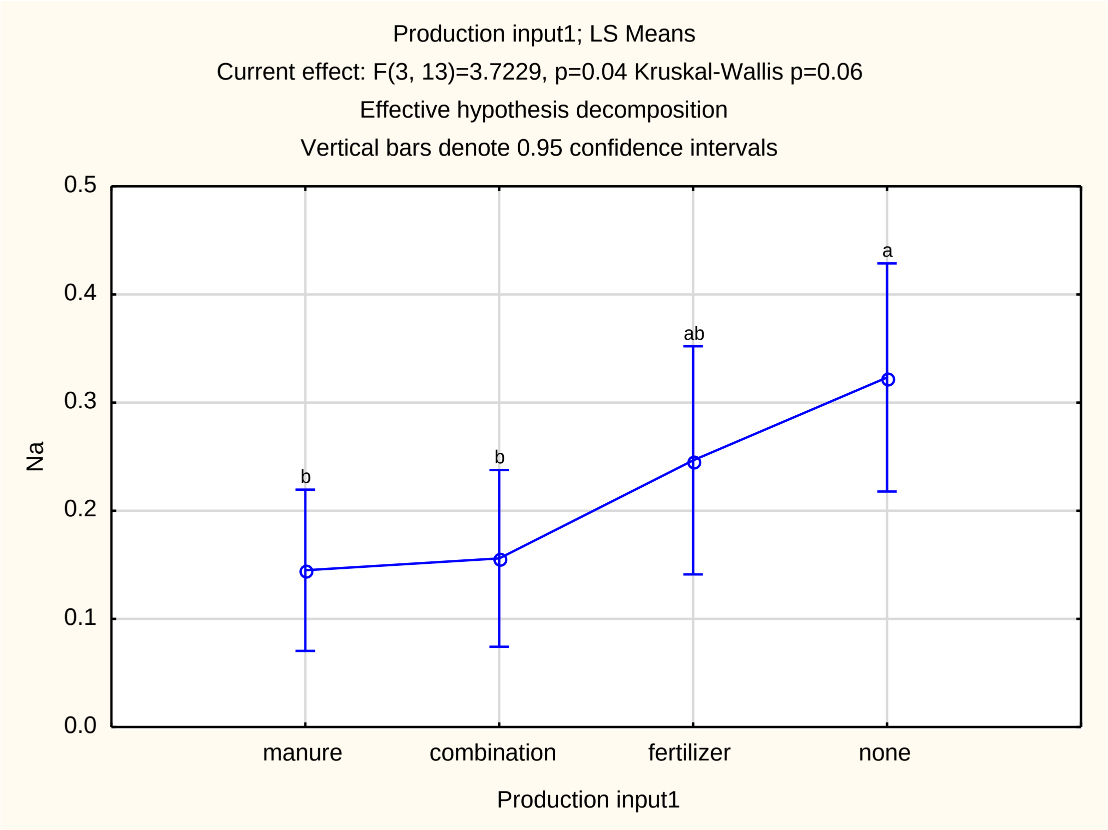


Figure 5.6 Shows the differences between production inputs and Sodium (Na) concentration (mg/kg).

Table 5.3 indicates that manure, input combinations and fertilizer do not differ significantly from each other ($p>0.05$) indicated by the same alphabet (b), but they differ significantly from none (soils without any chemical inputs) and $p<0.05$. On the other hand, fertilized and none treated soils did not differ from each other ($p>0.05$) indicated by the same alphabet (a).

Table 5.3 Least Significant Difference (LSD) test for sodium (Na)

Input type	Manure	Combination	Fertilizer	None
Manure		0.83	0.11	0.011[a]
Combination	0.83		0.17	0.018[a]
Fertilizer	0.11	0.17		0.29
None	0.011[a]	0.018[a]	0.29	

[a] indicates evidence against the null hypothesis at 5% level

We find no evidence against the null hypothesis that production input have different effects on soil potassium (K), calcium (Ca) and manganese (Mg), (p> 0.05), and can be observed Table 5.4. Nonetheless, production inputs indicated to have different effects on soil T–value (p<0.05) and could be linked with soil cultivation methods. For example, Stronkhorst *et al*. (2010) reported that cation levels (Mg, K and Na) were higher in the conservation agriculture soils than under conventional cultivation.

Table 5.4 Influence of production inputs on soil exchangeable cations (cmol (+)/ kg)

Input type	N	Mean	Std. Dev	Std. Error	P value	F test
Total Na	17	0.20	0.10	0.025	0.04	3.72
Manure	6	0.15	0.044	0.018		
Combination	5	0.16	0.069	0.031		
Fertilizer	3	0.25	0.055	0.032		
None	3	0.32	0.170	0.098		
Total K	17	0.96	0.83	0.20	0.05	3.38
Manure	6	0.78	0.51	0.21		
Combination	5	0.65	0.28	0.12		
Fertilizer	3	0.70	0.21	0.12		
None	3	2.11	1.50	0.87		
Total Ca	17	14.59	8.03	1.95	0.28	1.42
Manure	6	11.22	5.75	2.35		
Combination	5	12.49	9.09	4.07		
Fertilizer	3	18.68	7.31	4.22		
None	3	20.77	9.31	5.38		
Total Mg	17	5.40	4.34	1.05	0.12	2.38
Manure	6	4.42	4.15	1.69		
Combination	5	2.67	0.74	0.33		
Fertilizer	3	8.28	5.30	3.06		
None	3	9.02	5.04	2.91		

The LSD (Least Significant Difference) test shows that manure and the control (none) have different effects on T–value (cmol/kg) ($p = 0.014$), but manure did not differ from input combination ($p = 0.81$) and fertilizer ($p = 0.063$) (Figure 5.7). However, input combination differed from fertilizer ($p = 0.011$) and control ($p = 0.049$). Fertilizer (0.049) did not differ from manure ($p = 0.063$) and none ($p = 0.49$). The results show that treatment inputs are effect specific as it only influences specific soil minerals. For example, Celik *et al*. (2004) showed that organic treatments (manure and compost) have a significant effect ($p < 0.05$) on water retention capacity while fertilizer did not.

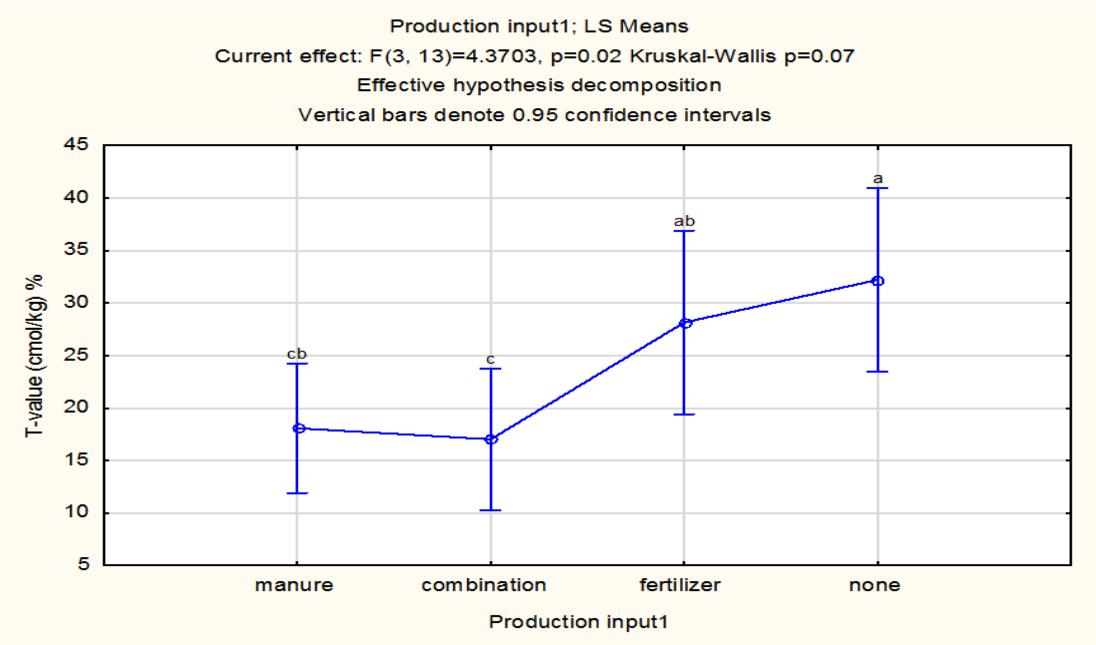


Figure 5.7 Shows the effects of production input on T–value (%)

Table 5.5 indicates that production inputs have equal effects on soil base saturation (N%, K% and P (mg/ kg). The null hypothesis was not rejected at 5% significant level.

Table 5.5 The effects of production inputs on base saturation

Input type	N	Mean	Std. Dev	Std. Error	P value	F test
Total Na%	17	0.24	0.205	0.049	0.17	1.93
Manure	6	0.23	0.163	0.067		
Combination	5	0.15	0.059	0.026		
Fertilizer	3	0.16	0.039	0.023		
None	3	0.46	0.397	0.229		
Total K%	17	4.67	3.22	0.781	0.60	0.65
Manure	6	5.27	4.49	1.835		
Combination	5	4.38	2.57	1.151		
Fertilizer	3	2.57	0.99	0.575		
None	3	6.05	2.75	1.588		
Total P (Mg/ kg) bray II	17	272.18	335.02	81.25	0.06	3.19
Manure	6	98.17	131.41	53.65		
Combination	5	361.8	380.93	170.35		
Fertilizer	3	88.33	57.20	33.03		
None	3	654.67	424.51	245.09		

The differences of cropping patterns on soil carbon are displayed in the Figure 5.8. Cropping patterns (mixed, mono cropping, rotational and their combination) have shown to have different influence on soil carbon percentage ($p<0.05$), thus the null hypothesis was rejected at 5% level (Figure 5.8). The rejection of null hypothesis means that cropping patterns have different influence on soil carbon percentage. Mixed cropping differ significantly from mixed and rotational ($p = 0.0098$), but does not differ from mono and rotational cropping ($p = 0.074$). Yet, mono and rotational and mixed rotational did not differ significantly from each other ($p = 0.61$).

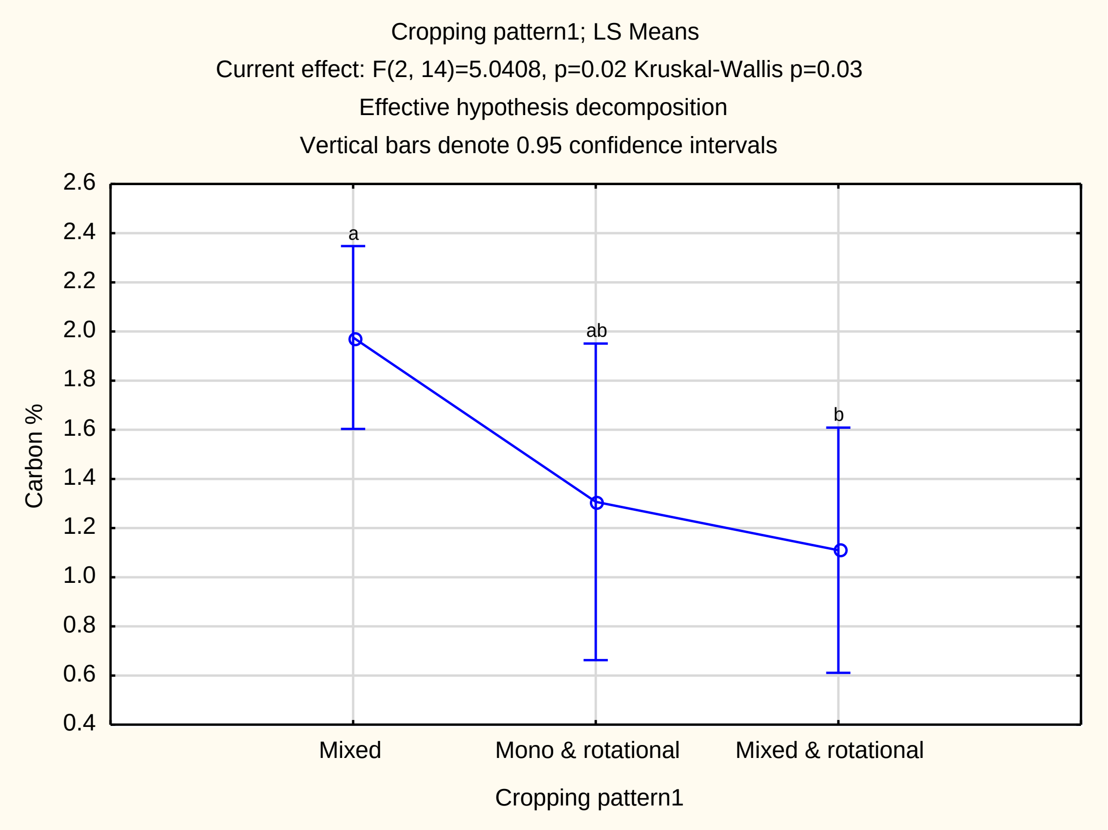


Figure 5.8 Displays the effects of cropping patterns on soil carbon percentage

There was no evidence against the null hypothesis that cropping patterns have different effects on the following (p>0.05): pH (KCl), stone percentage, phosphorus (P), potassium (K), exchangeable cations (Na, K, Ca and Mg), copper (Cu), zinc (Zn), manganese (Mn), boron (B), iron (Fe), nitrogen percentage, and base saturation (Na, K, Ca, Mg and T–value percentage).

Swarup *et al*. (2000) showed that long term fertility experiments in India, especially nitrogen (N) fertilizer have negative implications on yield, irrespective of cropping system and soil type. Since there was no evidence against the null hypothesis that cropping inputs and cropping patters influences soil chemistry. Consequently, we concluded that land management practices such as cropping frequency, tillage, and cultivation of perennial legumes and grasses (Manna *et al*., 2005) other than those measured for the study could probably have different effects on the soil mineral concentration. According to Hati *et al*. (2007), conservation of soil physical condition is an important component of soil fertility which relates to the type cropping system and cultivation method.

5.3.3. Range land and animal body condition

Most of the surveyed communities had degraded rangelands and can be observed in Table 5.6. Incorrect adjustment of stocking density is probably the cause. High stocking rate is suspected to cause bush encroachment (Lange *et al*., 1998; Vetter & Bond, 2010). Bush encroachment can be best described as the replacement of palatable plant species suitable for grazing with unpalatable bush types or poisoners plants i.e. *Aristida junciformis*, *Paspalum scrobiculatum*, *Sporobolus africanus*, etc. Rainfall especially in semi–arid rangeland systems is a critical factor that can be linked with plant growth and biomass quantity. For this reason, rainfall can be used as a primary factor for determining long term carrying capacity and stocking rate (Lange *et al*., 1998). It is logical to say that a positive correlation might exist between rainfall and annual carrying capacity, particularly in extensive production systems (Department of Agriculture Forestry and Fisheries, 2013). Scott–Shaw *et al*. (1996) stated that only 3% of the Natal Mist–belt Ngongoni veld remains in small amounts while most areas are fragmented.

Others studies in Okhahlamba Municipality of Kwa-Zulu Natal, found that decreaser plant species (plants dominating in a good veld condition) were deteriorated through excessive overgrazing (Stronkhorst *et al*., 2010). *Eragrostis curvula* (21%) and *Eragrostis racemosa* (46%) was the common species reported in the transect surveys, and both species indicate that the farm was overgrazed with no evidence of selective grazing. The authors reported a grazing capacity ranging from 5.15 to a maximum potential stocking rate of 11.13 animal units over 250 days or 7.62 animal units over 365 days. The veld condition scores of the farm (Gourton farm and the Gums) ranged from 33.3 to 50 percent. These results are comparable to that of the current study where a 40 to 60 percent rangeland condition was reported and a grazing capacity of 4 to 23 hectares (ha) per livestock unit (LSU).

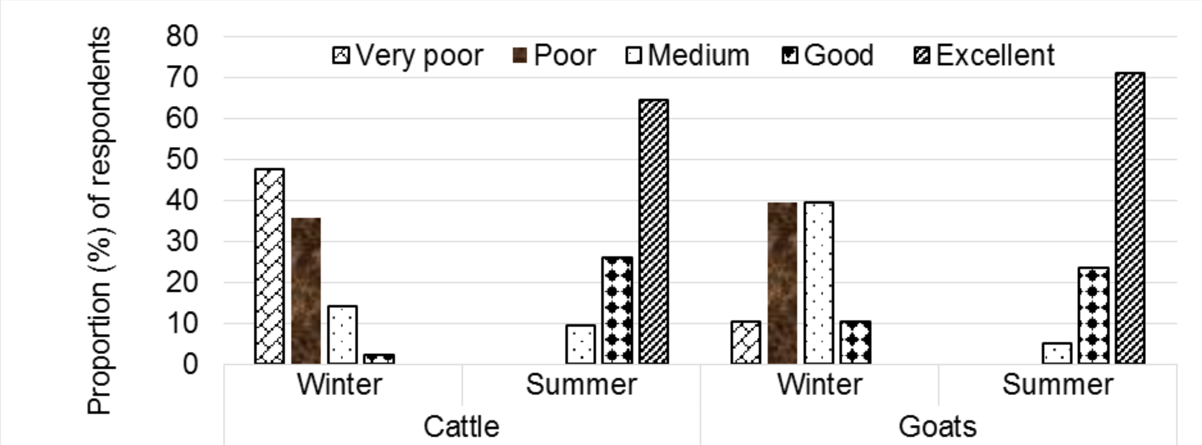
Table 5.6 Veld condition for various communities in Umvoti Municipality, Kwa-Zulu Natal

Area	Annual grazing capacity (ha/ LSU)	Browse capacity (ha/ goat)	Rangeland condition (%)
Emahlabathini	5	8	55
Etsheni area	16	4,5	45
Nqoleni	23	3,5	40
Ndimakude	14	4,5	40

Area	Annual grazing capacity (ha/ LSU)	Browse capacity (ha/ goat)	Rangeland condition (%)
Emadekeni	6	4,5	55
Kwasenge	6	4,5	55
Dambe/ Nophethu	12	4,5	40
Dimane/ Emakhabeleni	12	4,5	40
Dakeni	12	4,5	40
Sibuyabe	23	3,5	40
Kranskop	4	0	60

The fluctuation in livestock body condition between summer and winter is shown in Figure 5.9. Farmers owning cattle (n=42) stated that in winter, their cattle are prone to very poor condition as forage quality and quantity changes (48%). Goats in winter were able to survive better than cattle, since only 11% of the farmers (n=38) ranked goat's body condition to be very poor during winter. None of the farmers ranked livestock body condition poor in summer. Farmers ranked cattle body condition medium (10%), good (26%), and excellent (64%). While the majority ranked goats' body condition excellent (71%), good 24% and medium 5% in summer. None of the farmers reported a very poor body condition during the wet season, meaning that food during this period is available in an abundant amount.

Mengistu (2012), reported similar findings in Ethiopia, where animals loss body weight during winter. Feed availability seems to be a limiting factor specifically extensive livestock production in arid and semi–arid rural areas (Stares, Sarid & Kategile, 1992; Gwaze *et al*., 2009) because of poor grazing system or absence of grazing plan.



	Cattle Winter	Cattle Summer	Goats Winter	Goats Summer
Very poor	48	0	11	0
Poor	36	0	39	0
Medium	14	10	39	5
Good	2	26	11	24
Excellent	0	64	0	71

Figure 5.9 Seasonal changes in animal body condition.

5.4. Conclusion

The study revealed that there is no significant change in rainfall. Consequently, the claim made by respondents about the impact of rainfall on feed availability and veld degradation was not sufficient. Majority of the sampled soils were acidic and belonged to clay textual group. Production inputs evaluated in this study showed no differences on soil carbon percentage, pH, stone volume percentage, and soil minerals. The effects of production inputs on cation exchange and base saturation indicated no evidence against the null hypothesis. Cropping patterns evaluated for the study had different effects on soil carbon percentage. The secondary veld condition data indicated that most the surveyed communities at Umvoti Municipality are severe to medium degraded.

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Chapter 6
Conclusions and recommendations

6.1. General conclusion

In conclusion, Umvoti communal smallholder farmers are socially sustainable since cultural values and society norms were respected. However, economic and environmental sustainability was compromised because negative net income from farming was obtained and the rangeland was degraded through overstocking densities. Failure to control stocking rate may be due to limited academic knowledge and lack of regulatory policies and norms governing common grazing. Poor education limits the extent in which knowledge and information can be transferred among the farmers. Grazing of the commons is known to destroy the financial value of communal livestock production system because of high stocking rate aiming at achieving individual goals, than aiming at collective norms that might result in a consistent management of the commons so that future generations have access to it. Moreover, it also raises a question of who is responsible for managing the property of the commons and the answer lies on the Tribal Authority and regulatory norms or policies governing it, if there are any. More than half of the respondents (52%) said that the rangeland was overgrazed not only by livestock, but by other domesticated and wild animals and rangeland degradation undermines the environmental aspect of sustainability.

Production constraints that were mentioned by farmers included farming equipment, water, stock theft and access to market. Poor road infrastructure, transport accessibility and geographic distance from urban centres made it difficult for these farmers to participate on formal market. Consequently, farmers used private markets to trade their animals where a potential buyer goes straight to the farmer. Within these market strategies, communal farmers seem not to contribute to economic development because there are no data or record kept that can be projected on the South African Statistics. Consequently, the economic contribution of these famers is under rated, this limit communal smallholder farmers to compete and participate in large markets. Farmers will continue to struggle because they will not have the ability to influence external help from companies and/ or the government. This misconception has led into contrasting conclusions about the productivity or efficiency of smallholder livestock producers. As a result, these farmers are generally viewed as economically unproductive, backward and wasteful when compared with commercial production systems (Andrew *et al*., 2003).

The performance of extensive livestock production in communal areas of South Africa is also affected by seasonal biomass quantity and quality, especially on arid and semi–arid areas of the country. In this areas supplementation become important especially during drought and winter season. If animals are not given extra feed which is the case of this study where 78% of the farmers did not provide extra feed for their livestock, performance can be severely affected and in extreme cases deaths from hunger and disease infections may result.

Livestock diseases in some areas at Umvoti Municipality were managed using either veterinary products or traditional remedies (81%). However, 9% of the respondents did not control or treat sick animals because the disease was either unknown or veterinary services were not easily accessible. Poor disease control imposes danger to human health either by consuming contaminated meat or by inhaling a decomposed body of an infected animal. Possible diseases that can affect human beings includes: mad-cow disease, swine fever, anthrax, Lyme disease, brucellosis and avian influenza which also threatens the lives of other domesticated and wild animals if exposed to the same environment.

The socio–economic status of smallholder livestock farmers indicated that urban income transfers in the form of gifts and wages together with governmental grants ranked the highest source of livelihood strategy. Pension had a relative contribution of 36% to total household income while livestock contributes about 18%. The negative net income obtained from livestock might be associated with the fact that most the farmers were above 50 years and were already on pension and probably not economic active. These farmers were probably using income from other sources to cover livestock production costs since the income derived from sales was not sufficient. By doing so, the economic value of smallholder livestock farming was undermined. Moreover, farmers indicated to have access to one or more sources of income which could have discouraged them from selling their livestock. Multiple sources of income indicate some form of mixed livelihood strategies. Since farmers were accessing income from other sources to cover household costs and livestock production costs, the study concluded that mixed livelihood strategies does improve the sustainability of smallholders. Majority indicated that they use livestock for socio–cultural related purposes which, was more important than selling to generate income.

The constraints discussed above could decrease overall farm performance especially theft and deaths. For example, the overall goat and cattle off–take (removal) rate was 62.4% and 44.4%, respectively. Goats had higher off–take than cattle because they were probably easier to steal and were a target for predators because of their small size. Stock loss through disease infection and accidents resulted in economic loss for the owner, while theft may result to social conflict especially if the thief suspect resides within the community, which undermines the social sustainability of smallholder livestock farmers.

The use of livestock as a form of investment holds a promise, especially in areas where banks are far and not easy to access. Female animals represented the highest form of investment in cattle and goats, 67.4% and 69.3%, respectively. This was linked to the fact that cows and does constituted the highest proportion of the herd and were least sold or culled. On the other hand, bulls and bucks were the common sold or culled animals and constituted the smallest proportion of the flock size.

The study also revealed that there was no changes in rainfall as farmers reported drought to be the driving factor behind rangeland degradation together with overstocking rate. The R–square showed that only 1% on rangeland dynamics can be explained by rainfall changes with a p–value greater than 0.05. Production inputs (manure, fertilizer, control and combination) indicated to have different effects on soil sodium and T–value (total exchangeable cations in the soil), but had equal effects on the other soil minerals that were evaluated. Furthermore, there was no evidence against the null hypothesis for cropping patterns (mono, mixed, mono & rotational, and mixed & rotational) soil chemical properties, except for carbon ($p<0.05$) and the null hypothesis of equal treatment (cropping patterns) on soil carbon was rejected at 5% level.

The rangeland condition was medium degraded with a condition score of 40 to 60 percent. The grazing capacity was however too low (23 ha/ LSU) for some areas. In other areas the stocking density (4 hectares per livestock unit) was moderate acceptable.

Although many authors have stated that majority of smallholder, subsistence and communal or rural farmers in South Africa rely on diverse livelihood to reduce vulnerability to income, food shortages and poverty, has underestimated the value of agriculture. This study has highlighted the importance of multiple livelihoods; existing issues experienced by smallholders and described their farming practices which could undermine its sustainability. The study also indicated that economic sustainability assessment of smallholder livestock producers is not adequate to judge their productivity because the purpose of keeping livestock in rural areas is multifunctional in nature.

In the light of the results presented here, it is clear that off–farm income does improve the economic sustainability of smallholders in rural communities of Kwa-Zulu Natal because the net income from livestock farming was negative meaning that households used urban income transfers to subsidise livestock farming. However, grazing land, water and the availability of fence represented a major constraint that decrease overall farm performance, in terms of production (meat and milk) and income loss from stock theft and death from either disease infection or car accidents. Nutrient mining was not a big issue from the analysed soil samples, but fertilizer seemed to affect soil carbon content. Identification of these key management strategies appears to hold a great promise to seek for external support and in improving public perception about the productivity of smallholder livestock production systems, which could improve their overall sustainability. Improved public perception can stimulate both private and public support allowing farmers to get access to information and resources, which holds a great potential to increase agricultural performance of rural farmers in general.

6.2. Recommendations

There is a need for helping farmers in coming up with strategies for overcoming theft, feed and water shortages, and disease control to avoid economic losses. The Tribal Authority or the community as a whole also need to formulate norms or rules governing the use of communal rangelands. There is also a need to encourage youth participation because they represent future farmers of the world.

6.3. Further research

- The study investigated the contribution of off–farm and farm income contribution to household livelihood and production constraints experienced by smallholders in Umvoti, therefore, there is still a need in coming up with ways for addressing those constraints.
- Further studies could consider investigating the dynamics of rangeland nutrients availability that are important for livestock performance and the palatability index of the rangeland.
- More research is required on coming up with sustainability assessments that best fit South African conditions.
- Due to limited time and resources, a small sample size was used for the study, therefore future studies may consider broadening the sample size.

Chapter 7

List of appendices

Appendix 1: Questionnaire on general livestock management

SUSTAINABILITY OF SMALLHOLDER AGRICULTURAL PRODUCTION

University of Stellenbosch

Department of Animal Sciences in collaboration with the Department of Forest and Wood Science

Private Bag XI, Matieland, 7602

TEL: 021 808 3295

UMVOTI LIVESTOCK PRODUCTION SURVEY

QUESTIONNAIRE

Enumerator Name ________________________________Date of interview / /

Supervisor Name: ____________________________

Co-supervisor Name:

Province: ______________________________

District/ municipality Name**:** ____________________ Code no. [ ]

Station / camp Name**:** _______________________ Code no. [ ]

Village Name**:** ____________________________________Code no. [ ]

[ ]

Farm type: Communal ☐ Small-scale ☐ Large-scale commercial

Level of education (*Tick one*)

Lower	Primary	Secondary	Tertiary

Household No ☐

Wealth category *(Tick one)*

Rich	**poor**	**medium**	**not classified**

General Household Information

The name of the interviewee remain anonymous	This information would not be included in the analysis, neither for policy, government or judgement solely based on learning purposes				
Interviewee ______________					
Household head (HHD)					
	Age		**Gender**		
			Male		Female

Position in household		**Number of people residing in household**		**HHD are you involved in any community & national activities**		
Household head		Males			**Yes**	**No**
Spouse of head		Female		Do you vote		
Brother		Children <15 yrs.		Are you a church member		
Sister				Do you a farming association		
Son				Do you share equipment		
Daughter		**Land ownership** (*tick 1 or more*)		**Land allocation size** (*hectares*)		
Other (*specify*)		Own		Crops		
Ethnicity		Rent		Pasture		
Black		Other (*specify*)		Forest		
White				Total hectares		
Coloured				Communal		
Other						

Is livestock the main farming enterprise	
Yes	No

Livestock kept				
Rank (1, 2, 3) *1 = primary important*				
Types	*Mark here*	Quantity		Rank
Cattle				
Sheep				
Goats				
Chickens				
Pigs				
Donkeys				
Other (*specify*)				

Source of income (*1 = first priority*)		
Source	Tick	Rank
Crops		
Livestock		
Home industry		
Salary/ wages		
pension		
Manure sale		
Other (*specify*)		

Livestock composition					
Cattle	Quantity	Sheep	Quantity	Goats	Quantity
Calves		Lambs		Kids	
Cows		Ewes		Does	
Heifer		Rams		Bucks	
Bulls		Castrates		Castrates	

Effluent processing	*Tick*
Irrigation	
Discarded	
Other (*specify)*	

Contribution to employment	
Permanent workers	Number
Family workers	
Youth > 18 yrs.	
Women workers	
Jobs created the last 5 yrs.	

Manure handling	
Sold	*Tick*
Used in farm	
Composted	
Discarded	

Cropping patterns	
	Tick
Mixed	

Ethics and human development		
	Yes	No

Educated labours			Mono	
Uneducated			Continuous	
Do you train new workers or family members			Rotational	

Is irrigation used for:

	Yes	No
Perennial plants		
Annual crops		
Pasture		

Water source		
	Home	*Livestock*
River		
Farm dam		
Municipality		
Aquifer/ spring		
Distance from water source (Km)		

Road infrastructure	
Stone or dust	
Tare or asphalt	

Production system

System type (tick one or more)		**Purpose of keeping livestock** (*chose on 1 or more)*	*Rank (first 3) 1= most important*	**Members of the family who owns livestock** (tick one or more*)*	
Industrial/ intensive					
Semi-intensive		Meat		Household head	
Extensive/ pastoral		By-products		Spouse	
Free range		Breeding		Son (s)	
Feedlot		Cash		Daughter (s)	
Weaner system		Ceremonies		Other (*specify*)	
Other (*specify*)		Culture		__________________	
		Other (*specify*)			

Members of household responsible for livestock				
(Tick as appropriate; more than one column in a row may be ticked)				
F= female M= male	Adult	Boys	Girls	Hired

					labour
	M	F	<18	<18	
Buying of animals					
Selling/ slaughtering					
Breeding decisions					
Feeding/ grazing					
Health management					

Type of animal housing *(tick one or more)*		**Winter feeding/ supplementation regime**		**Grazing system**	
Kraal		Lucerne hay		Rotational	
Camp		Homemade ration		Continuous	
None		Grains			
Other (*specify*)		Crop residues			
		Other (*specify)*			

Number of camps		**Grazing season**			
		Summer		**Frequency of grazing** *(average number of grazing's per year per camp)*	
		Winter			
		Autumn		**Camp size**	
		Spring			
				Stocking rate (AU/ha)	

Disease management for livestock rank one (1)

Access to veterinary services *(Tick as appropriate)*	
Government vet.	
Private vet.	
Veterinary drug supplier	

Extension service	
None	
Other *(specify)*	?

____

Prevalent diseases that occur on farm (i.e. disease seen by farmer in livestock)

If none tick this box					
Local name or symptoms of disease		Are animals treated when sick?			
(rank most common first)		Yes	No	Treatment given (if known)	
1					
2					
3					
4					

Vaccination/ preventative treatment given

If none tick this box			
Local name or symptoms of disease		Done routinely	Done when need arises
1			
2			
3			
4			

If done routinely specify how often	
Weekly	
Monthly	
Other *(specify)*	

Ecto-parasite (external parasites) control

	Done when need arises		Done routinely			Dry season			Wet season	
Method *(Tick)*	Wet	Dry	Wet	Dry		*Week*	*Month*		*Month*	*week*
	Season		Season		**Every**					
None										
Spray										
Traditional										

If traditional method specify ________________________

e.g. Dipping_______________

Other (*Specify)*

Do you have excess to:	*Tick*
Solar or	
Generator	
Electricity	
Other (*specify)*	
_____________	

Work intensity	Tick
Weekly	
7 days a week	

Available income per worker in Rand	
Per day	
Per week	
Per month	
Per year	

Do you specialise in any product produced in the farm like:	Yes	No
Packing or processing?		
Do you get any subsidies from the government		

Number of generations that have existed on the farm? In years (yrs.)	

Is the type of farming had been the same or changed over the years		
Changed	*Yes*	*No*

External inputs		
Tick *(one or more*)	Plant used for	Application rate
Fertilizer		
Animal manure		

Compost			
Other (*specify*)			

Marketing/ buying and culling

Number of entries within the last 12 months (*Enter X in a box if not known, 0 if answer is none)*				
Entry mechanism	Cattle	Sheep	Goats	Pigs
Bred (births)				
Bought				
Donated/ gift				
Exchanged/ lent				

Numbers of exits/ culls within last 12 months (*Enter X in a box if not known, 0 if answer is none)*				
Exit mechanisms	Cattle	Sheep	Goats	Pigs
Died				
Sold				
Slaughtered				
Exchanged or lent				
Donated/ gifted				
Stolen				

Sale outlet (*if sold in the last 6 months)*			**How far is the market in km**	
	Yes	No		
Were livestock sold?				

Livestock are sold within the farm	Yes	No

If yes (*tick one or more boxes)*	
Sold at auction or feedlot	
Sold to butcher	
Sold privately	
Sold to abattoir	
Other (*specify*)	

Are you making profit	Yes	No

If no why? ___________________________

____________________				

Reasons for culling/ disposal (*Ask as open question and tick any answers given in first half of box, one or more boxes to be ticked. Then rank top three by writing in second half of box 1 for primary reason for culling, 2 for second and 3 for third)*

	Males	Rank		Females	Rank	
Size						
Conformation / shape						
Colour						
Temperament						
Health						
Body condition						
Performance						
Old age						
Other (specify)						
________________						
Do own a phone?	Yes	No				

Average number of stock sold per sector

Selling price	Auction	Abattoir	Butcher	Privately	Average sold	Average weight of the animal when sold
Sheep						
Goats						
Cattle						
Lambs						
Kids						
Calves						

General Problems

	YES	NO	
Stock theft			
Is your whole farm well fenced			*If no why?*
If yes, how many get stolen in a year?			
How much does theft costs you			

yearly?		
Problem of predators (dogs, jackals, etc.)		
How much does predation costs you per year?		
Are there any other major obstacles in your enterprise? If yes (what are they??)		

Do you think the government has done enough so far in improving the standards of small scale farmers? How can the government help??
____
____

If a labourer get injured is there emergency help	Yes	No		**Is clinic or hospital closer?**	Yes	No

How often is the veld or pasture cleaned			
Weekly	Monthly	Yearly	Never

Breeding criteria for the livestock rank 1

If breeding is **NOT** done, fill in **3** and go to next page

Primary reason for keeping male (s) tick 1 or more		
	Tick	Rank
Breeding		
Socio-cultural		
Other (specify)		
___________		
____________		

Mating system *(tick one or more boxes)*	Mark
Uncontrolled / natural	

Reasons for choice of male (s) for breeding		
Ask an open question and tick any reason for choice, considered in first half of box, one or more boxes to be ticked. Then rank top three by writing in second half of box1 for primary reason for choice, 2 for second and 3 for third.		
	Tick	Rank
Size		
Conformation/ shape		
Colour		

mating	
Hand mating/ Artificial insemination (AI)	
Group mating	
Other (specify)	
________________	

Temperament		
Performance		
Availability (no choice)		
Hardiness		
Other (*specify*)		
______________		
______________		

Average number of progeny per breeding season of livestock rank 1

Breeding length (*days/ months) specify*	

Breeding season	*Mark*
Summer	
winter	
Autumn	
spring	

Source and breed (s) used in the farm

Breed name(s) (specify if known – crosses can be included). Under rank (rank first 3)						
	Breed 1			Breed 2		
Source	Tick	Common name	Rank	Tick	Common name	Rank
Own bull (bred)		____________			____________	
Own bull (bought)		____________			____________	
Bull donated		____________			____________	
Bull borrowed		____________			____________	
Unknown bull		____________			____________	

Pure breeds

Number of pure breeds *	0	1	2	3	4	5
	(tick or mark x)					

If crossing of two breeds has resulted in a genotype that is recognised and maintained as a breed, then count this as a separate breed and include it on this form. If no pure breeds tick 0 in the box and complete section on mixed crosses form. If more than two pure breeds, third breed can be entered on mixed crosses form.

BREED 1		BREED 2	
Common breed name ______________________		**Common breed name** ______________________	
Local breed name ________________________		**Local breed name** __________________	
Trend within flock *(tick one)*		**Trend within flock** *(tick one)*	
Increasing		Increasing	
Decreasing		Decreasing	
Stable		Stable	
Unknown		Unknown	
Average number of progeny per breeding season		Average number of progeny per breeding season	

BREED 1		BREED 2	
Numbers of adult animals		**Numbers of adult animals**	
Males	Females	Males	Females
Number of young animals		**Number of young animals**	

Quality of traits perceived by owner

Traits	Poor	Average	Good	Not important/ no opinion
Size				
Conformation/ shape				
Mothering ability				
Disease resistance				

Drought tolerant/ adaptability				
Meat/ product quality				
Growth rate				
Fertility/ reproductively				
Foraging ability				
Other (*specify)*				
____________________________				
____________________________				

Cross breeds or mixed crosses and pure breeds

This form is also designed for a third pure breed. If there is a fourth pure breed this should be included under mixed crosses and ranked 1; likewise a fifth breed would be ranked 2.

			MIXED CROSSES **Breeds used to produce cross breeds**
			(rank up to four breeds in order of probable influence use owner's knowledge if known)
BREED 3			1. Common name ____________________
Common breed name ____________________________			Local name _________________________
			2. Common name ____________________
Local breed name ____________________________			Local name__________________________
Trend within flock *(tick one)*			3. Common name ____________________
Increasing			Local name _________________________
Decreasing			4. Common name _______________
Stable			Local name _______________________
Unknown			

3. Number of adult animals	
Males	Females
Number of young animals	

Numbers of adult animals		
Breeds	Males	Females
1		
2		
3		
4		

Quality of traits perceived by owner

Ask each question and for each trait tick one box, poor, average, good, no opinion)

Poor	Average	Good	No opinion/ not important		Poor	Average	Good	No opinion/ not important
				Size				
				Conformation/ shape				
				Mothering ability				
				Disease tolerance				
				Drought tolerance				
				Heat tolerance				
				Temperament				
				Control of flies				
				Meat taste/quality				
				Growth rate				
				Fertility				
				Foraging ability				
				Other (specify)				
				____________				
				____________				
				_____________				

Appendix 2: Livelihood questionnaire

Economic Viability

How much did you spend on your farm within the last 12 months?

Expenses Item	Amount (R)
Purchase of animals	
Paying lobola	
Paying fines	
Feed and supplements	
Veterinary services and drugs	
Labour (permanent and temporary)	
Machinery and equipment	
Transport and marketing	

Share of households using and purchasing inputs

Fertilizer used	Bought (R)	Donated
Organic		
Chemical		
Pesticide purchase		
Seed purchase		
Traditional		
Improved		
Certified		

What is your total household income (R’s) per month?

0–499	500–999	1000–1999	2000–2999	3000–3999	4000–4999	5000+

What is your income from your farming activity per month?

0–500	501–1000	1001–2000	2001–3000	3001–4000	5000+

How much did you get from the sale of the following last year? / benefits of livestock

Item	Amount (R)
Weaner	
Cows	
Bulls	
Oxen / steer (inkabi)	
Total cattle	
Milk	
Meat	
Dung	
Total sheep	
Ewe	
Ram	
Whether (intondolo)	
Total goat	
Chickens	
Crops	
Home industry	

What is the soil condition?

Soil productivity status

Condition	Rating
Very poor	
Poor	
Medium	
Good	
Excellent	

1 very poor; 2 poor; 3 medium; 4 good; and 5 excellent

What is the condition of animals?

Seasonal livestock body condition

Season	Cattle body condition	Goat body condition
Summer		
Winter		