An evaluation of past cattle dipping practices in the former Venda area of Limpopo Province, South Africa: Implications for sustainable development

by

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DECLARATION

I, MARUBINI REUBEN RAMUDZULI, declare that the thesis: AN EVALUATION OF PAST CATTLE DIPPING PRACTICES IN THE FORMER VENDA AREA OF THE LIMPOPO PROVINCE, SOUTH AFRICA: IMPLICATIONS FOR SUSTAINABLE DEVELOPMENT, hereby submitted by me, is my original work. I have not previously in its entirety or in part submitted it at any university for a degree qualification. All the materials and sources contained herein have been acknowledged.

MR Ramudzuli 24 March 2014

DEDICATION

This academic work is dedicated to:

My wife Azwidohwi Francinah

Our children Lugisani and Aluwani Marion

My Mother Edith Mutshutshudzi, and all my siblings.

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EVERY GOOD AND PERFECT GIFT IS FROM ABOVE, COMING DOWN FROM THE FATHER OF THE HEAVENLY LIGHTS, WHO DOES NOT CHANGE LIKE SHIFTING SHADOWS.

THERE IS NOTHING IMPOSSIBLE WITH GOD.

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ABSTRACT

An extensive compulsory cattle dipping programme was introduced in Venda from 1915 to counter rinderpest and East Coast Fever (ECF). This study approached the sustainability of cattle dipping from environmental, economic, social and governance perspectives against the backdrop of the country's history and political ecology, focusing on the effects of dipping strategies and operations in Vhembe district of Limpopo Province (the former Venda) in response to ECF.

Dipping infrastructre continues to be used in Venda after the eradication of ECF in 1954 and even to the present, albeit below capacity. Arsenic residues occur in soils around all sampled dip sites, especially within 20 m from dip tanks and where red clays and organic-rich loamy soils prevail. Ecologically, dipping practice has therefore not been sustainable, while economically, farmers perceive dipping to enhance livestock health, and they gain benefit from continued use of cattle in agriculture and transport.

Being close to watercourses and villages, most dip tank sites pose community safety and health risks, with even fatalities occurring at untended and abandoned tank facilities. Yet the social sustainability benefits of dipping practice, such as the creation of forums where cattle owners and veterinarians interact, the resultant formation of cattle owners' associations, and the occurrence of recreational opportunities on dip days are also evident.

Government has been the main role player in providing dipping services, resulting in limited involvement of and cooperation between other role players; therefore the contribution of the Limpopo Draft Policy on Cattle Dipping (2011) to efficient dipping governance was evaluated. A Sustainable Community Cattle Dipping Model was consequently developed to address the shortcomings in governance, as well as ecological, economic and social issues of the sustainability of dipping practice.

This thesis contributes to an understanding that cattle dipping in communal areas are spatial entities that reflect the dynamics of structure-agency. It underscores environmental injustices like arsenic contamination occurring around dip tanks, and the effects of inequitable distribution of dip sites on human health and safety. The economic benefits and limitations of existing dipping practice are also highlighted**.** It culminates in the development of a Sustainable Community Cattle Dipping Model to enhance the sustainability of dipping practice.

Key words: cattle dipping, Venda, sustainability, arsenic, East Coast Fever, ECF

SUMMARY

This study of cattle dipping practice introduced in 1915 in Venda argues the sustainability of dipping practices as a strategy to manage the outbreak and spread of East Coast Fever (ECF) and later other tick-borne diseases in South Africa.

Chapter One provides a background of the study on data collection methods employed, including field observations and measurements, lab analyses of soil samples and interviews conducted with the various stakeholders involved with dipping. **Chapter Two** discusses ticks as vectors of cattle diseases, their impact on the cattle industry, and general tick control strategies. It focuses on the cattle dipping strategy developed in South Africa from 1904 onwards in response to the occurrence of ECF, and current strategies used to manage livestock dipping operations.

Chapter Three accounts the history and political ecology of South Africa relating to cattle dipping, highlighting the government's introduction of an extensive compulsory dipping programme in communal areas to counter the threat of East Coast Fever. After the disease's eradication in 1954, the dipping service continued due to its associated benefits.

Chapter Four examines the environmental impact of tick-control measures, especially arsenic products, focusing on soil impacts at dip sites. This research found Arsenic traces around all sampled dip sites, with high concentrations typically closer to dips, and also where red clays and organic-rich loamy soils prevail.

Chapter Five investigates economic aspects of dipping like its cost effectiveness, and found cattle dipping to be economically effective in Venda, with continued use of dipping infrastructre after 1954, and that cattle farmers perceive dipping to enhance the health of their cattle, translating into sustained social wealth and the utility of using cattle in agriculture and as means of transport. Dipping infrastructure is currently underutilised, making it less cost effective.

The investigation of cattle dipping's social sustainability in **Chapter Six** found that most dip tank sites pose a threat to communities' safety and health,, as they are close to watercourses and villages; tanks are generally not secured by perimeter fences; and dipping operators are exposed to chemical contamination. Dipping helped establish an important forum for cattle owners and government veterinarians, and facilitated the formation of cattle owners' associations, certain recreational opportunities, and creating awareness about cattle diseases.

Chapter Seven highlights governance sustainability limitations associated with cattle dipping, as the government was and remains the main role player in the provision and management of these services, limiting the involvement of other role players. A Sustainable Cattle Dipping Community Model is subsequently developed to address governance, ecological, social and economic issues of the sustainability of dipping practice.

Chapter Eight highlights the contributions made by this study of cattle dipping practice, which are: 1) cattle dipping activity in the communal areas should be understood as spatial entities that reflect dynamics of structure-agency; 2) environmental justice **aspects like the occurrence of arsenic contamination in the areas surrounding dip tanks** and the inequitable distribution of dip sites affects human health and safety and therefore have implications on ecological, economic and social sustainability, and 3) the development of a Sustainable Community Cattle Dipping Model to address the shortcomings identified in the current Limpopo Draft Policy on Cattle Dipping (2011).

TABLE OF CONTENTS **Page Number**

CHAPTER FIVE: THE ECONOMIC SUSTAINABILITY OF CATTLE DIPS

CHAPTER SIX: THE SOCIAL SUSTAINABILITY OF CATTLE DIPPING

CHAPTER SEVEN: THE LIMPOPO DRAFT CATTLE DIPPING POLICY AND DEVELOPMENT OF A SUSTAINABLE COMMUNITY CATTLE DIPPING MODEL

CHAPTER 8: CONCLUSION AND RECOMMENDATIONS

LIST OF FIGURES **Page Number**

LIST OF TABLES **Page Number**

CHAPTER 1
RESEARCH BACKGROUND

1.1 INTRODUCTION

Humanity is faced with a world of unequal development and far reaching human-induced environmental problems that threaten the well-being of humans and other organisms. Contemporary society considers sustainable development to be the best way to address the vast, complex and interrelated problems for the sake of current and future generations (Redclift, 1991; Owusu, 1998; Waas et al., 2011). The aim of this study is to evaluate past cattle dipping practices in Venda, a former homeland area in South Africa, now covered by the Vhembe district of Limpopo Province, as well as the current draft Dip Policy of 2004 (as updated in 2011) within the context of the parameters of sustainable development. It also aims at providing guidance on how cattle dipping in the communal areas could be implemented in future by the development of a Sustainable Community Cattle Dipping Model, which is discussed in more detail in Chapter 7 of this thesis.

In South Africa state organised cattle dipping programmes were introduced during the early 20th century following outbreaks of rinderpest in the late 19th century, the advent of East Coast Fever after the Anglo-Boer War and the realisation of the threat of Foot and Mouth Disease. Dipping services were organised and provided by the state in the communal areas occupied by blacks/Africans[1]. Although Rinderpest was brought under control and East Coast Fever eradicated in 1954, the white-controlled government continued to provide dipping services until 1994 with the transition of the country to a democracy. Now, twenty years later, the government is reconsidering the re-introduction of communal cattle-dipping programmes.

[1] South Africa's black or Negroid population has been labelled under various terms, as the political idiom adapted along the ideologically accepted nuance of the day under Apartheid. These people have been variously referred to as Natives, Bantu, Africans and Blacks. After South Africa's democratisation in 1994, it was popular to refer to all non-Caucasians as Blacks (capitalised) - reminiscent of the former Apartheid categorisation of Whites and Non-Whites. However, it is lately accepted practice to refer to the various race groups as follows: whites (Caucasian), blacks (Negroid), coloured and Asian. In the context of this thesis, the term African is used as an adjective (relating to Africa – as in African culture, custom, climate, uses or territory) or as proper noun (an African, or Africans – Negroid person/people who inhabited the region before colonisation by Caucasians); black (uncapitalised) – as ethnic description of Negroid persons.

The argument of this thesis is that the success of past cattle dipping programmes cannot be evaluated only in terms of the eradication or control of cattle diseases, but should be seen in the total context of sustainable development. Likewise, future dipping programmes should be developed with this aim in mind.

This chapter presents an introduction and background to this research project. It starts by providing an introductory description of the concept of sustainable development. The chapter then presents an overview of South Africa's history, especially as it relates to the spatial distribution of land occupation by race groups, followed by the historical background of the Vhavenda tribe. Thereafter follows a statement of the research problem, the aim and objectives of the study, an explanation of the research methodology, and lastly the description of the study area.

1.2 THE CONCEPT OF SUSTAINABLE DEVELOPMENT

Sustainability is the most notable form of environmentalism. It has been the subject of a meteoric rise to the status of a buzzword in academic circles and beyond. According to Storddat, as cited by Wilbanks (1994), the concept developed first from concerns in the industrialized countries about conserving nature in the face of global economic and demographic pressures. These pressures related to the geographic exploration of the tropics, and were pushed by a sense of crisis about the implications of population growth, along with a general rise in awareness of environmental issues in the late 1960s. As a result of concerns about environmental challenges raised at the Stockholm Conference of 1972, the United Nations Environment Programme promoted the concept of eco-development. This concept in turn led to the establishment of the World Commission on Environment and Development (WCED, 1987a) that was headed by the Swedish Prime Minister Brundtland; hence the Brundtland Commission. The commission submitted a report entitled *Our Common Future* to the UN General Assembly in 1987 (WCED, 1987b).

The WCED is generally credited with bringing the concept of sustainable development to the global stage, defining the term as

> "*...meeting the needs of the present generation without compromising the ability of future generations to meet their needs*" (WCED, 1987b: 43).

The concept found more explicit expression in the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992 (UNCED, 1992) – commonly referred to as the "Rio Summit". Its meaning was further consolidated at the World Summit on Sustainable Development in Johannesburg in 2000 (WSSD, 2000). It was at this summit where international targets in the form of millennium development goals were set. The goals focussed on: providing food and nutrition, providing adequate clean water and sanitation, providing energy, nurturing children, finding shelter, providing an education, and finding employment (Illich, 1970; Westcoat and White, 2003). As a result, sustainable development became a buzzword in academic circles, politics, and beyond. Wilbanks (1994) noted that the concept has become a catchphrase in discussions and actions centred on development, as it seems to capture a widespread feeling that the earth is at risk of destruction. This feeling is strengthened by scientific and non-scientific evidence of various forms of environmental degradation. Parallel to this is evidence, in the form of poverty, violence, homelessness and hunger, that economic and social systems are not delivering sustained progress toward a better life for most.

The concept of sustainable development was widely promoted by the World Conservation Strategy, which sought a more focussed approach to the management of living resources, and to provide policy guidance on how to do so. It was seen as a way of making environmental conservation play a role in improving human welfare (IUCN, 1980; Barrow, 1995). It is now recognised by both the public and policy makers that environmental sustainability is a prerequisite for all human endeavours (Shackelton et al., 2011). Consequently, the sustainable development concept has been adopted as the yardstick for evaluating the worth of development projects.

An appreciation of environmental awareness in terms of sustainable development led to an understanding of the characteristics of resource use (Brown, 2001). This means that in resource development (planning, implementation and decision making) there has to be on-going integration of social, economic and environmental factors (Aucamp, 2009) to ensure that development serves present and future generations (Wilbanks, 1994).

Sustainable development is seen as a process of mediation among social, economic, and environmental needs, which results in positive socio-economic change, and that does not undermine the ecological and social systems upon which communities and society are dependent (UNCED, 1992). Sustainable development can also be regarded as economic growth that is ecologically sustainable, and satisfies the social, economic and political needs of the underclass without damaging the physical environment (Wilbanks, 1994). Unless we rethink the ways we live with each other and with our earth, we will never experience comfortable and secure human life.

The purpose of sustainable development, whether in the form of evolutionary change or intervention, is to ensure physical, social and economic continuity, which leads to minimal community disruption (Middleton, 1995). In this regard, Figure 1.1 presents Elliot's (2008) model that illustrates the significance of sustainable development. There is thus little doubt that the prudent use of the natural environment is vital for the perpetuation of communities' livelihood (UNCED, 1992).

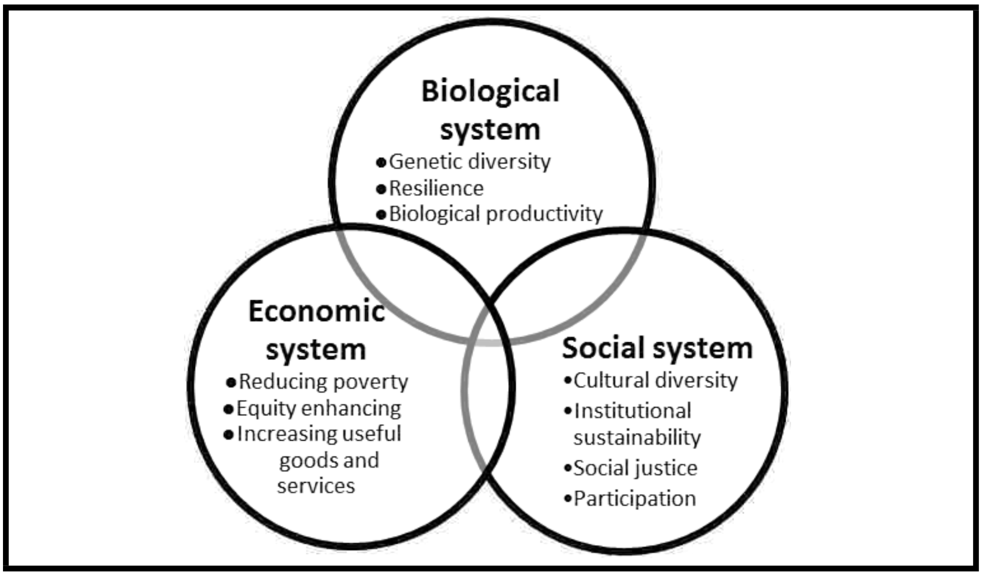


Figure 1.1 Sustainable development model (source: Elliot, 2008)

The explanations of the concept of sustainable development illustrated in the above diagram emphasize that there is a broad realisation that the social, economic, and ecological components are integrated, and that change in one inevitably catalyses changes in the other two (Shackleton et al., 2011). Human well-being depends upon ecological systems and their associated provision of ecosystem services. Linkages between ecosystems and human well-being are an important field of study of the health of the global ecosystem involving biophysical, social and economic specialists from around the world (Shackleton et al., 2011).

Underlying principles of sustainable development include *continuity*, which considers perpetuity of natural wealth into the future; *environmental integrity* emphasizes the sustenance of essential ecological processes and life support systems; *equity* which is about fairness or justice between the poor, marginalised and the rich global communities, and also towards nature; and *public participation* which promotes local communities' participation in matters concerning the management of development projects and their environment.

Another perspective worth taking note of, is the sustainability model developed by South African Department of Agriculture and Tourism (DEAT, 2008), where governance is regarded as a fourth element of sustainability which encapsulates or underpins all of the other three elements as illustrated in Figure 1.2.

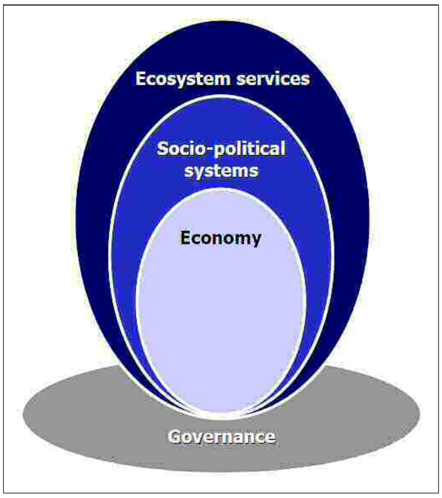


Figure 1.2 The four dimensions of sustainability (source: DEAT, 2008)

DEAT regards the three pillars model of sustainable development as insufficient to explain sustainability, and have replaced the concept by a 'cascade of dependencies' of the familiar three spheres, which are dependent on a fourth element of 'governance' to comprehend issues, and also to develop and enforce policies. The cascade of dependencies is represented in the tiering or 'nesting' of economy within socio-political systems, and likewise these two dimensions are contained within the overall ecosystem services component, which are necessary to support it. Governance can then be seen as the necessary policy, legislative, administrative and management systems underpinning the other spheres of sustainability (DEAT, 2008).

Other interpretations of sustainable development are those presented by Giddens (1979) and Holling (2001). Giddens' perspective is based on the interpretation of reality in terms of structure. From the structuration perspective the existing realities of development are to be viewed on the geography of the live world of our everyday life experiences, which are associated with the social systems, norms and values that create places. Places, on the other hand, are always becoming in a historically contingent process, and also are situated within time and space (Pred, 1978). According to Holling (2001) ecosystems develop in adaptive cycles of exploitation, conservation, release and reorganization. These cycles can be described in terms of the following three dimensions - ecological 'wealth' or richness, connectedness and resilience and provide a framework for the opposing forces of growth and stability versus change and variety. Holling's interpretation of panarchy relates the development of human projects, especially agriculture, to natural systems like forests in that all have an adaptive cycle of growth, followed by collapse, regeneration, and further growth. This interpretation contends that natural systems may be exposed to the danger of outside shocks such as droughts and diseases in their process of growth, which may lead to their total collapse. However, as other cycles operate above and below, they may provide stability and resources to buffer the system from shocks and to help it recover from shock (Holling et al., 2001).

Sustainable development is a concept that connects well with the heritage and strength of the discipline of geography. Its definitions encompass relationships between humans and their environment (resources) as they manifest themselves in space. In it one sees the influence of both locational and social theories. It is also linked to many current fundamental questions in geography that societies have, including globalisation, resource perception and exploitation, resource development and allocation, environmental problems, political ecology, the application of geographical information systems (GIS) and impact assessment. Even though the meaning of the concept appears paradoxical and somehow ambiguous, with environment on the one hand and development on the other, Blaikie (cited by Wilbanks, 1994) contends that it has the potential to serve as an intellectual dynamic and a normative focus for integrating our different perspectives on the world around us.

1.3 THE GEOGRAPHICAL BASE OF SUSTAINABLE DEVELOPMENT

In trying to understand the surface of the earth as the home of humankind, Abler et al. (1971) reason that geographers' approach is guided by the **spatial perspective**, i.e. their study of location and distribution of features on the surface of the earth. There is always an element of variance with regard to the traditions that explain the study of geography. The approach underpinning the geographic study of cattle dip tanks, as is indicated in the title of this thesis, is that of human-environment interrelationships. The **man-land tradition** emphasizes the interrelationships between the human and physical environments. The key focus of this tradition is on how man lives and how man makes a living in the physical environment in which he is found. Man is regarded as central to the world's ecosystem, influencing it and being influenced by it (Whynne-Hammond, 1985).

Underlying the human-environment approach is the philosophical basis that the study of people cannot be undertaken without reference to their milieu. In this regard Jones and Eyle (1977: 26) state that:

> "*…to talk about people without reference to their milieus is to forsake geography altogether"*.

The study of human-environment relationships includes among others, human perception of and adaptation to the physical environment, and humans' alteration of the landscape. Alterations of landscapes view the human as an agent transforming the environment either by improving or denigrating it. Halford Mackinder (1887), one of the pioneers of geography, identified geography as a discipline which traces the interactions of humans and their physical environment.

The human-environment paradigm in geography can be traced back to the Classical Period (Martin and James, 1993). During this formative era of geographic inquiries, the emphasis was more deterministic; that is, human behaviour was taken to be determined by the influence of conditions of the natural environment. Prime importance in geographic enquiry was allocated to the impact of the physical environment upon man, asserting that the physical milieu sets a tightly constrained context for human life. Human behaviour was seen as primarily adaptive in the face of environmental circumstances, responding to the stimuli imposed by climate, soils, relief, and vegetation (Gold, 1980). This view was promoted by the early geographers such as Friedrich Ratzel and Ellen Churchill Semple. Semple became famous for her remark in her book *Influences of Geographic Environment:*

> "*Man is a product of the earth's surface. This means not merely that he is a child of the earth, dust of her dust; but that the earth has mothered him, fed him, set him tasks,*

> *directed his thoughts, confronted him with difficulties that have strengthened his body and sharpened his wits"* (Semple cited by Martin and James, 1993: 330).

Contrary to the deterministic viewpoint, the rise of the philosophy of humanism in geography shifted the focus from human-land interaction to that of **possibilism**. This concept was formulated by geographers like Friedrich Ratzel and Paul Vidal de la Blache (1926). Vidal de la Blache regarded the environment as an inert forum for man's activities while man himself was viewed as the active agent. In his *Anthropogeographie*, Ratzel insisted that nature sets limits and offers possibilities for human settlement. Vidal believed that the natural environment offers possible avenues for human development, and the precise avenue chosen being very much a human decision (Cloke et al., 1991). A more flexible explanation raised by Vidal is the one where man-environmental relationships are viewed in terms of social relations. Social relations in this regard consist of an intricate network of ties and ideas which provide a stable way of perceiving and conducting daily life in a particular geographical setting.

Humans' centrality in the world ecosystem is shown by his endeavour of exploiting the natural elements in order to satisfy the needs that sustain life. Zimmerman (1951) refers to these environmental components which humans use to satisfy needs or sustain life as *resources*. The meaning of the concept of resource is derived from values human beings attach to natural entities as well as the functions they perform.

Abler et al. (1971: 343) clearly state:

> "*...people use their environments according to their needs, their want and the know-how they absorb while growing up in their society that rears them*".

This implies that the use of the environment depends on the value system and the technology of the inhabitants. It also implies that the inhabitants must conceptualise their needs or wants and how to satisfy them. The conceptualisation of human needs and wants arises from the meaning or value humans attach to the environment in relation to how the environment serves them or how they utilise it. In other words, how a group of people interprets the environment depends on how they perceive it as a group.

Humans' perception, on the other hand, is closely connected to their value systems which play a role in decision making and implementation of such decisions. What is considered as the environment, therefore, is a mosaic of human action that has come about after a comprehension or perception of particular steps with regard to answering the challenges that humans meet in their daily lives. Regarding this view, Fielding (1978: 282) asserts:

> "*In any area, survival is dependent upon human's ability to perceive and learn about the physical environment*".

The application of the value system or attitudes to the environment gives rise to what Vidal de la Blache calls the personality of the region. The personality of the region is the outcome of the way in which society exploits the resources, how society reacts to its habitat and its challenges, and how it organizes itself; it is accordingly an outcome of its culture (Jones and Eyle, 1977).

Understanding the personality of a region involves describing and explaining continuous interactions among and between human and environmental variables. Various concepts have been used to describe this continuous interaction, of which the sustainable development concept is but one example.

The few foregoing explanations of sustainable development show that it has become a screen behind which resources are being allocated and decisions are made. However, there is value in it in a broad, even vague concept that allows people with perhaps otherwise irreconcilable positions to reach common ground (Dryzek and Scholsberg, 1998). The concept brings together two strands of thought about the management of human activities; one concentrating on development goals, and the other on controlling or limiting the harmful impacts of human activities on the environment. An idea that is derived from this concept is that the development of public policies need to aim at the achievement of the society whose primary goals are: a) to meet the needs of a much larger but stabilizing human population; b) to sustain the life support systems of the planet; and c) to substantially reduce hunger and poverty (Hardoy et al., 1997; Dryzek and Scholsberg, 1998; Westcoat and White, 2003). It encourages people to operate within a certain level of ethics and technological aptitude that will enhance the optimised utilisation of the currently available resources and delay or slow down their depletion. This will relieve pressure on the environment in such a way that even the future generations will still have resources to be able to meet their needs (Hardoy et al., 1997).

1.4 CATTLE DIPPING SYSTEMS AND SUSTAINABLE DEVELOPMENT

This thesis focuses on the sustainability of cattle dipping. The sustainability of cattle dipping systems is based on a model of complete sustainable development. The completeness of sustainable dipping is regarded as an aspect that is dynamic, interventionist, conservationist and complete. It is dynamic because social realities and systems are always becoming or developing (Pred, 1978). Giddens (1979) argues that the societal and institutional rules and norms that influence human agents and agency keep on changing. Therefore there have to be measures that are put in place to accommodate and adapt to changes without jeopardising the structure-agency relationship, since human actions sometimes impact negatively on the environment both on a short term and long term basis. The uncontrolled use of resources can lead to the depletion of some resources, especially stock resources. In addition, some life forms can become extinct and the quality of the natural environment can also deteriorate, subsequently affecting human life. These issues should be kept in mind where man exploits and develops the environment, dip tanks included. Conservation measures must be put in place to prolong the supply of resources as well as enhancing the quality of the environment. Conservation results in the fostering of adaptive capabilities of both the physical and human systems. Also, the prolonged supply of resources creates and diversifies opportunities for development.

A model of the windmill can thus be used to illustrate the complete model of sustainable development in this thesis. For the mill to turn there has to be a balanced connection of the blades to the cog or axis of the wheel. When the blades are well balanced, the propeller turns easily even if there is a slight breeze. If one of the blades is not in line with others, the wheel may wobble and not pump water. There is therefore an element of complementarily and completeness for the windmill to pump water.

As illustrated above, the topic of this thesis is stock dipping as an intervening strategy to control diseases that are transmitted by ticks in the Venda area of north-eastern South Africa, and its impact on sustainable development. The allocation of land to Africans within the context of South Africa’s history, and also agricultural practices by Africans in this context, serve as background to the study.

1.4.1 South African Historical Overview: 1652 – 1910

Agriculture and consequently the establishment of cattle dipping tanks in the former Venda area cannot be understood in isolation from the historical processes that have affected South Africa as a whole. Basic to this is the development and entrenchment of the disintegrated or segregated South African geographic space (Yawitch, 1982) as espoused by apartheid ideology.

The area that became known as South Africa reflects the political ideologies and systems pursued by its successive governments (Simon and Ramutsindela, 2000). South Africa's political and economic evolution did not occur within a vacuum, but was set within a deep-rooted pattern of European thought, as reflected in social class structures and which was manifested in the ways which colonies were organised at a variety of spatial scales (Lester, 2000). In South Africa this bred what became known as the segregationist order. Throughout the country's historical development there has been a power struggle associated with political dominance and the control of natural resources, particularly agricultural land and minerals. The main role players in this regard were European communities, notably of Dutch and British origins, the indigenous Khoisan people, and the different independent African kingdoms and chiefdoms of the region (Switzer, 1993; Beinart, 2001). Dominating and accommodating ideologies among the different role players have been continually contested by ideologies of conquest, seizing, resistance, dispossession and subjugation in South Africa (Switzer, 1993; Feinstein, 2005).

The African communities detested the occupancy by the Dutch and later also English communities who were regarded as foreigners intent to take the land. Several battles were fought with these European settlers. Notable forms of resistance by African communities were several frontier wars over a period of hundred years between the British settlers in the Cape Colony (Switzer, 1993), the Battle of Blood River between the Afrikaners and the Zulus in 1836; the Bambata rebellion in Natal; the skirmishes between the Afrikaners and the Barolong of the Orange Free State; the skirmishes between Sekhukhuni and the Afrikaners and the British settlers respectively; and the Mphephu wars between Venda and the Afrikaners and the British respectively, to mention but a few. The last African tribe to be subjugated was the Vhavenda in 1906 after the last Mphephu war with the British (van Warmelo, 1932; Kirkaldy, 2005). Eventually, different African tribes were brought under the white government's administration.

The objective of the earliest Dutch colonists of South Africa from 1652 was about production aimed at replenishing the food supply of passing ships to support the Dutch-Indonesian trade route past the Cape of Good Hope. However, as the South African colonist population increased, especially after their numbers and skills were bolstered by the influx of French Huguenot refugees between 1688 and 1706, and as farmers started having access to the markets outside the country, there was a need to expand agricultural and farmland over a wider area. These European colonists of subsequent generations also increasingly saw themselves as "burghers" or locals, with decreasing ties and loyalties to their European fatherlands. Over the next century they developed their own derivative of the Dutch language, calling it "Afrikaans" and assumed the name of "Afrikaners" rather than Dutch burghers. Their eastward expansion led to the clashes of the Dutch or Afrikaner settlers with the original tribes of the Cape area. Political control of the Cape Colony changed hands after the defeat of the Dutch by the British in 1795, when they held on for seven years, briefly returning to Dutch control for a few years following the Napoleonic Wars and was then formally annexed by Britain again in 1806. The Dutch perceived a threat by the British to their emerging Afrikaans language as a language of power, and to Afrikaner cultural and economic interests. They mobilised themselves as an ethnic group by migrating into the interior of the country through a movement that started in 1838 and became known as The Great Trek (Switzer, 1993). In part, this was a response to the recently settled British migrants to the Eastern Cape and the abolition of slavery in 1834 by the British. Subsequently, the Afrikaners established their own Afrikaner republics in the interior of the country; the Transvaal Republic or Zuid-Afrikaansche Republiek and the Orange Free State, respectively. These two republics were also known as the Boer colonies or republics and became political allies in their struggle against British oppression, culminating in two Anglo-Boer Wars in 1881-82 and 1898-1902. The second Anglo-Boer War is also referred to as the South African War.

After seizing control of the Cape Colony in 1806, the British strengthened their quest for more material acquisition to sustain the capitalist mode of production by expanding their control towards the interior eastern boundaries. They defeated the African tribes which they encountered by using their superior administrative and military tactics and weaponry.

The time the British gained total control of the Cape Colony coincided with the period of improvement in the marketing and trade conditions of South Africa's agricultural products.

Commercialisation of white agriculture was accelerated. However, some white farmers were out-competed by the African farmers of the time. A strategy that was devised to limit the strength of African farmers was to reduce their access to land. The act of legislature that enabled this was the Glen Grey Act of 1894 (Beinart, 2003). The objectives of the act were: to reduce the size of agricultural plots owned by African farmers; to force a greater proportion of the male population into the migrant labour market – to work on the white farms; and also to promote and maintain territorial segregation between African and British settlers. Land allotments in African territories were to be communal and could not be mortgaged or leased. The Glen Grey Act is regarded as the first official practice of land segregation in South Africa and was extended to several other districts over time. African territories became reserve areas for labour that was required in white areas.

By the mid 1890s a complex of key capitalist concerns had been established based on minerals; especially after the discovery of diamonds in Kimberley in 1867, and gold on the Witwatersrand in 1886. The concerns had also extended into all other sectors of the economies of the Boer Republics and the British self-governing colonies and territories, in which both the British and Afrikaners had vested interests. The interests included amongst others the British quest of expansionism for economic growth coupled with political supremacy; the demand for labour on the farms by Afrikaners; and the need for labour in the mines and industries. In the process of realizing the quest of expansionism and economic growth, the white settlers systematically expropriated African territories. Contrasting views about the above interests also resulted in conflicts between the Afrikaners and the British, which eventually led to the outbreak of the South African War between 1899 and 1902. The Afrikaners were defeated during the war, and they subsequently forged political unity with the British colonies of Natal and the Cape Colony in 1910. The state that resulted from the unity was the Union of South Africa. The Union, however, eventually excluded political power to black communities (or African communities– see footnote 1 on p 1), and therefore their role in the ruling of the country, by 1926.

1.4.2 The Context of Land Allocation to and Agricultural Practices by South African Blacks : 1910 - 1994

After the formation of the Union government in 1910, the state developed into a powerful and well organized instrument of persuasion as well as coercion that served the interests of a segmented but relatively stable racial alliance of white middle- and working-class interests (Switzer, 1993; Mager, 1999). The running of the country was based on the policy of racial segregation, with white people occupying a large percentage of the land area, and black people occupying a small area. The foundation of racial segregation in South Africa was the recommendation of the South African Natives Commission of 1905. Black areas were regarded as labour reserves wherein communities ran their own tribal affairs but under the control of the white government. Planning of black spaces was formalized with the passage of the Natives Land Act of 1913 and the 1936 Native Trust and Land Act, respectively. The 1936 act divided the land into two sections: Thirteen percent was allocated to blacks and other 'non-whites' who constituted 75 percent of the population, and eighty percent was allocated to whites who constituted less than 25 percent of the population (Tatz, 1962; Unterhalter, 1987; Lemon, 1987; Christopher, 1988; Christopher, 1994). The administrative driver was the then Native Affairs Department (NAD) (Evans, 1997; Posel, 1997).

The policy that accompanied spatial planning in black areas led to the establishment of betterment villages. De Wet (1995) points out that betterment planning in South Africa mirrored colonial environmental policies in other British African colonies, which entailed the restructuring of African uses of space between residential and agricultural land. Betterment was a spatial reorganisation process in tribal areas whereby land was organised into concentrated village settlements, separated from pastureland and arable land.

Improvements in black tribal areas were introduced in South Africa after the 1936 nationwide conservation survey of African townships, colloquially known as *locations,* that was aimed at re-planning settlement to save them absolute ruin (Beinart, 1984; Platzky and Walker, 1985). The division of land was that in a village each household received a small plot of land (approximately 3000 m^2) to build a house plus between two and five morgen (1 morgan = 875 m^2) of arable land for cultivation. The small size of the plots ensured only the most basic crop production: mainly intercropping comprised of maize, pumpkins and ground nuts. Agricultural land was divided between arable land for crop production and grazing areas for stock rearing. It was eventually adopted as a best model of developing black territories by the

National Party government when it introduced the Separate Development model (McCusker and Ramudzuli, 2007). The expressed rationale of the schemes was to rehabilitate the land from the alleged perils of overgrazing and inefficient African land use, but Beinart (2001) contends that, in reality, such schemes facilitated increasing population densities in the so-called native reserves, making them convenient labour reserve areas.

An early step toward realizing the goal of separate development was taken in 1951 with the passing of the Bantu Authorities Act (Butler et al., 1977). The Act established national and regional administrative structures and began the process of spatially differentiating the black population into ethnic groups. The reorganization of space continued further in 1959 with the promulgation of the Promotion of Bantu Self Government Act of 1959. This Act provided a legal and administrative framework for separating black areas from white areas in South Africa (McCusker and Ramudzuli, 2007) and made provision for the creation of ethnic self-governments of black territories called *Bantustans*. The Bantustans included Transkei for Xhosas, Bophuthatswana for Tswanas, KwaZulu for Zulus, Ciskei for Xhosas, Gazankulu for Shangaans, Kangwane for Swazis, KwaNdebele for Ndebeles, QwaQwa for South Sothos, Lebowa for Northern Sothos, and Venda for Vendas. Subsequently, black areas were accorded either the *Homeland* or the *Independent National State* status, depending on whether they opted for 'self-governance', or preferred to remain under South African administration (Horrel, 1973; Malan and Hattingh, 1976). The main driver behind this was The Bantu Homelands Citizenship Act of 1970. This Act decreed every black a citizen of a specific homeland (or Independent National State) – i.e. of a Bantustan - whether or not he or she lived there. All blacks were regarded as foreigners in white designated areas and they had to obtain permission to be in the white areas, either for work or a visit (Unterhalter, 1987; Davenport, 1991; Christopher, 1994). The legislation that drove this practice was the Population Registration and Group Areas Acts of 1950 (Christopher, 1994). Figure 1.3 is an example of a citizenship document that was issued to blacks as per the requirements of the Homeland Citizenship Act of 1970.

The political terms of spatial segregation officially used for the African areas by central government at various stages in recent South African history are: labour reserves, regional tribal authorities, Bantustans, homelands and nation states (independent national states). Reserves date from the pre-apartheid period; and the other terms represent stages in the evolution of the policy of apartheid and refer to the various ethnic political constructions that have been created on the basis of the reserves (Platzky and Walker, 1985).

Figure 1.3 Identity documents (Pass books) for blacks according to the Separate Development Policy: 1 Pass book, 2 Permission to be in urban areas according to Group Areas Act, 3&4. Venda Homeland Identification Documents

In April 1994, a new democratic South Africa was born. The extension of political rights to the whole citizenry of the country was an event celebrated globally. With the end of apartheid, communities including communal rural farmers waited expectantly for infrastructure and economic development.

1.5 LAND RE-ORGANISATION AND DISPOSSESSION OF THE VHAVENDA TERRITORY AND PEOPLE IN THE 20th CENTURY

The Vhavenda people referred to in this study is a tribe that is found in the north-eastern part of the country; an area that predominantly straddles the Soutpansberg mountain ranges of South Africa. The historical legend of the tribe links the origin of the Vhavenda to the Great Lakes of Africa, formerly called Land of the Zendj by ancient Arab explorers (Marole, 1966). Oral history states that the tribe migrated southwards from the Great Lakes area being led by their successive kings until they crossed the Limpopo/Vhembe River.

The migration of the Vhavenda assumed the form of tribal waves with some groups crossing the Limpopo (Vhembe) River as early as the 12th century. The earliest Venda people to occupy the northern part of South Africa were the Vhangona. These were small groups who were scattered in different areas of the region. The Vhangona were followed by the bigger, more organized Singo group (Lestrade, 1930; Kirkaldy, 2005), who traversed the Limpopo River around 1700 and settled at Dzata I and II along the floodplain of the Nzhelele River valley. The Singo group conquered the Vhangona, and in the process brought political centralization in the area, where successive kings ruled the area for a long period. Harnisch (cited in Kirkaldy, 2005) argues that at the height of its power, the Dzata Empire extended as far as the Olifants River near Phalaborwa in the south, the Blouberg in the far west, and northwards across the Limpopo River (Liesegang, 1977).

After the death of the last Singo leader, Thoho-ya-ndou, civil war broke out. Dzata was abandoned and the tribe fragmented into independent chiefdoms. The princes managed to establish themselves as independent rulers in their respective areas. The area became known to be dominated by three great chiefs (*mahosi*) of Singo descent; namely chief Mpofu (Ramabulana), chief Tshivhase, and chief Mphaphuli. There was also a considerable number of lesser chiefs and headmen who exhibited varying degrees of independence, but who showed allegiance to the powerful three as a result of marital ties and tribal political agreements. Some of these were Rambuda, Nethengwe, and Madzivhandila (van Warmelo, 1932; Kirkaldy, 2005).

The Tshivenda language has been influenced by the interaction with the Shonas of Zimbabwe and early Sotho speakers, as evidenced in the strong linguistic resemblance that Tshivenda language has with both Shona and Sesotho/Sotho-Tswana (Kirkaldy, 2005). There are many other cultural elements in common between the groups, e.g. similar patterns of stone-walled villages. The Venda tribe is therefore linked with the occupation of Great Zimbabwe and Mapungubwe. On their movement southwards, the Singo were protected by a magical drum with magical powers, which was known as *Ngoma Lungundu*, the drum of the dead or the drum of Mwari/Mwali. Only the chief beat the drum and because of this important role, he was highly revered.

Before the introduction of western commercial economy, Venda people were mainly subsistence agro-pastoralists and were also known for their skills of hide tanning, wood carving, and working with iron.

Wessman and Weinthal (1908: 28) made the following observation about the Vhavenda's iron forging and smelting skills:

> "*The most prominent art in Bawendaland is that of the forge. Everywhere in the country one can find old dilapidated furnaces which served for producing and melting iron".*

All social actions of the Vhavenda are based on the principles of social cohesion, respect of the elderly, and general mutual respect. The elders mainly play a role of mediating conflicts among societal members, and they are therefore held in high esteem. Venda communities exist in a form of extended families, which is essential when it comes to the sharing of labour and the provision of social security. Activities such as working the fields, construction, child rearing and looking after cattle are done on a collective basis. The Vhavenda also hold a high conception of justice and in practice the supreme court of justice consists of the chief of an area and his advisers or magnates. Cattle have been used as means of reckoning wealth, and they are a prized possession since they are an important currency for many societal activities.

Vendas are highly religious people. They traditionally worship their god Mwari/Mwali through the intercession of their ancestors or the dead. In the pursuit of this, they expect protection from their dead, and they also fear the influence of their deceased. In addition to Mwali there are provincial gods, village gods, and sometimes even house gods (Wessman and Weinthal, 1908). The god and other gods are worshipped for rain, good harvest, protection against the enemies, protection against witchcraft, and passage of age, to name a few. People who are held in high esteem are the chiefs and their medicine men. Places that are set aside for the dwelling of the ancestors could be sacred groves or forests, lakes, waterfalls, mountain summits, stream pools, and cattle kraals (van Warmelo, 1932; Kirkaldy, 2005). In some cases, the idols are kept at home in the form of sacred animals or trees planted in the centre of a homestead. Cattle are very important in the realm of Venda worship and are slaughtered during the performance of rituals as sacrifices. They are also sometimes given the status of family gods.

The traditional spatial layout of Venda settlements was in a form of scattered isolated farmsteads and chiefs' kraals with several clustered homesteads. Currently, however, the settlements are in a form of clustered planned villages where most of the settlements assume the names of their historical, traditional or clan names. Land use is mainly agricultural and it is divided in into communal arable and grazing areas, respectively; or as it is also known, the betterment system.

At around the early 1800s the Vhavenda tribe was first exposed to the European form of administration through contact with the first white hunters and pastoralists, white traders and missionaries. It is assumed that the Vendas at first allowed the pioneering white community, the Voortrekker group, to settle in their territory. However, issues such as land loss suffered by Vendas, the demand for their labour (*diensdoende*) by the whites, and also the demand of tax, created a potential for conflict. Resultant skirmishes led to the all-out Boer Mphephu war of 1898, the year when the Anglo-Boer War also commenced. The war was followed by the total subjugation of the tribe by the victorious British government in 1905 (Nemudzivhadi, 1985; Kirkaldy, 2005).

After their defeat by the British in 1905, and the subsequent formation of the Union of South Africa in 1910, Venda became one of the native reserves under the jurisdiction of the Union of South Africa, reserved specifically for the occupancy of the Tshivenda speaking people. Thereafter the area went through all the political concepts of spatial segregation, attaining legislative assembly status under South Africa in 1969. The Bantu Homelands Constitution Act of 1971 granted Venda self-government status in 1973, and in 1979 Venda was granted independent status (Independent National State) within the Republic of South Africa, along with three other Bantustans, namely Transkei, Bophuthatswana and Ciskei by virtue of its National Party-appointed leaders accepting this status (Nemudzivhadi, 1985). Even though Venda ran its internal and foreign relations, the independence was somehow partial because the South African government still supplied most of the funding for its budgets and contributed many key civil servants, police and army officers to ‘assist’ in the administration of the state.

When South Africa held its first multiracial elections in 1994, the homeland system was dissolved and Venda was incorporated into a unified South Africa as part of the Limpopo Province. The name Venda is presently perceptual as the area is associated with Venda speaking people.

1.6 FURTHER 20th CENTURY CRISES: DROUGHTS AND ANIMAL EPIDEMICS

From the later years of the 19^{th} century through to the beginning of the 20^{th} century, three major events impacted the rural community in north-eastern South Africa, an area that is currently perceptually known as Venda. The first two of these were described in the foregoing section 1.5, namely the reorganisation and consolidation of the traditional political landscape of the region; and the strategy of land dispossession, conquest, and subjugation. The third event was the outbreak of drought and animal epidemics (Kirkaldy, 2005): Rinderpest in 1897 and East Coast Fever in 1901.

In the advent of the outbreak of East Coast Fever in South Africa in the early 20^{th} century, the white national government introduced an extensive and systematic cattle dipping programme involving all communities as an intervention measure to save the cattle industry in the country. Dipping was made compulsory for all cattle farmers, commercial and subsistence; and it was supported by other supplementary measures such as paddocking, fencing, impounding of stray cattle, reduction of animal movement as well as culling.

The introduction of cattle dipping was an integral part of the past political ecology of South Africa; a system of spatial segregation. Dipping tanks were established both on commercial farms and in rural black communal areas. The white commercial farmers, assisted through state subsidies, were encouraged to administer their own dipping, while the service of dipping in the black areas was provided for by the state through the Department of Native Affairs (Mbeki, 1964; Beinart, 2003). The system was driven by the entire administrative framework that unfolded with the management of black territories and in this context dipping was first introduced in the former Venda territory in 1915 (Marole, 1966; Nemudzivhadi, 1985). According to the Tomlinson Commission (Tomlinson et al., 1955), dipping services had to be provided for by the government since black communities did not have the necessary resources. Information about animal diseases and dipping was provided by the authorities.

When East Coast Fever broke out in 1901, the authorities in the Venda area were faced with a dilemma on how control the spread of the disease. This was because of three reasons. Firstly, Venda people were too attached to cattle that they could not accept any foreign practise or method of attending to diseases of their cattle. As happened in many black communities, the social system of the Venda community was bound up in the closest possible manner with livestock ownership. Livestock and especially cattle were the Vendas' most prized possession, being valued on account of their commercial, religious and social significance: cattle were used for ploughing, for buying brides (payment of *lobola*), paying fines, offering sacrifices, and settling tribal disputes. A similar observation about the value of cattle was made by Ainslie (2002) about cattle ownership and production in the communal areas of the Eastern Cape. Because of the religious and social significance of cattle to the Vendas, the death of an animal could not be attributed to a disease and was therefore either regarded as an omen or a cause of some witchcraft. Secondly, the limited control of animal movement during the earlier days of the outbreak of the disease made the disease spread rapidly. Thirdly, the proximity of Venda territories to Zimbabwe (formerly Rhodesia), Mozambique and the Kruger National Park made it to fall into an East Coast Fever zone during the outbreak of the disease. Therefore, when Venda eventually fell under the jurisdiction of the Union, dipping of cattle was made compulsory in order to control the outbreak of East Coast Fever. According to Marole (1966) and Nemudzivhadi (1985), the first cattle dips were introduced in Venda in 1915 and the area presently has 127 dipping sites (Randela, 2000). Oral history records that earlier dipping tanks were erected along the corridors bordering Zimbabwe and the Kruger National Park.

The introduction of a dipping strategy in South Africa could be considered as a panarchy that provided stability in animal rearing, and saved the South African cattle industry from total collapse. It, however, did not escape the influence of the country's political ecology. The structure of cattle dipping in South Africa was an integral part of the spatial settings in the country, thus of the social systems, norms and values which created places reflecting racial segregation. Therefore the establishment of the tanks in the communal areas was assimilated into the interpretation of the divided local politics. Commercial farmers viewed dipping as a useful activity for the control of diseases, while the establishment dip tanks in the tribal areas was not initially accepted as a utility, and their operation was perceived as political and cultural imposition (Mbeki, 1964; Beinart, 2003). A misconception existed that cattle diseases were brought in by whites (burghers) who used them to bewitch cattle belonging to blacks so that they could easily take the black man's territory (Giessekke, 2004). This misconception was compounded by activities such as the counting of animals during dipping days, penalties associated with non-compliance, and the animal tax that cattle owners were expected to pay. Forms of resistance that ensued were aimed at discouraging cattle owners from sending their animals to the dip tanks, or cooperating with the dipping authorities. In some instances, the resistance was accompanied by intimidation, violence, vandalism and the destruction of dipping infrastructure (Mbeki, 1964; Yawitch, 1982; Mager, 1999; Ainslie, 2002). The resistance to cattle dipping was eventually controlled through a series of legal frameworks that went together with the process of consolidating the system of spatial segregation in South Africa.

East Coast Fever was eradicated in South Africa in 1954 through the practice of dipping, along with the coercive measures instituted to make stock owners compliant. Compulsory dipping was consequently discontinued in 1960 at large, except in the communal areas, where the service remained compulsory. The purpose of continuing the practice in communal areas was to control other less destructive tick-borne cattle diseases and the provision of stock dipping by the government in the homeland areas remained compulsory until 1994 (Fletcher 2004; Sefara, 2010). Up to this time cattle dipping was a compulsory system that was provided by the National Department of Agriculture (NDA) as part of the Primary Animal Health Care Policy (PAHC) in the communal areas. However, as the new political dispensation unfolded, the apartheid space-economy was restructured, and many policies of governance were consequently reviewed or completely removed from the statute books. One of the policy casualties was the cattle dipping policy in the African communal areas, which was abandoned for lack of funds and budget cuts after 1994 (Randela, 2000). Hereafter cattle owners in the communal areas were left to their own devices to treat their animals against the effects of ticks.

Ten years later, the decision of not providing the service in the communal areas was reconsidered, as a result of a new outbreak of Foot and Mouth Disease (FMD) that threatened the export industry of cattle products to the international market (Sefara, 2011). It should be noted, however, that FMD is not addressed by dipping, but that cattle dipping events allow for the inspection of cattle and the detection of FMD. Because of the past success of controlling and managing the outbreak of cattle diseases in the communal areas around cattle dip centres, it was decided to resuscitate the provision of veterinary services around the cattle dipping system. The Veterinary Section of the Department of Agriculture has subsequently reintroduced dipping systems in the communal areas on a gradual basis since 2004 by supplying communal cattle owners with acaricides that are used in the old dip tanks. Even though the government has not as yet developed a new policy on stock dipping, it has established a national task team that is currently drafting a proposal for a new dipping policy (Mampane, 2004). Meanwhile certain provincial governments, including the Veterinary Division of the Limpopo Department of Agriculture have produced a Draft Dipping Policy Document (Mampane, 2004), which has recently been updated (Mampane, 2011), whose purpose was to provide guidance implementing cattle dipping in the communal areas.

As cattle dipping is in the process of being reintroduced, it is considered appropriate to take stock of past practices in order to assist the development and implementation of new agricultural strategies during the present developmental phase.

1.7 DEFINING THE STUDY AREA

The study area for this research has been the heartland of the Venda people since 1906. Although it constituted an independent homeland from 1979 to 1994, it now forms part of the Vhembe District Municipality of the Limpopo Province.

The Venda area is situated between latitude 20^0 and 22^0 South and longitude $29^015'$ and 30^0 East. It is an area that straddles the Soutpansberg mountain range of South Africa. The climate of Venda area is subtropical with high temperature and humidity in summer and temperate, frost-free winters, making the area suitable for the survival of various insects, including ticks (Howell et al., 1983). Figure 1.4 shows the location of Venda within the Vhembe District Municipality in Limpopo Province.

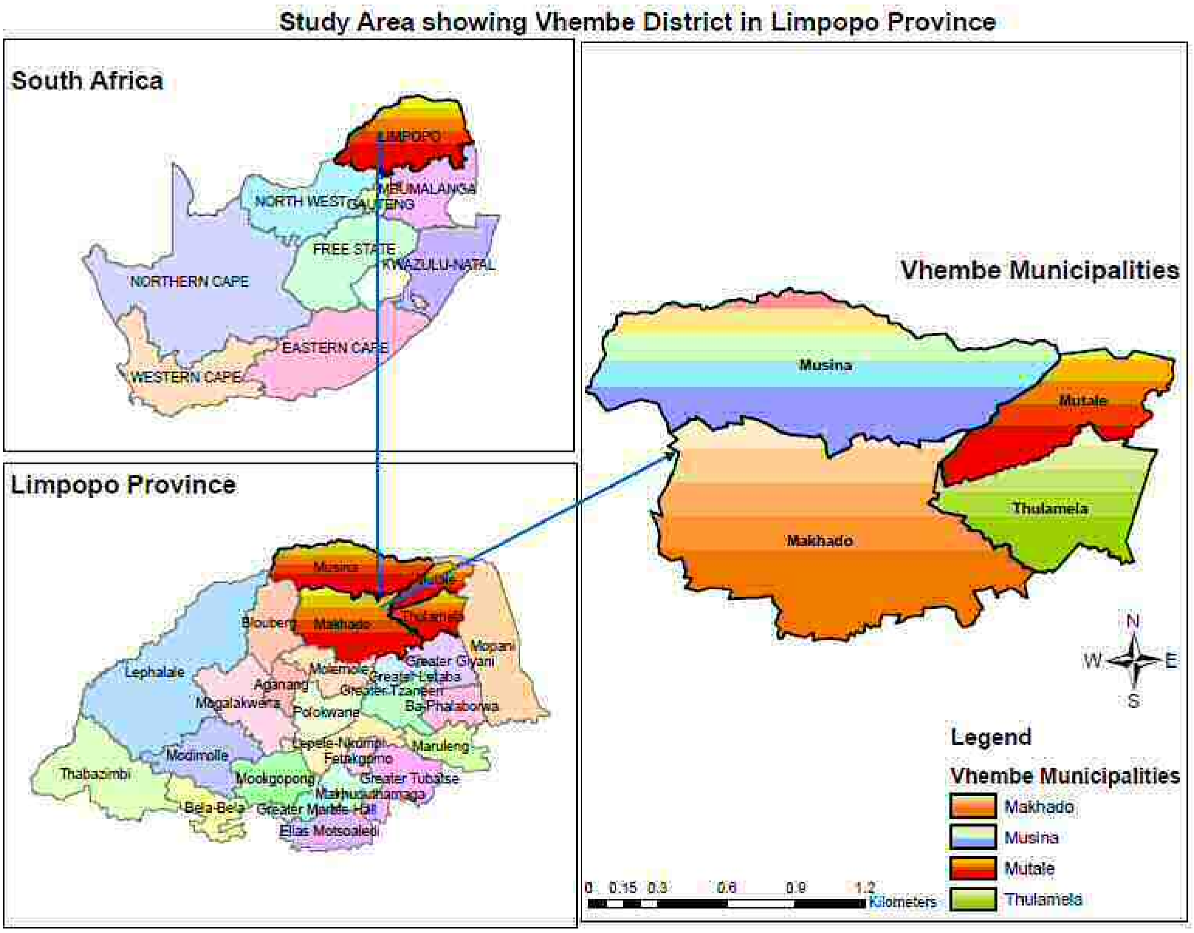


Figure 1.4 The location of Venda in the Vhembe District Municipality

The choice of Venda as a study area is based on four considerations. The first consideration is that Venda territory lies in the lowveld. This is an area that is infested with *Rhipicephalus appendiculatus*, a tick that is a vector of *Theileria parva* organism that causes East Coast Fever. The second consideration is that the Venda area is mainly occupied by subsistence communal farmers. The third consideration is that the natural environment of the area can be deceptive: while the area may appear pristine to the lay person, its peripheral location away from urban areas may make the area to suffer unnoticed from environmental injustice. The fourth consideration is the researcher's desire to do this study on dipping in an area that is inhabited by people whose language he could speak for the purpose of communication when collecting data. This would remove communication barriers and as such influence the accuracy of the data supplied.

The distribution of dip tanks, an important aspect of this study, is indicated in Figure 1.5.

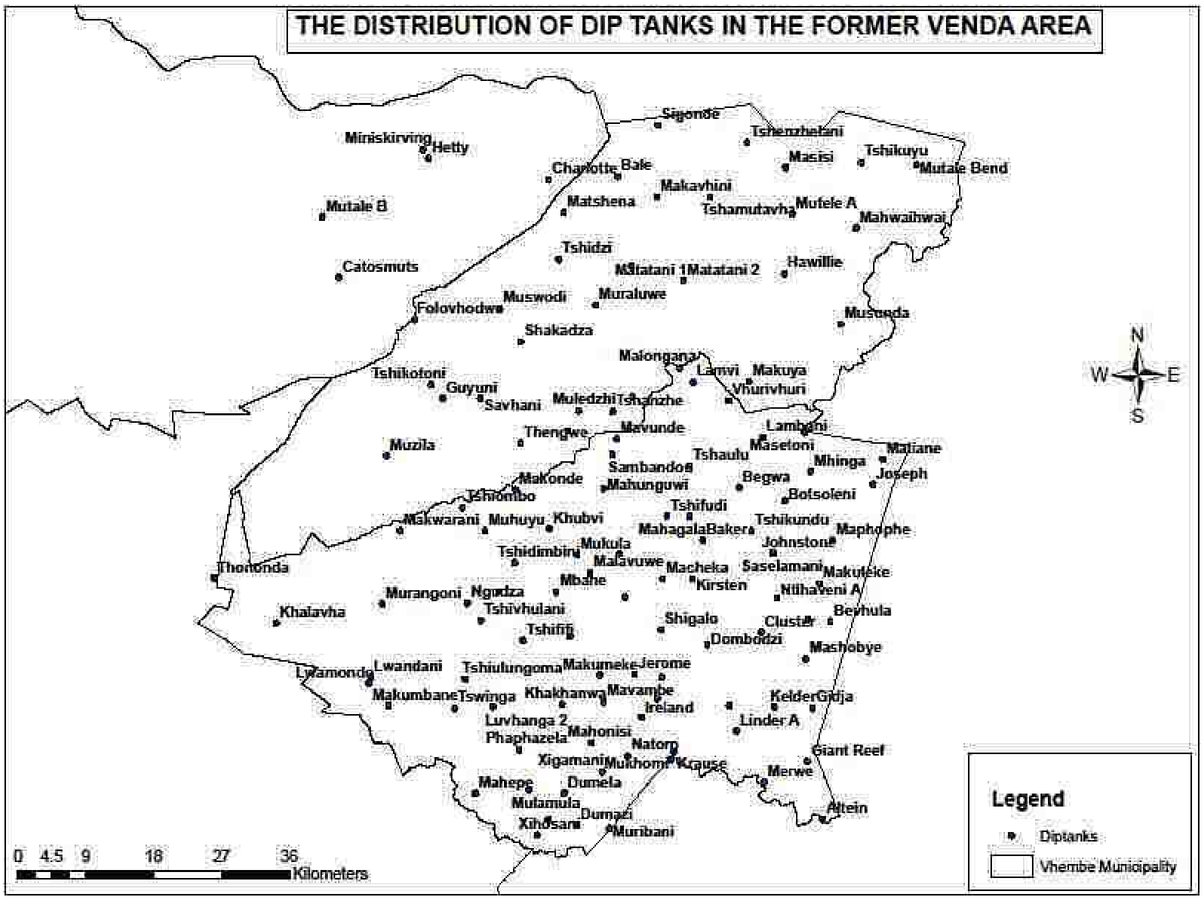


Figure 1.5 The distribution of dip tanks in Venda

1.8 STATEMENT OF THE RESEARCH PROBLEM

After the introduction of cattle dipping as one of the measures of controlling ticks and the resultant tick-borne diseases, a number of academic studies, commissions and reports have highlighted various aspects related to cattle dipping. Issues that are covered include amongst others: The historical development of dips (Anon, 1981; Nemudzivhadi 1985; Norval et al., 1992; Beinart, 2003; Coetzer et al., 1994); communities' perception of dips (Randela, 2000; Wanza, 2012); environmental contamination associated with the concentration of dipping chemical residues (Hilfinker, www.Reni.net; McDougal, 1997; MacLaren et al., 1998; Thomas et al., 1999; Noonan-Para et al., 2004; National Toxics Network, 2003; Robinson et al., 2004; Verdoorn and Marais, 2004; Moremedi and Okonkwo, 2007); the location and management of dip tank sites (Fletcher, 2000; Escobar et al., 2006; Oberem et al., 2006; New Zealand Ministry for the Environment, 2006); and health impacts related to dip poisoning (Scottish Environment Protection Agency, 2006; Health and Safety Executive, 2007).

Unfortunately these studies are not holistic and integrated. The concept of sustainable development has opened new research opportunities for closing the gaps in our knowledge, which is essential in the understanding of cattle dipping practices that are in line with the principles of a sustainable development model. This research addresses the practice of cattle dipping in terms of the environmental, social, and economic parameters in the Venda area of South Africa. This pursuit was undertaken along the following stages and themes, in order to address the critical issues that are mentioned in each step, in order to find meaningful and revealing correlations between observed phenomena or causes and predicted effects or consequences.

1. A historical background investigation about the development of cattle dipping in Venda was done in detail in order to gain insight into aspects related to the perception of people and local management practices. These perceptions were subsequently taken into account during the development of a workable and sustainable policy and management model.

2. The life cycles, distribution and species of ticks encountered in Southern Africa were investigated, as well the diseases that they cause, especially among cattle. This serves as backdrop to understand the use of chemicals to control ticks, the practice of cattle dipping and the distribution of dip tank facilities. The investigation provides insight into the characteristics of different types of tick and the appropriate measures and chemicals used to control them. In addition, people have also been exposed to the impact of various dipping chemicals in Venda over a historical timeframe of nearly a century. Knowledge about these chemicals can also give an understanding into the long term legacy and implications of various chemicals for environmental and human health.

3. A study of the distribution of dip tanks in Venda area was undertaken to present us with an understanding of the localised social impact, economic impact, pollution, and health phenomena on the settlements and rivers in close proximity to the dip tanks.

4. An examination of the ecological sustainability of dip tanks was decided upon to provide insight into the chemicals that were used in the practice of cattle dipping over time. It will therefore aid an understanding of where the chemical residues are likely to be concentrated and what remaining harmful substances may still occur in soil

profiles and sediments. As stated in paragraph 2 above, the presence of residual chemicals can also give insight into the long term legacy of various chemicals for environmental and human health.

5. It was determined to be necessary to examine the economic dynamics of cattle dipping in the former Venda area, as this could provide insight into the financial costs and benefits that are associated with cattle dipping in the area.

6. Cattle dips are not only physical structures; they are also social realities that reflect structure-agency dualism. An understanding of the distribution of dip tanks was therefore regarded as necessary in this research, as it could present us with a clear understanding of their role in promoting issues such as social cohesion, social justice, and social capital.

7. After the discontinuation of cattle dipping in the communal areas in 1994, which also included Venda, the Veterinary Section of the Department of Agriculture in Limpopo Province is currently in the process of resuscitating this service. However, the government has not as yet formulated a new policy on stock dipping, but only a draft policy document (Mampane, 2004), which has subsequently been updated (Mampane, 2011) but is not yet formalised or adopted.

   The draft Cattle Dipping Policy is discussed and evaluated in the light of the research findings. Hereafter a Sustainable Community Dipping Model is developed to enhance the policy: It addresses shortcomings of the policy and proposes a more sustainable approach to cattle dipping and endeavours to generate more sustainable outcomes. In order to have a viable policy document the introduction of the new dipping systems has to be well informed by evaluating past practices. This study will assist to avoid repeating past mistakes.

Thus, given the fact that we draw from the past and present experiences in order to develop new ideas that can be useful in future, this study engages with past cattle dipping practices in the Venda area by considering the main principles of sustainable development, and also seeks to establish a sustainable model that can guide the implementation of future cattle dipping strategies and policies.

1.9 AIMS AND OBJECTIVES

1.9.1 Research Aim

The overall aim of this geographic research is to critically evaluate the sustainability of cattle dipping practices as a reflection of the structure-agency relationship in the broader human-environment interaction context in the former Venda territory. It therefore investigates the ecological, economic and social realities of cattle dipping practices from a sustainable development perspective with the purpose of establishing a sustainable dipping model as framework to guide the implementation of new agricultural strategies and policies in the former homelands.

1.9.2 Specific Research Objectives

In the light of the above aim, specific objectives of this study are to:

1. Explore the historical background of the development of cattle dipping in Venda within the context of the South African political ecology.
2. Explore the theoretical background of ticks and the use of dipping as a control measure.
3. Investigate the location of cattle dips and map their distribution in the study area.
4. Examine the ecological sustainability of dip tanks by investigating the occurrence of chemical contaminants in the dip tank sites.
5. Examine the economic dynamics of cattle dipping in the former Venda area.
6. Examine the social sustainability of dipping tanks in the Venda area in terms of social cohesion and capital.
7. Develop a suitable model for the future considerations: framework for policy development and implementation.

1.10 METHODOLOGY

The data which the researcher dealt with in the study was geographical in nature in that such data were capable of explaining spatial issues. The type of data has been both quantitative and qualitative. Several methods were employed for the collection of information. The employed methods included several field methods, archival search, field observation, focus group surveys, and key informant interviews.

The collection of primary data included:

1. The location of the dip sites was determined by using GIS and Remote sensing techniques that included the use of Global Positioning System GPS for plotting the coordinates of the dip tanks. The coordinates were used to generate maps that constituted the spatial basis of the study areas.
2. Direct field observation for ground truthing about dipping activities, the state of dip tanks and the measurements of distance between dip tanks and villages and water sources, respectively.
3. Every society has topics that are not discussed in written documents but which are transmitted orally (Gilbert, 1993). It was therefore important to seek the oral testimony regarding the history of dipping from the Key Informants (KI) who has been exposed to the activity for a longer time.
4. In depth key informant face to face interviews, and focus group surveys were also conducted with cattle farmers and veterinary government officials in order to get a wider understanding of dipping systems in the communal areas.
5. Collection of soil samples at identified sites to test for dip-related contamination.

Secondary information for the conceptual and literary background of the area of study was accessed from books, journals, and archival records. Archival information was useful for historical information with regard to the outbreak of East Coast Fever; the establishment of dip tanks; dipping operations, and their management.

1.11 STRUCTURE OF THE THESIS

The thesis consists of a collection of chapters compiled in a form of linked units. Details of materials and methods are presented in the individual chapters. In most chapters a comprehensive literature review as well as a discussion of the results is presented under general discussion and conclusion of each chapter.

This thesis consists of the following chapters:

Chapter 1 **sets the scene of the research project**. It is in this chapter where the introduction of the study, the conceptual framework of the study; the geographic base of the sustainable development concept and an overview of South Africa’s history and that of land and cattle dipping practice in Venda in particular is presented. It also describes the study area and the problem statement, the outline of the study aim and objectives, and presents the methodology of the research.

Chapter 2 provides a **comprehensive literature review on ticks and tick control methods**. Aspects that are covered in the chapter are: an overview of ticks which explains the nature and characteristics of ticks, the life cycle of ticks, and the geographic distribution of ticks; the impact of ticks and tick-borne diseases and tick control measures.

Chapter 3 presents the **overview of East Coast Fever as a cattle disease**. It focuses on the nature and characteristics of the disease, its geographic distribution, how and when it occurred in South Africa, its impact and the resultant establishment of cattle dipping in South Africa in general and in the Venda region in particular.

Chapter 4 examines the **environmental sustainability of stock dipping**. The first section of the chapter provides the general literary background with regard to the use of chemicals in agriculture. Linked to this is information about the nature and characteristics of chemicals that were used in dipping. This is followed by the methodology that was used in collecting soil samples and testing soil for determining the occurrence of dip chemical residues. The chapter also presents the results with regard to the concentration, distribution, and extent of chemical residues around the respective dip tanks.

Chapter 5 examines the **economic sustainability of stock dipping** in the study area. The chapter examines the historical evidence with regard to the incurred costs of earlier dipping; the existence of the economies of scale with regard to dip tanks in terms of percentage of utilization, cost of animals per dip tank; and the livelihood strategies that cattle owners associate with the establishment cattle dip tanks.

Chapter 6 examines the concept of **social sustainable development** in relation to **stock dipping** in the former Venda area. The chapter consists of an introduction and literature review pertaining to the concept of social development. It then establishes the social nexus of cattle dipping to the community by examining the linkage between the establishment of cattle dips with regard to the aspects of environmental justice, peoples' safety and social development and cohesion.

The foregoing chapters follow sequentially, as do Chapters 7 and 8. However, the last two chapters contain some repetition of material already covered in especially the first three chapters, in order that they form complete units - i.e. so that Chapters 7 and 8 each form a cohesive whole with sufficient background material to stand alone.

Chapter 7 focuses on the **sustainability of governance systems** driving **dipping** in the region. This is done by taking stock of existing legislation and policies, as well as investigating the current roll-out of dipping. The main policy document that is assessed is the 2011 Limpopo Draft Policy on Cattle Dipping (Mampane, 2011). Hereafter a model is developed to enhance the sustainability of dipping practice by addressing the shortcomings identified in the policy; the model is labelled the *Sustainable Community Dipping Model*, which could be added to the existing cattle dipping policy and should result in more sustainable governance, with spin-off effects in environmental, economical and social sustainability.

Chapter 8 **discusses the research findings** and highlights the contribution of this research to the geography of cattle dipping in South Africa, and more specifically its contribution to a more sustainable cattle dipping policy and its implementation. It suggests recommendations for future cattle dipping policy; and possible research areas emanating from the study.

CHAPTER 2

TICKS AND TICK DISEASE CONTROL MEASURES

2.1 INTRODUCTION

Cattle dips were introduced in Venda in the early 20th century as a result of the outbreak of East Coast Fever, a disease that is transmitted by ticks. Ticks are the most important ectoparasites affecting domestic animals in terms of reduced productivity and fertility, outbreak of diseases, and often death, thereby limiting successful stock farming. The application of appropriate measures is therefore critical to control ticks (Howell et al., 1978; Turton, 1999; Hunter, 2004a), but should be applied with due consideration for environmental and human health.

This chapter presents an overview of ticks as pests and illuminates the study by describing their physical nature, their behaviour, their geographical distribution, and the diseases they transmit. This understanding is important for the evaluation of the sustainability of past cattle dipping practices and also for the consideration of new strategies and programmes. Appropriate measures and methods of controlling ticks are also discussed, as these are of critical importance to understanding the environmental and social impacts associated with tick control. Tick control usually involves the use of chemicals which can have detrimental short and long term impacts on environmental and human health, which link to the biological sphere of sustainable development.

2.2 TICKS: AN OVERVIEW

2.2.1 Nature and Characteristics of Ticks

Ticks are bloodsucking arachnids of the Order *Acarina*, related to, but larger than mites, having barbed proboscis for attachment to the skin (Randomhouse Webster's College Dictionary, 1994). They are ectoparasites with all active stages (larvae, nymphs and adults) requiring a blood meal for development. Ticks prefer to live in woods, tall grass, weeds and brush. They climb onto low vegetation and attach to suitable hosts which pass by, including animals, pets and people (www.uky.edu).

There are two major groups of ticks, namely, soft ticks (*Argasidae*) and hard or shield ticks (*Oxididae*) (Fletcher, 2000). Soft ticks are relatively unimportant to this study because they are mainly found in dry areas where they are exposed to limited hosts. They are, however, voracious bloodsuckers; a behaviour trait that can rapidly induce anaemia in animals.

Ticks of economic importance in cattle are the shield ticks (*Ixodidae*), which are eight-legged parasites with a hard dorsal plate or scutum. All hard ticks share a similar basic life cycle with three mobile stages – firstly a small six-legged larva, then a slightly larger eight-legged nymph and finally the easily recognisable eight-legged adult (Howell et al., 1978; Oberem and Schröder, 1993). The life cycle is as follows: the adult, fully engorged female tick falls from the host and lays eggs in a protected place. The eggs hatch into larvae, also known as pepper ticks, which climb onto grass stems to wait for a suitable host. The larvae then attach onto the passing host that brushes past the grass stem and engorge themselves on blood.

Figure 2.1 The inside of the ear is a preferred feeding area in cattle for brown ear ticks

Different species and stages of ticks attach to specific, preferred feeding areas (predilection sites) of the anatomy of the respective host; namely, the ears, shoulders, dewlap, genitalia, between the legs and tail end. Figure 2.1 shows the preferred area of brown ear ticks. The various species of ticks also have preferred hosts, for example, the preferred host of the brown ear tick is buffalo and secondly cattle; the preferred hosts of the blue tick are cattle, dogs, antelopes and even lions.

When a tick has been attracted to a host and is attached to its preferred site, it inserts its mouthparts through the skin of the animal and secretes an anti-coagulant. The body's natural reaction to the irritation is to increase the blood supply to the area where the tick feeds undisturbed (Fletcher, 2000). All species of ticks are adaptable, and should the preferred host not be available, they will attach to other animals that may be in the area. Ticks generally exhibit a seasonal occurrence; larvae occur during autumn and winter, most nymphs during winter and spring, and most adults during summer (Bothma, 1996).

2.2.2 The Life Cycle of Hard Ticks

Hard ticks are subdivided into three groups according to the number of hosts they require to complete their life cycle (Howell et al., 1978; Horak and Fourie, 1991; Fletcher, 2000; Oberem et al., 2006). The identification of the subgroups reflects the behaviour of ticks in terms of their relationships with the respective hosts and the diseases they transmit. The three main groups are:

1) One host ticks – the ticks that pass their entire development from larva to nymph, to adult on the same animal without dropping off. The only time they leave the host is when the female falls to the ground to lay eggs. The two major species of one host tick are **common blue tick** (*Boophilus decolorutus*) and **pantropical blue tick** (*Boophilus microplus* –recently renamed to: *Rhipicephulus microplus*). These ticks are the easiest to control as they spend their total feeding period (approximately 21-25 days) on one animal.
2) Two host ticks – ticks that pass their larval and nymphal stages on one animal and adult stage on a second animal. The engorged nymphs drop to the ground, moult, and male and female ticks emerge. The emergent male and female ticks now find the second host; mating occurs and the female drops to the ground to lay eggs. The two major species are: **African bont-legged tick** (*Hyalomma marginatum truncatum*) and the **red-legged tick** (*Rhipicephalus evertsi* subsp. *evertsi*).
3) Three host ticks – ticks that pass their larval stage on one animal, nymphal stages on a second animal, and adult stage on a third animal. The two major species are: **brown ear tick** (*Rhipicephulus appendiculatus*) and **bont tick** (*Amblyomma hebraeum*).

Figure 2.2 indicates the identity of ticks in terms of their hosts and life-cycles.

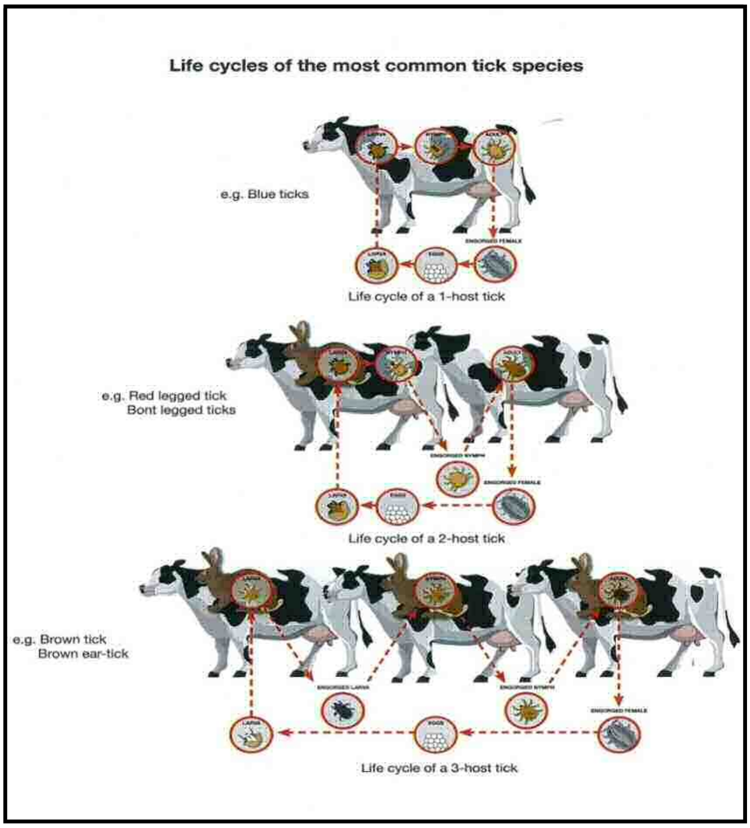


Figure 2.2 Life cycles of the most common ticks (source: Oberem et al., 2006)

2.2.3 The Geographic Distribution of Ticks

Ticks are objects of geographic inquiry as their distribution varies from place to place, and they also evolve over time. Tick species evolved in distinct geographic regions of the earth and thus the influence of a particular species of tick was historically limited to its region. This is, however, no longer the case. Population movement and an increase in commerce make ticks to travel to new environments and become established with great success. As they travel, so can the diseases which they carry. Favourable climatic conditions or habitats seem to contribute to the occurrence and distribution of ticks (Hope, 2005) and they generally thrive in the lower and middle latitude areas. The distribution also reflects the life-cycle of the respective ticks with one host ticks having the widest distribution worldwide; the common tick in this category is the **common blue tick** *(Boophilus decoloratus)*. Two host ticks are found in Africa, the Middle East, and the Indian sub-continent, while three-host ticks are found in Africa south of the Sahara, south-eastern USA, and areas around Meso-America (Figure 2.3).

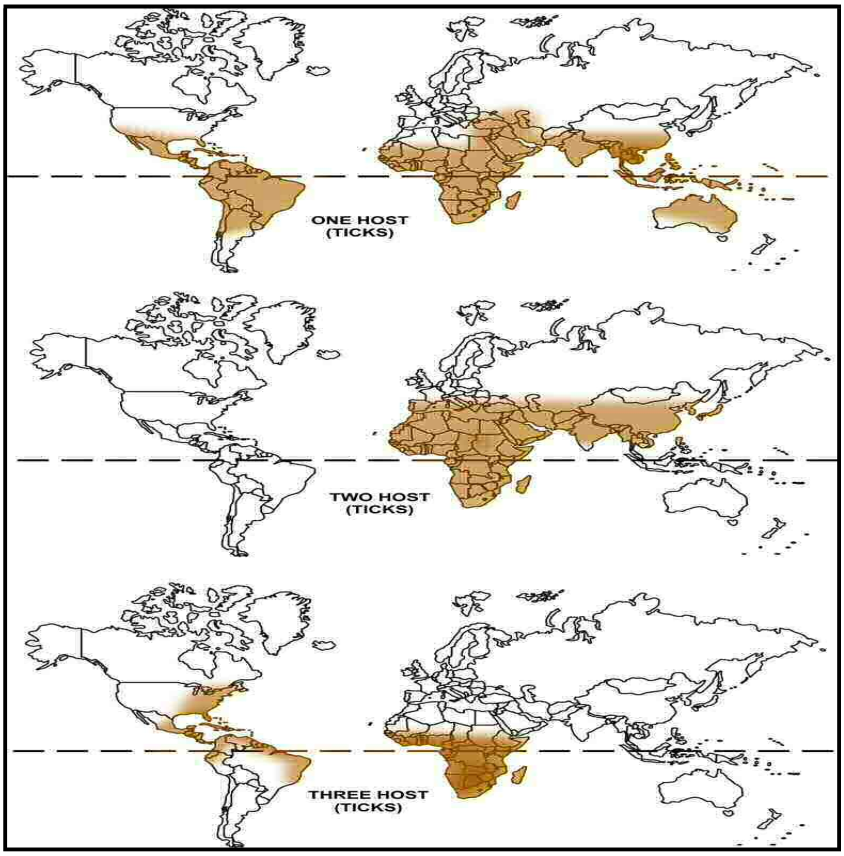


Figure 2.3 The global distribution of ticks in terms of their behaviour (source: Ciba-Geigy 1997)

Several surveys have been conducted to determine the distribution occurrence of ticks in South Africa (Nyangiwe, 2007). The species that are of major economic importance in the South African cattle industry are the **bont tick** (*Ambyloma hebraeum*), the vector of heartwater-causing pathogens; the **pantropical blue tick** ***(****Rhipicephalus microplus* – formerly *Boophilus microplus)*, the vector of redwater; the **blue tick** ***(****Boophilus decoloratus)*, also a vector of redwater; and the **brown ear tick** ***(****Rhipicephalus appendiculatus)*, the vector of East Coast Fever *(theileriosis)*. Oberem et al. (2006) identified and mapped the distribution of the common ticks, which is shown in Table 2.1.

The suitable environment of the bont tick is the bushveld and wooded and grassy regions of South Africa, an area covering Limpopo Province, eastern KwaZulu-Natal, the northern portion of the Eastern Cape, and eastern Mpumalanga. The blue tick is prevalent in the warmer areas of the country, a region that covers the South African lowveld and the eastern coastal belt. The brown ear tick is prevalent in the densely-vegetated warmer summer rainfall areas of Limpopo Province, Mpumalanga lowveld, coastal KwaZulu-Natal, and the Eastern Cape (Oberem et al., 2006).

Table 2.1 The Geographical distribution of ticks in southern Africa (source: adapted from Oberem and Schroder, 1993)

Tick name	**Species type**	**Geographical distribution**
African blue tick	*Boophilus decoloratus*	Limpopo; KwaZulu-Natal; northern and eastern Free State; Eastern Cape; coastal strip of south and south-western Cape.
Brown ear tick	*Rhipicephalus appendiculatus*	Lowveld areas of Limpopo and Mpumalanga; coastal KwaZulu-Natal; Eastern Cape, southern and south-western regions of the Western Cape.
Bont tick (or African cattle tick)	*Amblyomma hebraeum*	Eastern Limpopo; coastal KwaZulu-Natal; Eastern Cape, southern and south-western regions of the Western Cape.
Red-legged tick	*Rhipicephalus evertsi*	Eastern half of southern Africa, and south-western coastal areas.
Pantropical blue tick (Southern cattle tick in US)	*Rhipicephalus (*formerly *Boophilus) microplus*	Limpopo, Gauteng and Mpumalanga; KwaZulu-Natal; Eastern Cape coast, eastern coast of Western Cape
Large striped legged tick	*Hyalomma marginatum rufipes*	Whole of southern Africa, except eastern and northern coastal areas.
Dull striped legged tick	*Hyalomma marginatum turanicum*	Karoo region.
Small smooth striped stripe legged tick	*Hyalomma truncatum*	Southern Africa, except the Transkei and Eastern Cape east of Port Elizabeth, KwaZulu-Natal and eastern Free State.

2.3 THE IMPACT OF TICKS AND TICK-BORNE DISEASES

Ticks and the diseases they transmit are a major hindrance to livestock production. Their effects on animals are either direct, whereby the physical condition of animals is affected, or indirect, which affects yields and productivity (Theiler, 1964; Oberem and Schröder, 1993; Fletcher, 2000).

Direct effects of ticks include:

1. Anaemia refers to actual blood loss from bloodsucking and results from heavy tick infestation on cattle. The actual blood loss caused by heavy tick infestation lowers the physical condition of animals, causing reduction in the meat production and milk yield (Gates and Wescott, 2000; Jonsson, 2006).
2. Jaundice due to the breakdown of red blood cells.
3. Anorexia and weight loss due to *tick worry*, which is the state of uneasiness and irritability of tick-infested livestock. Irritation leads to biting, licking, scratching and subsequently reduced fibre (wool and mohair) production. When cattle are irritated, they become restless, which together with tick worry may lead to poor conditions in animals. Norval et al. (1988) reported that cattle heavily infested with brown ear ticks *(Rhipicephalus appendiculatus)* have been observed to lose weight by around 1.5 to 4.4 kg.
4. The mouth parts of ticks puncture the skins during feeding. This causes damage to hides and skins, and subsequent loss to the leather industry.
5. Tick saliva contains toxins which affect the organs where the ticks are attached, and may also lead to paralysis and sweating sickness in animals.
6. Tick bites cause tissue wounds, and the wounds may become infected with fungi, bacteria and other parasites. Parasitic infections of bite wounds become septic with resultant abscessation, mastitis or loss of teats and udder quarters.
7. Other direct negative effects of ticks include milk drop, malaise, lymph node swelling, abortions, diarrhoea, bull infertility, and death (www.fao.org).

Indirect effects of ticks are the transmission of diseases with the resultant heavy mortality, reduction in meat and milk yield, severe debility, delayed age of puberty and of first calving, long calving intervals, low bull numbers, and subsequently loss of production (Makala et al., 2003; Nqeno et al., 2011). This is because ticks possess the ability to harbour and transmit disease-causing viruses, bacteria, and protozoa. Some ticks are the vectors of a number of diseases, as they harbour and transmit parasites that cause diseases whilst sucking blood from the animals.

In animals such as cattle, the most common and important tick-borne diseases are redwater (*babesiosis*), gall sickness (*anaplasmosis*), heartwater (Dreyer et al., 1998), East Coast Fever and *ehrlichiosis* (Oberem et al., 2006). These diseases are transmitted by different species of ticks and such ticks are prevalent in certain geographic regions.

Redwater is a disease of cattle in which pear-shaped parasites (*Babesia bigemina* and *Babesia bovis*) appear in the red blood cells and destroy them (Bock et al., 2004). The pigment of the red blood cells is released into the blood, appears in the urine and makes it red. These parasites are carried and transmitted by blue ticks, *Boophilus decoloratus* and *Rhipicephalus microplus* (Howell et al., 1978; Cranefield, 1991; Turton, 2004). The disease is prevalent in southern Africa and the south-western parts of the United States of America where it is known as Texas fever.

Gall sickness is another cattle disease that is caused by a parasite *Anaplsma marginale* that invades and destroys red cells. It is carried by the same ticks that cause redwater, i.e. blue ticks, *Boophilus decoloratus* and *Rhipicephalus microplus*, and cattle can suffer from redwater and gall sickness at the same time. The term gall sickness is used to mean any disease of cattle that is accompanied by jaundice (Marufu, 2008).

Heartwater is a cattle disease that is caused by the organism *Cowdria ruminantium,* which is carried by the bont tick (*Ambylomma hebraeum*) as vector (Figure 2.4).

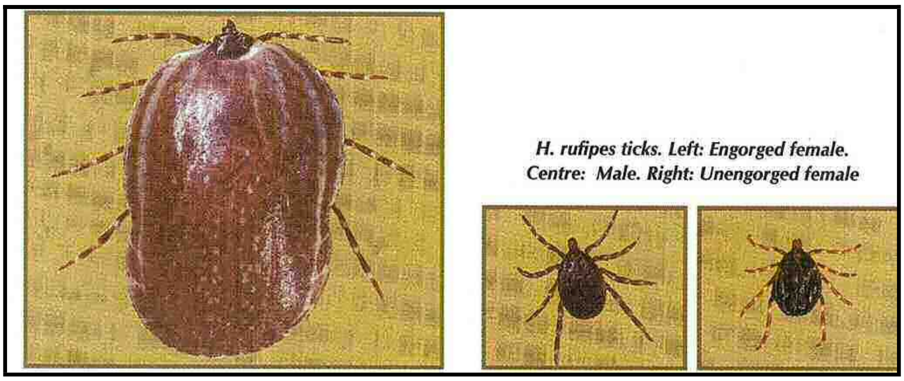


Figure 2.4 Bont tick (source: Oberem et al., 2006)

The infection of animals normally leads to the accumulation of water in the heart. This problem is associated with fever, diarrhoea and nervous instability, and death in cattle.

East Coast Fever is another tick-borne cattle disease that is caused by an intracellular protozoan of the genus *Theileria parva*. The disease is transmitted by ticks of the genus *Rhipicephalus appendiculatus* (Figure 2.5).

Figure 2.5 Brown ear tick (source: Oberem et al., 2006)

Because ticks usually attach to the ears of cattle, the tick is often called the brown ear tick (Kaba, 2003). The disease is marked by intense fever, difficulty in breathing, gastrointestinal haemorrhage, muscle wasting, and generalised weakness and death (www.vie.dis.strath.ac.uk). After the infective bite, the parasites localise and multiply in lymph nodes. The lymph nodes take about one or two weeks to become enlarged after the bite. Because the ticks usually attach to the ear, the parotid lymph node just below the ear becomes enlarged first. The tick prefers an environment that is sheltered by bush and long grass.

Table 2.2 Important diseases transmitted by ticks (source: Oberem and Schröder, 1993)

Disease	**Host**	**Causative Organism**	**Transmitting Tick**	**Disease Symptoms**
Redwater (babesiosis)	Cattle	*Babesia bigemina*	*Boophilus decoloratus*	Red urine, fever, loss of appetite, anaemia, jaundice and death.
Redwater	Cattle	*Babesia bovis*	*Rhipicephalus (Boophilus) microplus*	Red urine and occasional nervous symptoms.
Anaplasmosis	Cattle	*Anaplasma marginale*	*Boophilus decoloratus*	Fever, constipation, jaundice, and death.
Heartwater	Cattle, sheep and goats	*Cowdria ruminantium*	*Amblyomma hebraeym*	Fever, nervous symptoms, diarrhoea, and death
East Coast Fever	Cattle	*Theileria parva*	*Rhipicephalus appendiculatus*	Swelling of nymph nodes, failure of rumination, loss of appetite, difficult breathing, coughing, fever, and death.

2.4 TICK CONTROL MEASURES

There are no universal criteria for the control of ticks and tick-borne diseases (Nari, 1995). The adopted strategies should be influenced by, amongst others, the type of ticks and their resultant behaviour, the tick borne disease in the area, the local ecological conditions, and also the ever changing economic and political situations, the breed of livestock, the educational level of livestock producers, and the perceived economic benefits (Nari, 1995; Hunter; 2004b; Turton, 2004). The main methods are both treatment and preventative (Norton et al., 1983; Hunter, 2004b).

A treatment strategy involves the administration of drugs when signs of a disease are noted in animals (Turton, 2004). This practise is successful in situations where livestock farmers are familiar with the symptoms of respective diseases. Its success in communal areas requires effective agricultural extension services.

Preventative measures may involve the maintenance of enzootic stability, the quarantine system that controls the movement of animals, disease surveillance, vaccination, and dipping (Nari, 1995).

Enzootic stability is a situation in which all factors influencing disease occurrence are relatively stable, resulting in little fluctuation in disease over time; changes in one or more of the factors (for instance, reduction in proportion of individuals with immunity from exposure to infectious agents) can lead to an unstable situation in which major disease outbreaks occur (www.mondofacto.com/facts/dictionary). In order to maintain enzootic stability a system that allows the building up of immunity against diseases by exposing cattle to ticks is introduced. Its main aim is to reduce the number of ticks, but also to maintain sufficient numbers to allow the exposure of animals to infected ticks which will immunise animals against the existing tick-borne diseases. In other words, animals that are exposed to a number of ticks develop natural immunity. Natural immunity in cattle can also be induced through vaccination.

The plunge dip is one of the common methods of tick control (Fletcher, 2000; Turton 2004), whereby the animals are completely immersed in the dipping compound or solution in a dipping tank. Associated with plunge dipping are the uses of spray races, hand and mechanical spraying, pour on or spot on, and using ear tags and tail bands impregnated with tick-killing chemicals or acaricides. With spray race, an animal walks through a race where it is sprayed with the dipping chemical solution; with hand spraying, the dipping solution is applied to each animal with a hand-operated spray. Hand dressing or spot treatment involves treating the sites where ticks commonly occur.

Plunge dipping and its associated methods can be intensive or strategic (Hunter, 2004). Intensive control entails the frequent and continuous treatment (weekly in summer and every two weeks in winter) to minimize exposure of animals to ticks. The animals are therefore not exposed to the tick borne disease. Strategic control, on the other hand, needs less frequent dipping than intensive control. Animals should be exposed to ticks in order to promote natural immunity by triggering the antibodies of endemic diseases. The advantage of this measure is less expenditure on dip and dipping equipment. The disadvantages are that either there are still ticks around to cause damage and tick worry which can severely affect production. It may also not be successful in situations where there are different types of tick species, and also in rangeland communal farming where grazing land is not paddocked.

Besides the two measures mentioned above, there are also biological and traditional ways of controlling ticks (Dreyer et al., 1998). These measures include, amongst others: the rearing of tick-tolerant cattle, for example Nguni animals; the use of guinea fowls and bantams to control sandpans; the use of wasps whereby they are allowed to lay their eggs in unengorged ixodid nymphs (as the nymphs engorge they drop off and are then destroyed by developing wasp larvae); exposing cattle to Oxpeckers that feed on ticks and lice; the infrequent use of fire to destroy ticks in grazing areas that may be infested with ticks; exposing cattle to bacterium like *Bacillus thurinqiensis* that are lethal to ticks; the application of traditionally prepared remedies; and hand picking and spraying by hand with residues of tar and charcoal.

Plunge dipping is the most common method of intensive control. Its main advantage is that it is relatively cheap where large numbers of animals are involved. The nature of plunge dipping is discussed later in this chapter. Other advantages of this measure are the elimination of tick worry and its negative effect on growth and production.

The disadvantages of intensive control measures are that cattle are totally susceptible to tick-borne diseases and if a problem arises with dipping (technique and resistance), large numbers of animals may develop tick-borne diseases. This method is also not recommended for cattle breeds which are tick tolerant, such as Ngunis and Afrikaners, because their resistance is acquired on exposure to ticks and will be lost under intensive control. Another disadvantage of intensive treatment is that it requires capital investment for dipping apparatus and dips.

As mentioned in the introduction of this chapter, this research focuses on cattle dipping as a strategy of controlling ticks and tick-borne diseases. The discussion of cattle dipping strategy follows below.

2.4.1 Cattle Plunge Dipping Strategy

Plunge dipping of cattle (Figure 2.6) entails the animal jumping into the dip and swimming through the dip wash which contains the tick killing chemical (Oberem et al., 2006). Swimming across the tank helps to ensure that the animal receives a thorough wetting as all the skin becomes completely exposed to the tick-killing chemicals. The cattle are either dipped on a weekly or fortnightly cycle depending on the tick challenge of a particular area (Randela, 2000). This practice has proved to be a more cost effective method where large numbers of animals are involved.

Figure 2.6 Cattle plunge dip tank

The capacity of a tank is determined by the number of cattle to be dipped: A dip tank of 10 000 litres is large enough to dip 800 head of cattle in one dip session (Fletcher, 2000;

Thomas et al., 2011; Oberem et al., 2006); a tank of between 10 000 and 15 000 litres allows large herds of cattle, whilst tanks greater than 15 000 litres are considered uneconomical. The chemicals used include arsenicals, chlorinated hydrocarbons and organophosphorus compounds. Their continuous use depends on their potency, their pollution to the environment, and the resistance by ticks to the particular dip mixture.

2.4.1.1 Dip tank structure

A good dip tank area is designed to include five basic components, as indicated below:

1. **An approach area** where cattle gather before they dip. It is a wide space which appears like a kraal that is protected by poles on both sides.
2. An **entrance race** that leads the animals from the approach area into the tank. The entrance race narrows toward the tank and it allows animals to walk towards the tank in single file.
3. The **dip tank** itself is filled with dip wash. The tank is ideally about 8 m long, 1.6 m deep, and 1.6 m wide. It has an entrance which is connected to the approach area by a narrow foot path that restricts animals to enter the vat one at a time. The entrance slopes into the water by means of steps that cause the animals to jump off into the dip. The tank must have a low wall along its sides to prevent the dip from running over and it should also have a roof over to prevent dilution and evaporation (Oberem et al., 2006). The tank is constructed with reinforced impervious concrete to prevent the dip from leaking into the soil underneath.
4. The **exit** from the tank slopes into the exit race which leads to the **drainage area**. The drainage area allows excess fluid from treated animals to drip off and flow back either directly to the tank, or to a separate sump linked to the tank by a pipe draining into it. The use of the pipe is two-fold; it allows dip fluid to flow into the tank and it also prevents rainwater from flowing into the tank.
5. **The earth sink or poison hole** which is next to dipping tank is used to collect disused dip effluent or brine when the tanks are cleaned after every three years (Fletcher, 2000; World Animal Review, 2004).

Figure 2.7 represents the structure of a dip tank.

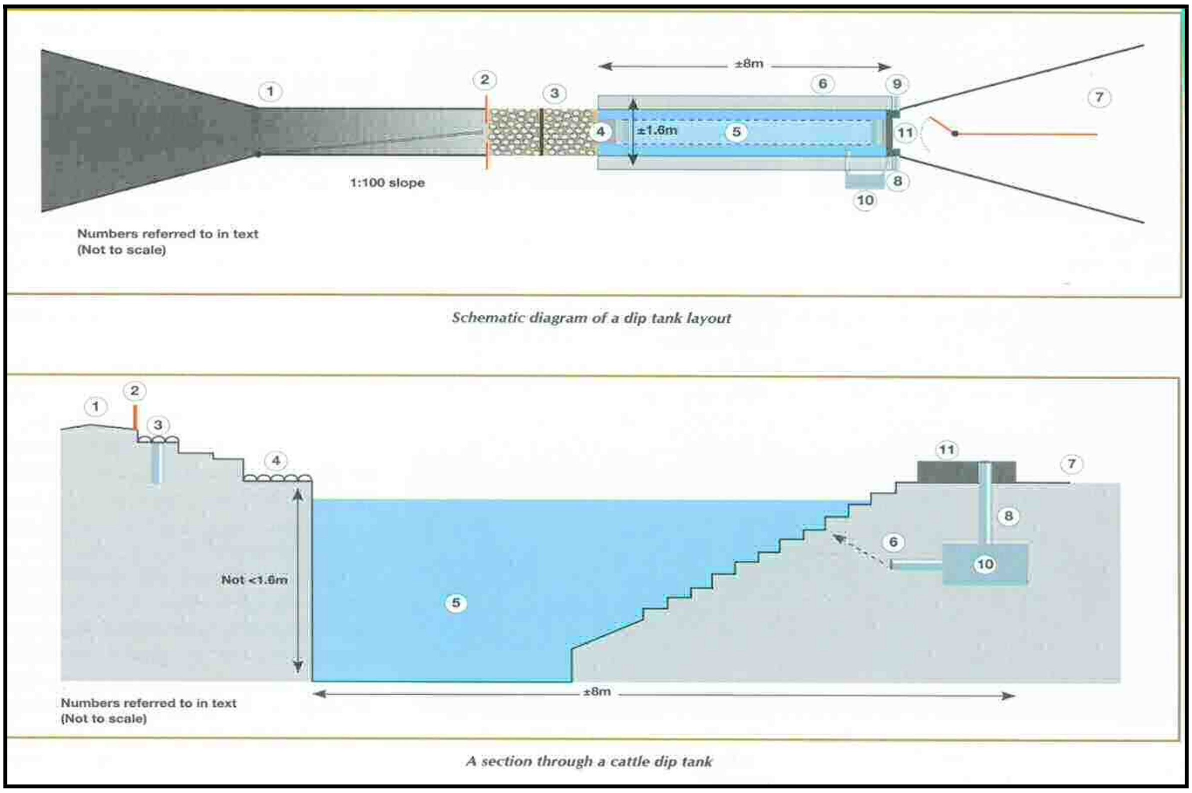


Figure 2.7 Diagram of a dip tank layout (source: Oberem et al., 2006)

2.4.1.2 Dipping establishment guidelines/requirements

Unfortunately some of the chemicals used for controlling tick infestation are non-biodegradable and poisonous, for instance organophosphate compounds such as arsenic and DDT. Where significant effluent of contaminants finds its way to nearby freshwater and underground water courses, they are likely to pollute aquatic ecosystems, surrounding soil, vegetation and underground water. The accumulation of chemicals in water and soil may lead to the entry of such toxic elements into the food chain, affecting both plant and animal species. Subsequently, the chemicals pose a danger to human and animal health and safety, and ultimately to ecological integrity. Terrestrial plants in soils with a high content of contaminants such as arsenic may show inhibition to growth, photosynthesis and reproduction. Humans may also be affected directly, as in the case of drinking polluted water and inhaling volatile fumes from chemicals that are prepared for dips or indirectly via animal and plant products that have been exposed to contamination (The Greenhouse People Environmental Centre, www.greenhouse.org.za). Environmental harm resulting from dip chemical contamination may be both acute and chronic.

As a result of the observation concerning the dangers that are associated with the establishment of dip tanks, policies and guidelines have been put in place with regard to the location, construction and management of dips, and the remediation of disused dip sites (US Department of Agriculture, 1967; Fletcher, 2000; Escobar et al., 2006).

The location of dip tanks must always consider the minimization of polluting water sources and soils around the dip site. It is important that the dip tank be situated in an area that is accessible to the cattle before being dipped in order to sustain the condition of cattle. To prevent water pollution, the dip tank must not be built along rivers or watercourses (Oberem et al., 2006). If the tank is next to watercourses, dip effluent may easily flow into the streams when dip tanks are cleaned. Dip solution may also wash off or drip from cattle into the water as they cross the stream after dipping. According to the Scottish standards, dip facilities must be sited at least 100m from watercourses, including ditches and drains, and at least 50m from wells, springs and boreholes. Building tanks on the banks of rivers or in watercourses must be avoided at all costs. Fletcher (2000) states that where tanks are situated away from streams, plans must be made to have water laid on by pipeline to facilitate easy filling and replenishment, in order to prevent the easy flow of dip effluent into watercourses.

In order to protect community members from exposure to the dangers of physical injury, contamination by dip chemicals, and even death by falling and drowning, care must be taken that dip tanks are situated away from settlements. Where dip tanks are closer to the settlements, there is an ever-present danger of children playing in and around the facility. The potential of exposing people and animals to the physical and chemical dangers of dipping should also be minimized and prevented by putting a perimeter fence around the dip site. Fencing can be supported by putting sign posting and warning signs for the general public to be aware of the existence of a dip tank. Furthermore, the correct planning for the location of a dip tank site must be done in conjunction with the town and village planning committees, particularly in communal areas. This should be supported by keeping a database of current and previous dips site because expanding agricultural and residential land uses may be established in contaminated areas (New Zealand Ministry for the Environment, 2006).

Where possible, a dip tank must be situated in an open area which has already been cleared. Where a tank of 15 000 litre capacity is established, the dip site should cover an area of at least 0,5 hectare. This is important because a large number of animals can be accommodated in such an area before they dip. However, if there are large trees and forested places nearby, they should not be removed as the removal of trees together with high soil compaction by cattle allow for considerable soil erosion (Fletcher, 2000).

In order to protect people from direct exposure to poisonous dip chemicals, care must be taken not to allow untrained or incompetent people to run the dipping operations. Also, dipping operators should wear protective clothing to protect them from being directly exposed to the chemicals. Unused or unwanted dip concentrates, empty containers and contaminated clothing should be safely disposed of. When dip tanks are emptied, the dip effluent should be discarded safely without causing pollution to the surrounding environment. When dips are cleaned, dirty water must be discarded into the holding sump and the disposal of waste must be done by a licensed waste disposal contractor.

Other issues about the safety, health and environmental risks of dip tanks relate to the management of disused ones. Physical barriers such as fencing should be put around the disused tanks. The tanks can also be covered or capped by thick soil or cement, while sealing the dip site with an impervious pavement is also advised. Where soil contamination has been observed, affected soil can be physically removed and treated. In some cases soil can be treated by planting chemical tolerant plants, a process known as phytoremediation. Such plants are able to concentrate soil contaminants in their above ground tissues. As part of planning, institutional controls such as zoning the land to prevent sensitive uses can be implemented. The contaminated area can also be set aside as reserve land for which less exposure can be expected (New Zealand Ministry for the Environment, 2006).

2.5 CONCLUSION

From the foregoing literature review, it is clear that ticks can be a major economic constraint for both commercial and subsistence stock farmers. This is because, whilst sucking blood from the animals, ticks have the ability to harbour and transmit diseases causing viruses, bacteria, and protozoa. The transmitted diseases may result in cattle mortality, and a reduction in meat and milk production. Associated with tick infestation are other negative effects such as damaged hides and skins, damaged organs, wounds, and poor animal growth, to mention but a few.

For the effective management of ticks and their related problems therefore, holistic knowledge about ticks is essential (Norval, 1977). The required knowledge entails the types of ticks, their behaviour, their ecological characteristics, their geographical distribution, and their resultant impact on animals, and their control. Owing to the fact that ticks have different characteristics, different measures are used to control them. It is also of critical importance to know the environmental and social impacts that are associated with the various measures and methods of controlling ticks.

As stated above, this study is about cattle dipping in South Africa that was introduced as a result of the outbreak of East Coast Fever. The discussion about the outbreak of the disease and how it was managed is presented in the next chapter.

CHAPTER 3

THE OUTBREAK AND CONTROL OF EAST COAST FEVER IN SOUTH AFRICA

3.1 INTRODUCTION

Reviewed literature about ticks show that various measures are used to control them. The effectiveness of the respective measures is however associated with the epidemiology and behaviour of ticks, and the diseases that the respective ticks transmit. Familiarity with the type of diseases is therefore essential, and makes knowledge about East Coat Fever, or theileriosis, pertinent for the purpose of this study.

Theilioris of cattle in Africa, caused by the microorganism *Theileria parva,* has had substantial impact on the development of the beef and dairy industries. Beef and dairy industries are the backbone of many African economies and form part of the livelihood base of many traditional families. Dips are known to be effective in eradicating tick-borne diseases effectively, including East Coat Fever (Norval et al., 1992). This chapter reviews the dynamics of East Coast Fever (ECF) in South Africa from the time of its outbreak until the time it was eradicated. The chapter provides: the background of the nature of East Coast Fever and its impact on cattle; the historical background against which the disease was introduced and spread in the country; its geographical distribution; and the development and implementation of cattle dipping as a control measure in South Africa, particularly in the communal Venda area.

3.2 EAST COAST FEVER DISEASE

East Coast Fever (ECF) is a tick-borne cattle disease that is caused by an intracellular protozoan of the genus *Theileria parva*. The disease is transmitted by ticks of the species *Rhipicephalus appendiculatus,* often called the brown ear tick (see Figure 3.1), as they usually attach to the ears of cattle (Kaba, 2003).

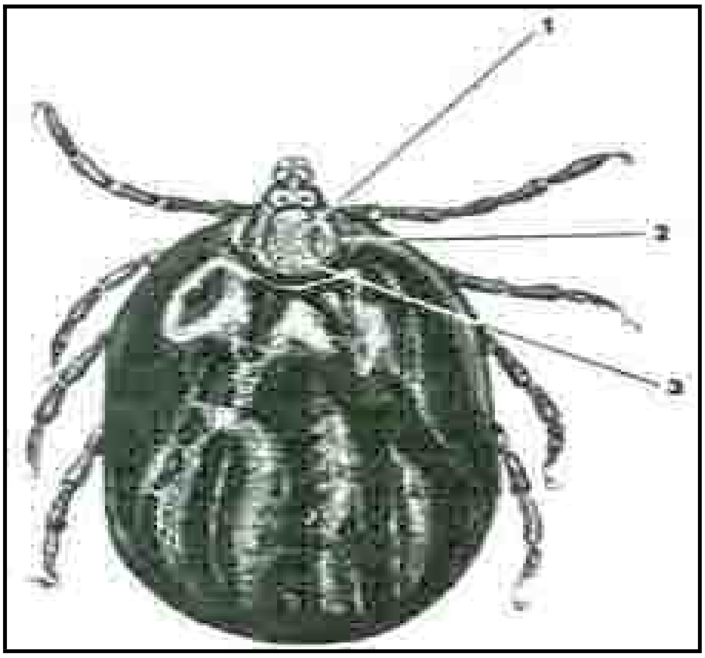


Figure 3.1 Brown ear tick (source: Department of Agriculture, Technical Service, 1983)

After the infective bite, the parasites localise and multiply in the lymph nodes of the host, which take about one or two weeks after the bite to become enlarged. Because the ticks usually attach to the ear, the parotid lymph node just below the ear becomes enlarged first. The disease is marked by intense fever, difficulty in breathing, gastrointestinal haemorrhage, muscle loss, and generalised weakness and death (www.vie.dis.strath.ac.uk).

3.3 GEOGRAPHICAL DISTRIBUTION OF EAST COAST FEVER

The distribution of East Coast Fever is associated with the distribution of the vector tick species, brown ear tick. The distribution of this tick, *Rhipicephalus appendiculatus,* extends from southern Sudan to South Africa and as far west as the Democratic Republic of the Congo, the former Zaire. In South Africa the area covers the Limpopo Province, Mpumalanga, coastal KwaZulu-Natal, Eastern Cape, and southern coastal regions of the Western Cape (see Figure 3.2). Humid sub-tropical conditions in the eastern and southern areas of South Africa seem to contribute to the high population of brown ear ticks.

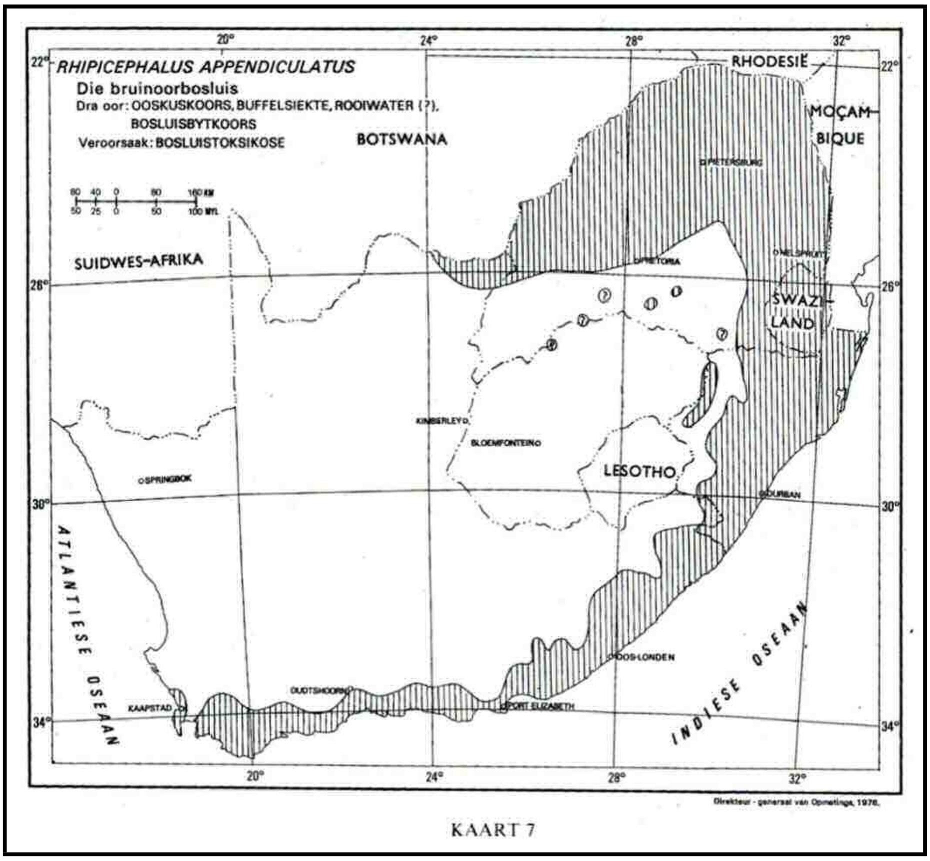


Figure 3.2 The geographical distribution of brown ear tick in South Africa (source: Department of Agriculture, Technical Service, 1983)

3.4 OUTBREAK OF EAST COAST FEVER IN SOUTH AFRICA

The origin of East Coast Fever in South Africa is traced to importations of cattle from the eastern African coast at the end of the 19th century, and was therefore given the name East Coast Fever. As stated above, the vector was identified as *Rhipicephalus appendiculatus,* which was by that time already widespread in the region but not associated with any disease. The reasons for the importation of cattle were twofold. The cattle population of much of southern Africa had been devastated by the introduction of rinderpest from the north in 1896 (Cranefield, 1991). The natural recovery of the cattle population which might have been expected following successful control of the outbreak of rinderpest was disrupted by the South African War of 1899-1902. The war led to the removal of cattle from the war zone, and an increased demand for transport oxen and meat by the military forces (Norval et al., 1992). Cattle were imported from a number of sources to meet the demands of the army and to rebuild the cattle population as hostilities drew to a close.

Cranefield (1991) presents a detailed historical account of the first occurrence and spread of East Coast Fever in South Africa and the former Rhodesia (now called Zimbabwe). He argues that cattle which were imported from Australia and India came through the east African port of Mombasa in Kenya, where they were temporarily off-loaded to graze. Mombasa is an area where East Coast Fever is endemic. In the processes they picked up the disease from the brown ear tick (*R. appendiculatus*) and upon arrival at the ports of Beira, Lourenço Marques (Maputo) and Durban, the survived infected cattle trekked inland to Rhodesia and South Africa as silent carriers of the disease. The ticks which fed on the infected animals transmitted the disease to the disease-free animals. The spread of East Coast Fever across the region appeared to follow the various transport routes from the coast (Walker, 2011).

Cranefield (1991) indicates that the disease first appeared in the Umtali (Mutare) region of Rhodesia (Zimbabwe) in October 1901. The cattle that were brought to Mutare and Salisbury (Harare) from Beira became sick and died. Farmers could not at first identify the nature of the disease; and confused the mortality of cattle with the virulent form of redwater infection, since redwater was pandemic in the area. Within a very short time the infection had spread throughout the length and breadth of Rhodesia, causing enormous losses wherever an outbreak occurred. The disease entered South Africa via Delagoa Bay in Mozambique (Portuguese East Africa). It was first seen near Komatipoort, about 75 km from Mozambique, and thereafter in Nelspruit around 1902. After that the Transvaal (comprising the present-day provinces of Gauteng, Limpopo, North West and Mpumalanga) was invaded, either directly through the Zoutpansberg by means of cattle smuggled from Rhodesia (National Archives of South Africa, A341/15b), or more likely the infection had entered from Mozambique, possibly originating from the shipment of Tanzanian cattle disembarked at Lourenço Marques (Maputo). East Coast Fever began to spread through Natal in 1904, and crossed into the Transkei in 1910. The disease was more pronounced in areas along the east coast and eastern borders of the Transvaal, partly because of the ecological suitability of the areas for the brown ear tick.

3.5 IMPACT OF EAST COAST FEVER ON SOUTH AFRICA

Within the first years of its occurrence, East Coast Fever covered virtually the whole country. Millions of cattle died, and the infected areas were almost cleared of cattle (Mukhebi et al., 1992). The stakeholders who were highly affected by the high mortality rate of cattle were the farmers, the commercial transport providers, the mines and the traders. With their cattle dead, farmers did not have stock to sell, and they also had no draught animals for cultivation; commercial transport providers did not have draught animals to draw their wagons; trading was disrupted because there was no transport for materials; and the mines also suffered from limited meat supply and means of transport. As early as 1903, the disease was well established in the Transvaal where over 40 000 cattle died. Between 1902 and 1945, the Transvaal lost approximately 90 000 cattle, Natal 400 000 cattle, and the Transkei region 705 000 cattle: all in all, approximately 1.4 million cattle had died from East Coast Fever in South Africa, while 100 000 more were slaughtered to prevent the spread of the infection (Norval et al., 1992).

3.6 CONTROL MEASURES OF EAST COAST FEVER

The impact of East Coast Fever in South Africa and her surrounding neighbours threatened to reverse the gains already attained after the eradication of rinderpest. Owing to the fact that veterinary services already existed in most of the territories of South Africa, and their capacity to control epidemic diseases had been developed as a result of their experience with rinderpest towards the end of the nineteenth century, the earlier measures of controlling the disease were similar to those that were used to control rinderpest. The campaign was implemented under the legislative framework, Ordinance No 38 of 1904 (National Archives of South Africa, LC442/05; Wheelright, 1911). Control measures that were introduced included: the fencing off of infected areas; the rigid curtailing of animal movement; impounding of stray and suspected animals; pasture spelling; quarantine procedures; and slaughtering of infected animals. The Commissioner of Lands could cause fences to be erected along the boundaries of any farms within an infected or suspected area or any native location or any town lands within the infected area (Cranefield, 1991).

These above mentioned measures failed to halt the spread of ECF. Hopes of early success were destroyed because of poor accessibility and control that resulted in the widespread movement of cattle as a result of skirmishes that arose between the authorities in the respective republics and the black tribes; and also the poor access to some tribal areas that were not yet under the control of the republics' administration. One of the recorded skirmishes is a minor Zulu rebellion in Natal in 1906 that became known as the Bambata rebellion (Norval et al., 1992). It led to the widespread movement of cattle which caused a major extension of the disease southwards.

The control of ticks as vectors of *Theileria parva* relied on the use of chemical solutions whereby animals were forced to swim through in the dip tanks. An effective method of controlling the brown ear tick that was developed was the use of short interval dipping. The first effective chemicals that were used in dipping were arsenic oxide and trioxide compounds called Albany Tick and Scab Dip and Cooper's Dip, respectively (National Archives of South Africa, TAB-LD 85 A451; National Archives of South Africa, TAD NOA451/3a; Phophi, 2003). Arsenical compounds were used because there was no alternative at the time. The compounds were used for about forty years until they were withdrawn due to their toxicity to animals and also the development of resistance to their effectiveness by ticks (World Animal Review, 2004). Arsenic compounds were followed by other toxic compounds such as DDT, DDE, toxaphene and BHC (Mafhara, 2004; Mampane, 2004). Other assumed less toxic acaricides, coupled with newer methods of controlling ticks such as spraying and hand dressing was introduced thereafter.

The first place where dipping was introduced in South Africa was Natal in 1902 (Bekker, 1959; Fletcher, 2000). The practice of cattle dipping had been borrowed from Australia. Cattle dipping also began to play a significant role in the control and eradication of ECF in South Africa at about 1909. Cattle dipping became more pronounced after 1910 after Arnold Theiler and his fellow veterinarians discovered that the disease was caused by a micro-organism *Theileiria parva* which is transmitted by a brown ear tick *(Rhipicephalus appendiculatus*) (Theiler, 1971; Cranefield, 1991; Davies, 2004). The name *Theileria* has been given to the micro-organism in honour of Arnold Theiler. Prior to the introduction of stock dipping, stock owners endeavoured to control the vector of East Coast Fever, the brown ear tick, by wetting their cattle using various preparations including nicotine, paraffin, coal tar and garlic.

During the earlier years of dipping, there was always an intermittent outbreak of ECF in areas that were considered to be clean of the disease. The effectiveness of the campaign therefore needed to be supplemented by other measures. At the Pretoria Conference of 1929 the various regional veterinary authorities and the government agreed to run national programmes on regular and effective dipping of the entire cattle population. A decision was taken to supplement the dipping programme with a regime that included intensive surveillance and close supervision for early diagnosis; strict movement control; fencing off of infected areas; branding of cattle; prolonged quarantine; and slaughter of infected animals (Anon, 1981).

One of the significant consequences of the East Coast Fever control programme was the introduction of compulsory dipping throughout the affected areas (Norval, 1983). This campaign laid the foundation for the legislation and techniques for control of infectious diseases of livestock in southern Africa, and the campaign became the envy of many other parts of the world. It included effective fencing, movement permits, regular production of cattle for inspection, quarantine of infected premises and slaughter of infected animals (Anon, 1981). The provision and implementation of dipping was in terms of the Stock Disease Act of 1911 and the Animal Disease and Parasite Act, 1956, as well as the Animal Disease Act of 1984. From its inception in 1929, the policy of East Coast Fever eradication was pursued for the next 30 years and the disease was finally eradicated from its last stronghold in Swaziland in 1960.

Norval et al. (1992) reported that thousands of dip tanks were built and by the 1920s all infected territories had on average one tank for every 1000 cattle. In places like Natal, the figure was one for every 300 head of cattle. Norval (1983) noted that by around 1960, over 10 million cattle were being dipped every 7-14 days throughout the year. The Transvaal area was the first of the South African provinces to achieve complete eradication in 1946, followed by Natal in the same year and then the Cape Province in 1947, the Transkei Region in 1954, and Swaziland in 1960 (Norval, 1977). It can therefore be stated that compulsory dipping in South Africa led to the complete eradication of East Coast Fever from the country by 1954 and from southern Africa by 1960. Hereafter dipping among commercial farmers was no longer compulsory (www.nda.agric.za), but farmers were encouraged to continue with it because of the prevalence of other tick-borne diseases (Coetzer et al., 1994). However, cattle dipping continued to be mandatory in the communal areas, due to the prevailing threat of stock diseases where grazing areas were not paddocked, where the resulting free rangelands allowed for easy transmission of such diseases. An additional reason for the continued practice of compulsory dipping in the communal areas was because communal cattle owners did not possess their individual dip tanks.

The main objective of the supplementary regime was to identify, isolate and eliminate foci of infection. Every individual farmer was required to keep a register of his cattle in which all births, deaths, and movements were accounted for. In the case of communal grazing areas, the register was maintained by the dip tank attendant. Cattle were usually checked by a veterinary inspector every month and the owner was required to account for any discrepancy between the number of cattle present and the number on the register. No cattle could be moved from one place to another without a permit.

A mixed mode was used in order to encourage the farmers to buy into dipping. Grants in aid or loans were provided to commercial farmers to build dip tanks on their own properties, while the government took the responsibility for building and administering the dipping services in communal areas. The reasons why the government provided the dipping service to the black communities were: (1) that many black communities stayed in East Coast Fever infested areas; (2) that black communities were so attached to cattle, that they could not easily part with them even if there was an outbreak of a stock disease – causing an easy and uncontrollable spread of the disease; and (3) the majority of black stock owners were not yet able to carry the financial burdens and the responsibility of efficient dipping (Tomlinson et al., 1955: 25). An excerpt from the Tomlinson Report reads:

> "*The social system of the Bantu Community is bound up in the closest possible manner with livestock ownership. Livestock and especially cattle are the Bantu's most prized possession - valuable to only a limited extent commercially, but infinitely so on account of their religious and social significance. Because the Bantu take little or no interest in the productive efficiency of their animals, the profit motive plays hardly any part in their animal husbandry".*

The establishment of dip tanks in the communal tribal areas was also not initially accepted as a utility, and their operation was perceived as political and cultural imposition (Mbeki, 1964; Beinart, 2003). The government authorities used the provision of the tanks as an incentive to lure people to move to the villages, and cattle dipping tanks in the black rural areas became a symbol of a major governmental programme that impacted South African society. The negative perception was mainly influenced by the disliked imposition of villagisation, and later betterment schemes. There was a misconception that cattle diseases were brought in by white settlers, who used them to bewitch cattle belonging to black people so that they could easily take their territory.

Activists of that time threatened communities who accepted villagisation and also took their animals for dipping. The practices that were highly resented were the counting of animals during dipping days, penalties associated with non-compliance, and the animal tax that cattle owners were expected to pay. Cattle owners were encouraged, and sometimes coerced by the activists to send fewer registered animals to the tanks during dipping days, a phenomenon known as “ghost herd”; and to alternate the herd of cattle, bringing some one week and others the next week. Others were forced never to bring their cattle to the dips at all. In some instances, the resistance became physical and was accompanied by intimidation, violent vandalism, and the destruction of dipping infrastructure (www.samilitaryhistory.org; Mbeki, 1964; Yawitch, 1982; Mager, 1999; Ainslie, 2002). Places where resistance to villagisation and the establishment of dip tanks were evident were in the Transkei, and the former Northern Transvaal’s territories of Sekhukhune and Matlalas (Yawitch, 1982).

The task of building and maintaining dipping tanks in the communal/tribal areas was given to the then Native Affairs Department (NAD), and the technical service was handled by the Division of Veterinary Services of the Union of South Africa (Fletcher – oral account, 2004; Sefara, 2010). The Veterinary Division liaised with the Native Affairs Commissioners, resident magistrates who were in charge of black areas (Native Affairs), and tribal chiefs. They were assisted by Territorial Councils in the respective districts (National Archives of South Africa, TAB A341/15a). Important role players regarding stock dipping in communal areas were: the Secretary of Agriculture, The Chief Native Commissioners, Native Commissioners, Government Veterinary Surgeons, Animal Health Inspectors and dipping assistants (National Archives of South Africa, TAB PS 73/13/07). Extension services came later after the introduction of the betterment system. Dip sites were initially located at central places that were accessible to cattle farmers from several chiefdoms. The number of dips increased when chiefs requested for more dipping sites in their respective areas. This became a common practice in all communal areas. The management of dipping service was transferred to the respective Departments of Agriculture in the black communal areas, both self-governing and independent national states. The provision and implementation of dipping practise in the homelands continued to be governed by the earlier mentioned South African stock disease legislation.

3.7 CATTLE DIPPING IN VENDA

Oral history and historical evidence report that the first plunge dip tank in the Venda area (Figure 3.3) was built in 1915 at Tshivhase location (Marole, 1966; Nemudzivhadi, 1985). It was established next to the Tshivhase Royal Kraal, at the upper reaches of the Mbwedi River. Other earlier dip tanks in Venda were allocated according to the tribal authorities' recommendations. With time, in order to reduce the impact of distance, other villages within the tribal authorities were allocated tanks. Their situation was, however, based on the centrality of the location in relation to the surrounding neighbouring villages.

Figure 3.3 The ruins of the first dip tank established in Venda in 1915

At the height of the eradication campaign, the former Venda area, which was by then called Sibasa District, had approximately 54 dip tanks (National Archives of South Africa, NTS 10751 - Native Affairs 1951). Table 3.1 shows a list of the tanks that were already established at around 1951. The records are unfortunately not complete.

Owing to the fact that Venda was part of South Africa, the provision and implementation of dipping was in terms of the Stock Disease Act of 1911, the Animal Disease and Parasite Act, 1956, Act 13 of 1956 and the Animal Disease Act of 1984. Cattle dipping was administered by the Veterinary Division of the Department of Agriculture which was located at Sibasa.

Table 3.1 Return of cattle and sheep dipping tanks (source: National Archives of South Africa, NTS 10751 - Native Affairs 1951)

RETURN OF CATTLE AND SHEEP DIPPING TANKS.

SIBASA DISTRICT - OCTOBER, 1951.

No.	Name of Tank.	Locality.	Date constructed.	By whom constructed.	Sheep or cattle.	Financed by.	Remarks.
865	Beuster	Palmaryville	?	?	Cattle	Local Council V.D.L.	-
391	Begwa	near Paswaan	1940	S.A.N.T.	"	"	-
392	Bobedhla	Shingwedzi Block	1940	"	"	"	
452	Caledon	Tabaans Block Trust Farm	?	"	"	"	Abandoned; leaking, no water. New tank to be constructed.
437	Dzamba	Ramputa Loc.	?	"	" & Sheep	"	Furrow to be constructed to supply water.
448	Folobodwe	Ngwanedzi River	?	"	"	"	-
446	Goedverwagting	Farm 111	?	Mission	"	"	Administered by Trust.
435	Khaku	Khaku Location	?	S.A.N.T.	" & Sheep	"	No water. Borehole needed and tank to be prepared & road from Zamba to it to be constructed.
869	Khalaba	Njelele	?	"	"	"	-
416	Khubvi	On Mbwedi River	?	"	" & Sheep	"	Furrow to be erected.
409	Lomondo	Lomondo Loc.	?	"	" "	"	-
457	Lambani	Lambani	?	"	"	"	Borehole needed
874	Muzia Fera	Muzia Fera	?	"	"	"	Furrow to be erected & repairs to tank needed.
861	Matshaka	Farm 1216	?	"	" & Sheep	"	Well to be deepened or borehole to be sunk.
400	Malanya	Tabaans Loc.	?	"	"	"	No water, needs repairs, needs well.
406	Mhinga	Mhinga Loc.	?	"	" & Sheep	"	Repairs needed & pump also
398	Mawambe	Mawambe Loc.	?	"	" "	"	Repairs to tank needed.
396	Makeppe	Knopneus Loc.	?	"	" "	"	Needs furrow, also repairs
872	Middelplaas Farm No.803	Tabaans area	?	"	"	"	-
860	Marseilles Farm No.765	Tabaans area	?	"	" & Sheep	"	Repairs needed.
426	Manini	near Sibasa/Punda Maria main road	?	"	" "	"	Furrow required.
445	Mandzoro	near New Union Gold Mine	1940	Private	"	"	-
867	Makuya	Makuya Loc.	?	S.A.N.T.	"	"	-
871	[illegible]	Tengwe "	1946	"	"	"	-
399	Maribane	Knopneus Loc.	1948	"	"	"	-
417	Makula	Takalani "	"	"	" & Sheep	"	Needs borehole & repairs.
415	Natal House	Near D.F.Hospital	"	"	" "	"	Repairs.
394	Nkuri	on banks of Klein Letaba	"	"	"	"	-
447	Ongedacht	Alias Masia	"	Mission	"	"	Mission.
397	Papazela	Molenje's Loc.	1948	S.A.N.T.	" "	"	Needs borehole urgently.
454	Palmaryville	near Sibasa Camp	?	"	"	"	-
413	Pepedi	" Pepedi Falls	?	"	" "		-
432	Paswane	Paswaan Loc.	?	"	" "	"	-
438	Ramputa	Ramputa Location	1948	"	" "	"	-
418	Ratogwa	" "	?	"	" "	"	Needs repair.
864	Rembander	On Farm No.59	?	"	"	"	Out of date tank. New tank needed.
428	Sterkstroom	" " " 18	?	"	" "	"	Needs borehole & Repairs.
414	Sibasa	near Sibasa's Kraal	?	"	" "	"	Repairs & Furrow reqrd.
390	Sambandau	on road to Makuya	?	"	"	"	Repairs needed.
866	Shiombo	Sibasa Crown Lands near Ramputa	?	"	"	"	Needs borehole & Repairs.
868	Shitutuni	Mphefus Loc.	?	"	"	"	New tank needed for Indun Budele & will serve Tonondwe Loc. as well.
429	Shififi	Near Sibasa M/Road	?	"	" "	"	Needs Borehole.
870	Shikundumalemma	Shikundumalemma Crown Lands	?	"	"	"	Repairs needed urgently, out of order.
404	Shikundu No.1	Shikundu Loc.	?	"	" "	"	W/Supply out of order repairs needed.
458	Shikundu No.2	" Extension	1947	"	"	"	-
408	Tshifulanane	Lomondo Loc.	?	"	" "	"	Borehole needed.
441	Tengwe	Tengwe Loc.	?	"	" "	"	Needs repair.
412	Tshisauhulu	Dzindi River near N.C. Office	?	"	" "	"	Furrow needed.
427	Tshibulane	on rd.to D.F.Hospital	?	"	" "	"	Borehole needed, repairs t
	Mahlenda	Schiel Farm	1948	"	"	"	-
	Natorp	Shingwedzi Blk.	1947	"	"	"	Needs Borehole.
	Tswinga	Pafuri Crown Lands	1946	"	"	"	" Furrow.

The main office worked with the district offices of Dzanani, Mutale, Tshitale and Vuwani. The district offices were divided into wards, and each ward had its own health inspector as well as several dip tanks. When Venda became independent in 1979, approximately 127 dip tanks were already established in the villages.

Cattle dipping was conducted as an extensive and systematic programme in Venda. The programme was run weekly during the summer season and fortnightly during winter (The Republic of Venda, 1979; Mafhara, 2004). Actual dipping was done in association with other supplementary measures, which mirrored the general practices in all the communal areas of South Africa, and included:

1. The official registration of cattle with the veterinary division – this was meant for monitoring the number of cattle each subsistence farmer had.
2. The impounding of stray animals in the official pounds and cattle owners paid a fine to rescue their cattle.
3. Cattle owners had to obtain official authorization from veterinary officers to transport the animals; the issuing of permits was mainly based on the health of the animals.
4. Restriction of the movement of cattle through the establishment of fences that crisscrossed the villages.
5. A rule that each dead animal, natural or through slaughtering, had to be reported to the Veterinary Research Institute at Onderstepoort (north of Pretoria) for disease monitoring. This was the responsibility of dipping assistants who worked with the Animal Health Inspectors of respective veterinary wards. If an animal died, blood samples were to be taken and screened. Farmers were expected to submit the spleen of the dead animal to the dip assistant for screening, whereafter slides were collected by the animal health inspectors and sent to Onderstepoort. The spleen was unfortunately never returned to the animal owner and was somehow kept as some sort of payment by the dip assistant (Nempumbuluni, 2008). Farmers who did not comply were always taken to task and they were fined on dipping days. This rule made the village veterinary assistants notorious.
6. Farmers who did not comply with the veterinary instructions were reported to the chiefs and headmen, and they had to pay a nominal penalty fee. In the worst case scenario, their cattle registers were confiscated, and they had to pay a heavier fine at the magisterial offices.

Cattle dipping was an event that started a day before the actual dipping took place. Owing to the fact that communal grazing land was spread out, farmers and their assistants collected the cattle from the grazing areas a day before. If the dip tank was not far from the village, the herds were kept in the respective kraals for a night. Farmers then had to herd the animals to the dip tanks early in the morning of dipping. For farmers who stayed further away from the tanks, cattle had to be herded to the tank site a night before.

The organization of dipping (Figure 3.4) was systematically done and cattle were separated and dipped in terms of individual herds. The first cattle to be dipped were those belonging to the chief and the dip assistant. The rest followed on a first come, first served basis (Mukhuba, 2011).

Figure 3.4 Cattle dipping at a communal dip site

Before the cattle were allowed to be dipped, cattle from each herd or kraal were counted by the dipping assistant, with each farmer having to account for his cattle. Cattle data included new-borns, dead cattle and those that were sold and all the data had to be recorded in the cattle register. Figure 3.5 is a typical example of a cattle register that was used during dipping days in Venda. The register was commonly known as “Springbok” (Thagisi, 2007), which was a colloquial name that black communities used to give to any project whose directive came from the central South African government (Sefara, 2010).

Should there be missing animals, individual farmers were always taken to task, and their registers would be confiscated by the dip assistant, to be released only after the farmer had paid a penalty at the chief's kraal.

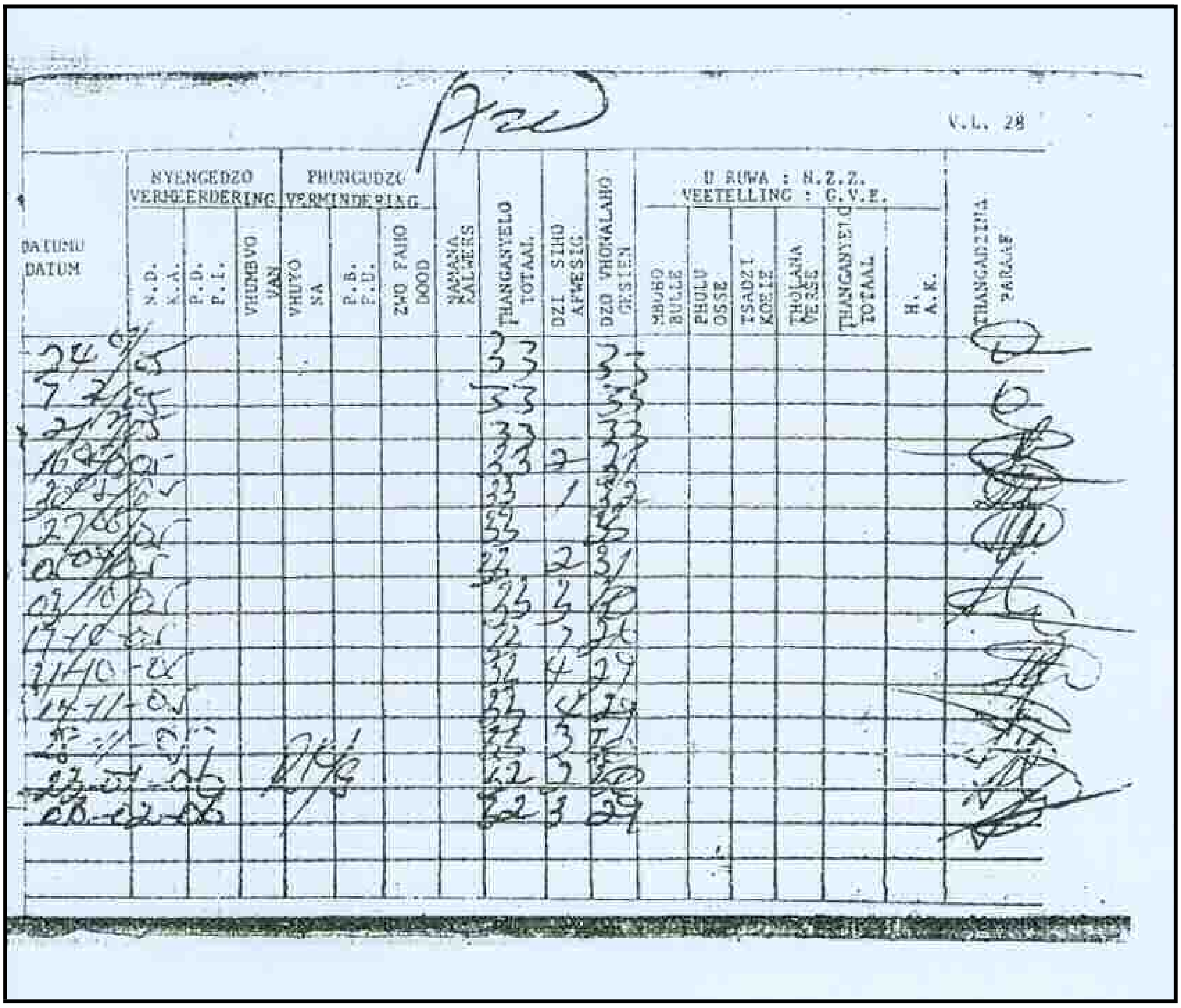


Figure 3.5 Cattle register/stock card (source: Vhembe Veearts, 2005)

The provision of dipping services by the government to communal farms in South Africa, including Venda, was scaled down after 1994 (Mafhara, 2004; Mampane 2004), and then provided only to communal areas bordering national parks such as the Kruger National Park (KNP). The main reason behind this was a shortage of funds (Mafhara, 2004). The purpose of keeping the service closer to the parks is to control the spread of diseases such as Foot and Mouth Disease (FMD) that is carried by buffalo. It should be noted that FMD is not treated by cattle dipping but dipping events allow for the detection of the disease. Figure 3.6 indicates the zones that have been set up to control the spread of FMD. National parks are regarded as Foot and Mouth Disease Infected Zones. Next to the parks are Enzootic (Buffer)

Zones; dipping in these areas is compulsory. Adjacent to the buffer zones are Surveillance Zones; farmers in these areas are encouraged to continue with dipping practise, even if only on a limited scale. The former Venda area falls under the surveillance zone. Dipping beyond the surveillance zones is voluntary and farmers do not get any assistance from government there. They continue individually with unsupervised practice.

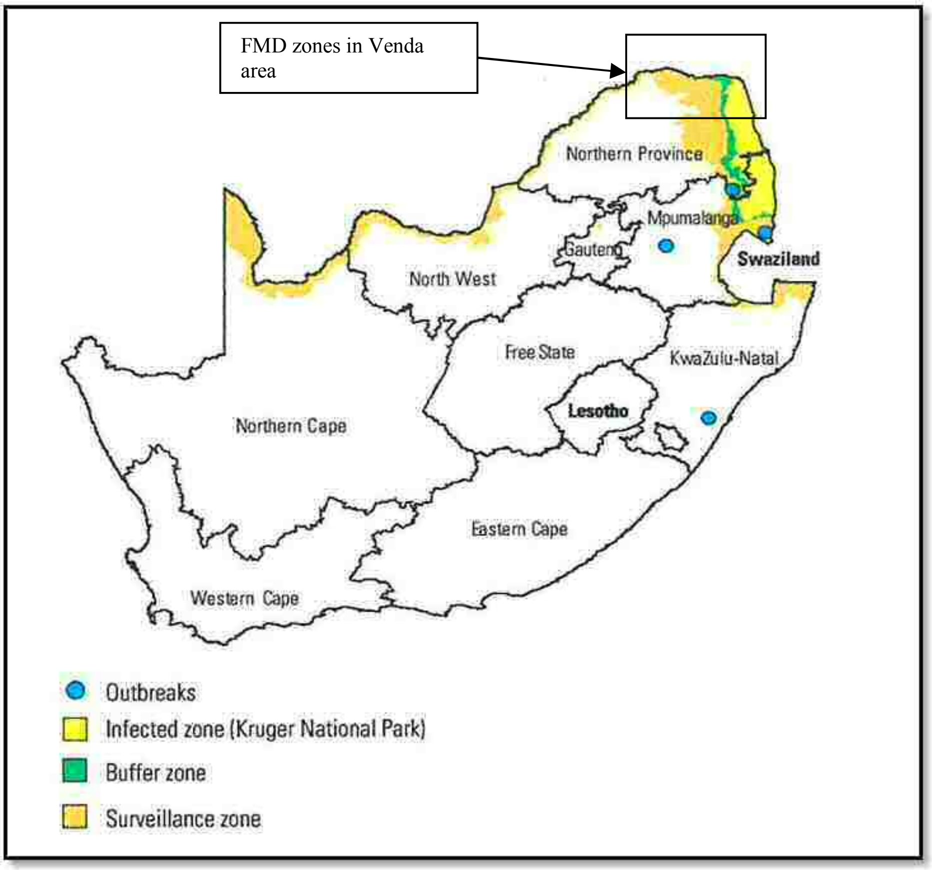


Figure 3.6 Foot and Mouth Disease control zones

After a re-look at the role of dipping in controlling ticks, the government through the Veterinary Section of the Department of Agriculture has from 2004 slowly reintroduced the dipping system in the communal areas. The main reason influencing this new direction is that during the era of ECF occurrence (up to 1954) and including the time up to 1994, dip tanks in the communal areas were successfully used to lure cattle farmers to a central area where additional preventive and monitoring services could be extended. The dip tanks were the only areas where the Veterinary Division could have unhindered access to communal farmers for monitoring other cattle diseases and the general health of livestock. As a result, the Veterinary Services sine 2004 regarded the former practice and benefits of dipping as a necessary means to deliver a spectrum of veterinary services, especially Primary Animal

Health Care (PAHC) (Nethengwe, 2013). The Veterinary Section now endeavours to supply communal cattle owners with acaricides for use in the old dip facilities. Even though the South African government has not yet produced a new policy on stock dipping, it has established a national task team that is currently drawing up a proposal of the new dipping policy (Mampane, 2004; 2011). In this regard they are relying on the various provinces to provide inputs to help formulate and finalise this proposed policy (NDA, 2005).

3.8 CONCLUSION

This chapter has identified the linkage of the establishment of dip tanks in South Africa with the occurrence of East Coast Fever (ECF). The arrival and spread of the disease is linked to the movement of cattle imported from Australia and India that came through the east African port of Mombasa in Kenya. The cattle were imported to replenish the cattle stocks that were previously almost wiped out by rinderpest stock disease. Due to its virulent form, and the resultant high cattle mortality, the occurrence of ECF almost paralyzed cattle farming and its related activities such as ox wagon transport, mining and inland trading in South Africa from 1901 up to 1954.

When it was discovered that the disease was caused by *Theileria parva* whose vector is the brown ear tick, cattle dipping was introduced as a strategy of managing the disease. The dipping strategy was also implemented in the Venda area. Together with supplementary measures such as effective fencing, movement permitting, regular production of cattle for inspection, quarantine of infected premises and slaughter of infected animals, it became a compulsory national policy that was pursued until 1960 when the disease was finally eradicated (Coetzer et al., 1994; www.nda.agric.za). The implementation of dipping also laid the foundation for the legislation and techniques for control of infectious diseases of livestock in southern Africa. After the eradication of ECF, the compulsory requirement for dipping was relaxed for commercial farmers. It, however, remained in the communal areas owing to the fact that there was always a threat of other tick-borne diseases since grazing in such places is not controlled. After the change of government in 1994, the provision of dipping service in the communal areas was withdrawn. Currently, however, the government is in the process of reintroducing the dipping programme in the communal areas.

CHAPTER 4

THE ECOLOGICAL SUSTAINABILITY OF DIPPING TANKS

4.1 INTRODUCTION

This chapter evaluates the sustainability of cattle dipping in the communal areas of Venda from an ecological perspective; this implies that the effects of dipping practice should not be harmful to the environment or pose a risk to the future use of environmental resources. The focus of the chapter is on the occurrence of dip chemical residues, particularly arsenic, in areas around cattle dip sites. Firstly, an overview of the hazards of agro-chemicals occurrence is provided, followed by the characteristics and general uses of arsenic – which was one of the compounds commonly used in cattle dipping operations, whereafter the causes of arsenic contamination and its impact are reviewed. This is followed by a description of the methodology of determining the concentration of arsenic residues around the dip tanks, and the chapter concludes with an analysis of the results.

4.2 OVERVIEW OF THE HAZARDS OF AGROCHEMICALS

Humanity's struggle with insects has intensified since the advent of agriculture. The most common line of fighting this war has been through the development of various chemicals to control and eradicate the organisms that can be considered undesirable. Chemicals or pesticides that society has developed include insecticides (insect killers), acaricides (tick killers), herbicides (weed killers), fungicides (fungus killers), and rodenticides (rat and mouse killers). Proponents of pesticide application contend that the following benefits outweigh their harmful effects:

1. Pesticides save human lives by controlling the number of insects that transmit diseases.
2. They increase food supplies and lower food costs.
3. Pesticides increase profits for farmers.
4. Pesticides work faster and better than alternatives.
5. Most chemical pesticides kill more than one pest in the same crop.
6. The health risks of pesticides are insignificant compared with human health and other benefits.

7. When used in the approved regulatory manner, pesticides pose no risk to either farm workers or consumers.
8. Safer and more effective pesticides are being developed, and many new pesticides are used at very low rates per unit area compared to older products.

On the negative side, however, it seems the successes have always been relative. Opponents of the widespread use of pesticides believe pesticides are harmful to the environment, and that their harmful effects outweigh the benefits. Pioneering studies on the ill effects of pesticides on the environment and human health were brought to the public attention by the seminal work *Silent Spring* by Rachel Carson (1962), which led to the banning of DDT in the USA and also led to the drafting of the US Environmental Protection Act and subsequent far-reaching changes to environmental legislation worldwide.

Furthermore, pesticides are designed to kill living things, whether they be insects, weeds, or plant pathogens, but any amount of chemical which misses its intended target can affect numerous other aspects of the environment. Some estimates suggest that for many insecticides as little as 0.1 percent of the amount applied to a particular field may reach the target organism (Piemental and Levitan, 1988), while the remainder becomes a contaminant in the air, surface water, groundwater, river sediments and plants. The resultant effects on non-target organisms and the pollution of land, air and water which can also affect human populations and pose direct threats to human health has caused considerable concern (Middleton, 1995; Mitchell, 1989). Mitchell (1989) indicates that every minute as many as 48 crop workers are poisoned, and one dies, from exposure to pesticides.

Some chemicals have a broad spectrum character, and instead of only killing the target pests, they also kill non-target organisms. Such non-target organisms are mainly the natural predators and parasites of target organisms that may have been maintaining a pest species at a reasonable level. Wiping out the natural predators can unleash new pests whose population the predators had previously held in check, causing other unexpected effects (Middleton, 1995). Higgins (2001) reports that the use of fumigation for the control of coca plants in Colombia was found to be destroying banana, plantain, and yucca fields as well. The authorities used the non-selective Roundup Ultra herbicide that contains glyphosate to control coca plants, the source of cocaine. It has also been alleged that the use of the chemical is wiping out natural plants and killing birds, mammals, and aquatic life in the fragile Amazon ecosystem. The herbicides are also linked to a variety of eye, respiratory, skin and digestive ailments.

Targeted pest organisms sometimes become resistant to pesticides as they develop immunity through natural selection over time. Bringing in new and more potent chemicals to control the resistant pest populations means that the environment is subjected to the effects of a bigger arsenal of chemicals, which increase the negative side effects on the natural environment.

Certain pesticides tend to accumulate in living organisms. In some cases, they not only accumulate to levels greater than are found in the environment, but concentrations keep increasing as they move up food chains, an effect known as biological magnification (Ravelle and Ravelle, 1988). This trait is mainly found in chemicals that have chlorinated hydrocarbons such as DDT and mercury-containing compounds. An example of this is when an organism ingests DDT, the chemical becomes concentrated in the organism's fatty tissue, from where it is lost at a very slow rate; if another creature in the food web or chain eats the first organism, the consumer will then be ingesting a concentrated form of DDT. The pesticides that contain these chemicals take long to break down into harmless forms. They do not degrade biologically and are persistent, and in finding their way into the environment they can build up in the soil and water to levels that are toxic or poisonous to plants and animals. The next section provides more examples of the detrimental effects of DDT.

The risks of pesticides are high in poor countries. This is because the majority of pesticides are applied by hand, educational levels are low, warnings are few, pesticides regulations are lax and use of protective equipment is rare. Some families also reuse pesticide containers for storing food and drinking water. In a study about agricultural chemical exposures and birth defects in the Cape Province, South Africa, Heeren et al. (2003) found a statistically significant association between birth defects and the exposure of the mothers to certain agricultural chemicals. MacLeod (2007) reports of physical abnormalities observed and documented by a medical doctor around the Groblersdal commercial farming area. The doctor, Johan Minnaar, observed health abnormalities that included the development of breasts on five year old girls, the temporary growing of breasts in teenage boys during spraying seasons, miscarriages, partial facial paralysis, cancers and ear malfunctions. Many of the patients that Minnaar treated suffered from milder poisoning symptoms such as asthma, sinusitis, headaches, dizziness and depression, leading the doctor to postulate that the abnormalities are directly linked to the unregulated use of agricultural chemicals by commercial farmers in the area (MacLeod, 2007).

Realization of the dangerous effects of many pesticides has encouraged some governments and also the international agencies such as the United Nations to introduce some guidelines in order to manage the impact of chemicals. The measures include the introduction of maximum allowable levels (MALs), the introduction of long lasting bans, the introduction of environmental friendly pesticides, the introduction of alternative methods to pesticides such as environmental control, genetic and sterile male techniques, biological control, behavioral control and resistance breeding.

The historical account of cattle dipping informs us that a series of pesticides have been used to prepare chemical mixtures to control ticks. Commonly used chemicals include DDT, Arsenical compounds, Aldrin, Dieldrin, Malathion, Aldicab and Carbamates, amongst others (Cutter et al., 1991; IDR Desk Reference, 2003/4; World Animal Review, 2004). The use of particular chemicals has continuously been changed as a result of the evolutionary resistance that ticks have developed after a time of exposure to it, as well as their toxicity to people and the natural environment, and financial limitations.

Only DDT and Arsenical compounds will be discussed in more detail, as these are the compounds that were most extensively used with dipping operations in South Africa (Wharton, 1983).

DDT

Studies on the impact of DDT have found that it has negative effects on human reproduction. Harley et al. (2008), in a study conducted among female greenhouse workers in Denmark and Colombia, found that potential maternal exposure, largely through work in agriculture, was associated with decreased fecundity, i.e. a longer time to conceive compared to a control group. Harley et al. (2008) also reported a decreased fecundity by migrant farm workers exposed to DDT from home and agricultural pesticide application in California. A study by Veeramachaneni (2008) found that DDT causes a testicular dysgenesis condition which leads to a decrease in the quality of semen.

Amongst other harmful effects of DDT, its ingestion by birds is manifested in eggs having shells thinner than normal, which are more fragile, and therefore it has an adverse effect on the protection of developing chicks inside. If such a situation persists, certain bird species may become extinct. Van Dyk et al. (2010) indicated that significantly high levels of DDT residues have been found in soils, potable water, leafy vegetables and chicken samples in the northern and eastern parts of Vhembe district where DDT spraying has been reintroduced for malaria control, since the area is located in an intermediate to high risk malaria zone. Bornman et al. (2010) found in research conducted in the Vhembe district, which encompasses all of the former Venda area, that maternal exposure to DDT from residing in a village where DDT was sprayed for malaria control was associated with urogenital malformations in newborn male children (Bornman et al, 2010).

While the effects of DDT use in agriculture has received significant attention in the literature, contamination caused by the use of arsenic in cattle dipping has elicited relatively little research, but it is the contention of the author that the environmental effects of arsenite compounds are as serious.

<u>Arsenite soda</u>

Arsenic oxide (As_2O_5) and trioxide (As_2O_3) compounds such as Albany Tick, Scab Dip and Coopers Dip were most commonly used in the dipping programme. A chemical compound that has been identified for investigation in this study is the arsenical compound, arsenite soda, known as Coopers Arsenic (National Archives of South Africa, TAD NOA.451/3a), of which the packaging is illustrated in Figure 4.1.

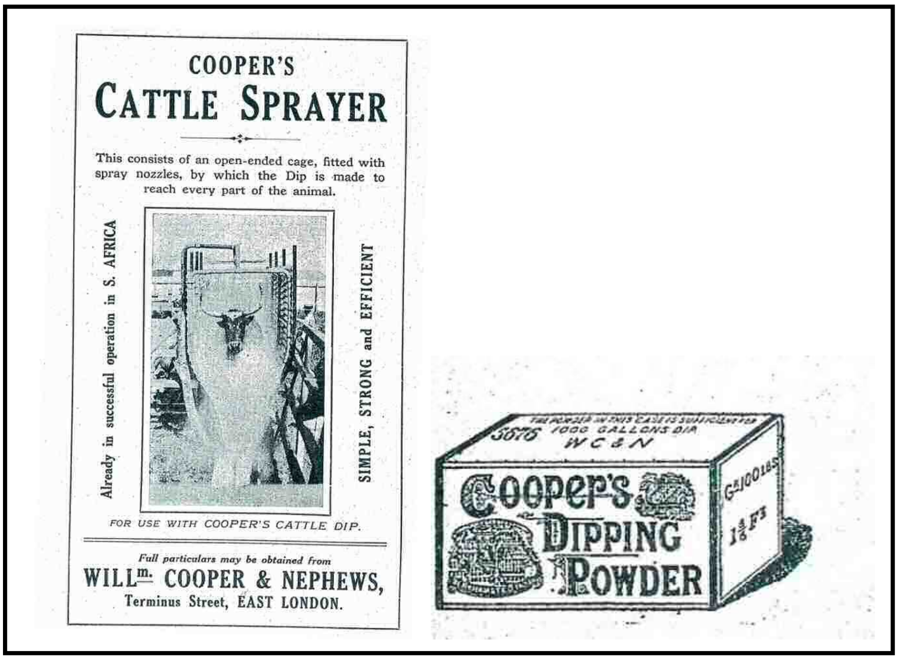


Figure 4.1 A marketing leaflet from the early 1900s showing a spray dip where arsenite soda (Cooper's Dip) was used

Arsenite (AsO_3^{3-}) is the chemical that was used earlier in cattle dipping and it is more toxic than arsenate (AsO_4^{3-}). During the time of its introduction, Cooper's Dip was praised as a super chemical and its wide use continued until the early 1970s, whereafter while it was eventually banned for all animal use in 1983 (www.nda.agric.za/doa). Sefara (2010) asserts that the use of the chemical was discontinued by the early 1970s for two main reasons: it was poisonous to cattle, people and the environment; and in addition the targeted ticks started to develop resistance to the potency of the chemical. It is believed that this chemical was subsequently replaced by less toxic chemicals.

Owing to the fact that arsenical compounds as used in cattle dipping are heavy metals and not biodegradable, they can also pose risks to the environment and human health. Therefore, it is important to investigate the levels of concentration in areas around dipping sites. For the sake of clarity, however, it is necessary to first understand the physical nature and characteristics of the chemical.

4.3 THE OCCURRENCE AND CHARACTERISTICS OF ARSENIC

Arsenic (As) is a substance which is a member of the nitrogen family that occurs naturally in rock and soil. The element is an odourless and tasteless semi-metal. It can combine with other elements to form organic and inorganic arsenicals, the latter being generally more toxic and more prevalent in water. Its introduction to the environment is a result of both manmade (anthropogenic) and natural (geogenic) activity. Naturally, its occurrence is associated with volcanic areas, and it enters the environment through ground water, mineral ore, and geothermal processes. It is released into the air, water and soil through weathering of arsenic containing minerals and ores. The anthropogenic occurrence is mainly through human made processes like mining activities, industrial plants, and also where it is used as a pesticide.

Arsenical compounds can be classified into three major groups, namely, inorganic, organic, and arsine gas (ATSDR, 2009). While inorganic and soluble arsenic is more toxic than organic arsenic, their relative toxicity of arsenicals generally depends on their inorganic and organic form, their physical state and purity, their solubility, and the rates of absorption and elimination by bodies. Arsenite (AsO_3^{3-}) and arsenate (AsO_4^{3-}) are examples of highly soluble forms of arsenic.

Arsenic has a high adsorptive capacity, and therefore easily clings on soil particles. Adsorption, however, depends on the characteristics of soil as well as soil drainage. Arsenic clings more readily on clay soils that are full of Iron (Fe), Manganese (Mg) and Aluminium (Al) (ATSDR, 2007) and it is conversely easily washed away from large-grained sandy soil (Mandal and Suzuki, 1992). Therefore, the high concentration of arsenic is mainly found in the top layers in areas with clayey soils (Merwin et al., 1994). With sandy top soils, however, the arsenic may leach away into deeper soil layers, and reach the base flow of nearby streams or seep into the underground water. The availability of natural organic matter in soil also influences the adsorption of arsenic, with humus, manure or compost-rich soils adsorbing more arsenic (Wang and Mulligan, 2006).

Arsenic can easily move from one medium to another, i.e. between soil, water and air. Its mobility is affected by factors such soil type, slope, and amount of rainfall. Soil type affects it mobility in that movement is more restricted in clayey soils than in sandy soils (Sheppard, 1992; Mandal and Suzuki, 1992), while it migrates easier downslope on steep slopes than with gentler slopes. Higher rainfall influences its mobility in that arsenic is easily washed away downslope and may be deposited into the sediments of stream beds (Gross and Low, 2013).

Arsenic is persistent and relatively stable in the environment and it is resistant to decay. Instead of decreasing through time, it accumulates and can therefore have long-term impacts. Similar to metals, the ingestion thereof is selectively accumulated by organisms that consume it, in a process termed bioaccumulation (ATSDR, 2007).

4.4 USES OF ARSENIC

Different arsenic compounds are widely used in the agricultural and industrial world. In agriculture arsenic is used in pesticides and defoliants, while its use in industry is linked with paints and dyes used for clothing and paper. Arsenic trioxide is widely used in the electronics industry as a component of conductor and semi-conductor devices. Arsenic is also used in coal fired power plants, metal producing plants as a hardener of metal alloys, in industries that purify industrial gases, as well as in wood processing plants as a preservative treatment for wood. Elevated levels of bioavailable arsenic in mining soils, agricultural areas, and human habitats may cause potential toxicity to human health, plants, and microbes (Anawar et al., 2008).

Arsenic is also used in the medical industry and in chemical warfare. For instance, arsenic may be found in some traditional remedies of Asian societies, such as in naturopathic or homeopathic remedies; it is also used for psoriasis and eczema treatment remedies, and in medicine that induces and consolidates chemotherapy for leukemia and other cancers (Chan and Huff, 1997; Miller et al., cited in Gehle, 2009). Arsenical products such as Chlorovinyldichloroarsine were used for chemical warfare in the 1920s and were known for causing severe skin burns on contact at low concentrations (Gehle, 2009).

4.5 REVIEW OF CAUSES OF ARSENIC CONTAMINATION

Where arsenic is found in high concentrations, it causes arsenic poisoning. This is more profound with soluble inorganic arsenite compounds. Contamination is expressed as maximum allowable values (MAVs) in parts per million**.** Because of the intrinsic danger of arsenic to society, the World Health Organization expresses the safe maximum permissible value (SMPV) for drinking water as 0.01 mg/l or parts per million (WHO, 2012). The fatal human dose for indigested arsenic is between 70 and 180 mg (WHO, 1981). According to the World Health Organization (1981) guidelines, the maximum allowable value of arsenic concentration in water is 0.01mg/l, but different countries use various maximum allowable values to determine the nature or extent of contamination. Water with As concentrations exceeding this value is considered poisoned and unsafe for drinking. The detrimental effects of arsenic poisoning are manifold (Texas A&M University, http://arsenic.tamu.edu/).

In agriculture, arsenic poisoning could result in the following:

1. Increased uptake by plants and increased arsenic in the food chain.
2. Arsenic induced plant physiologic disorders of phyto-toxicity.
3. Reduced crop yields.
4. Reduction in food quality.
5. Decreased market value of crops.
6. Detrimental impact on livestock health and food value.
7. Loss of agricultural sustainability.

The negative impact on the economy could be: 1) the loss of family productivity because of arsenic induced illnesses; 2) economic loss through the impact of arsenic on food quality and subsequent impact on the marketability of products, and 3) economic loss through a decline in consumer confidence.

As a persistent and non-biodegradable substance, increased levels of arsenic in the environment (in surface and underground water, and soil) may cause toxic effects to human health, plants, and microbes. It acutely and chronically kills some plant and animal species through bio-accumulation. Also, arsenic kills other beneficial creatures in the ecosystems such as earthworms, flies, and dung beetles.

Human consumption of arsenic contaminated foods over a long time can lead to arsenocosis, a chronic illness that produces skin disorders, gangrene and cancer of the kidneys and bladder. Where it accumulates in the nervous system, it induces mental related problems. Wang (http://lindachae.com/) indicates that chronic exposure to small amounts of arsenic in drinking water increases a person's risk of cancer and other diseases. Owing to the fact that the arsenic compounds are widely used commercially, there is always an increased risk of overexposure to the workers who handle these compounds.

The literature on the contamination by arsenic and the effects of exposure is extensive. Research on its toxicity and environmental impact has been conducted in countries where the chemical was introduced into the environment through both natural (geogenic) and human (anthropogenic) activities.

4.5.1 Geogenic Causes

Most research on the natural or geogenic contamination of arsenic emanate are from the Asian region, an area that includes Bangladesh, China, India, and Nepal, (see for instance: Das et al., 2000; Roychowdhury et al., 2005; Heikens, 2006). These are countries with a history of volcanic activities and high levels of arsenic in this region are concentrated mainly in river valleys (where it is bound primarily to amorphous iron-oxyhydroxide rich sediments) and water wells dug in places with shallow aquifers. Due to the strong reducing nature of groundwater in Bangladesh, the compound tends to break down and release arsenic into the groundwater (Wickson et al., cited in Ortiz Escobar et al., 1998).

People in the Asian region obtain water mainly from shallow tube wells that are dug or sunk on the water-bearing rocks that are often already contaminated with arsenic. They ingest the chemical either from drinking water or from crops that are irrigated with contaminated water. As a result, millions of people in the region experience arsenic poisoning. Ortiz Escobar et al. (2006) indicate that the arsenic calamity in Bangladesh, adjacent West Bengal, and India can be described as one of the largest known mass poisonings in human history, with an estimated 35-75 million people being exposed to arsenic contaminated water. Some areas, especially those on the south and east of Bangladesh have arsenic concentrations that exceed 1000 mg/l. Water in this region is so contaminated that local people regard it as the "devil's" water (Pearce, 2001).

4.5.2 Anthropogenic Causes

4.5.2.1 Global review

Countries where more research about the anthropogenic contamination of arsenic has been done are those linked with the history of its wide use as a constituent of fertilizers, herbicides and pesticides and as industrial preservative. Its most notable use is mainly linked with the introduction of cattle dips for the control of the spread of ticks and tick-borne diseases that were a menace to the cattle and sheep industry from the late 19^{th} century in countries such as Australia, New Zealand and the USA.

Most of the areas where there are high levels of arsenic contamination in Australia are found in northern New South Wales. These are the areas where cattle dipping was introduced from 1858 onwards as a result of the spread of cattle ticks, *Rhipicephalus microplus*. Arsenic was used for tick control in the area until the mid-1950s (National Toxics Network, 2003) and soils in many areas around old dip sites have been found be highly contaminated with arsenic, and as such are a major concern to the environment and human health (McLaren et al., 1998). Arsenic concentrations reported in some of these areas ranged between 37 and 1400 micrograms/kilogram (µg/kg) or 0.037 – 1.4 mg/l.

People who are threatened by contamination are mainly cattle dipping agents, Department of Agriculture workers (*tickies*) and the residents living on land contaminated by dipping activities. Cases of various health problems such as leukaemia and other cancers, psychological ailments, skin rashes and general ill health, and subsequent deaths have been reported. As a result, there has been a serious public outcry and pressure from environmental groups. In the state of New South Wales in Australia for example, the outcry forced the New South Wales Government to form the Dipsite Ministerial Advisory Committee (DIPMAC). The main mandate of DIPMAC in New South Wales is to facilitate opportunities for interested people and groups to comment on, provide input, and be involved in the decision making process of all stages of management and remediation of contaminated sites. A program that was subsequently developed to address the need for more community participation in the management of dip sites included amongst others the development of a Community Access Information Database; the development of a GIS of a local catchment; the development of a Management Plan for remediation of inactive dip sites, and the development of guidelines for on-site disposal and safe working practices at dip facilities.

The New South Wales state of Australia presently established a Cattle Tick Dipsites Community Information System whose purpose is to provide comprehensive information to the public and local government officials on each of the identified 1 647 dip sites.

A study by Noonan-Para et al. (2004) investigated the geochemical fate of arsenic in cattle-dip vat site soils in Australia found that soils around the dipping tanks where arsenic was used were highly polluted. The findings indicated that the contamination resulted from dipping structures that were not concrete-lined as well as from the poor disposal practices of the arsenic slurry that had lost its potency, such as disposing of it directly onto the neighbouring soils.

Robinson et al.'s (2004) study about the environmental availability of arsenic in New Zealand indicated that the use of arsenical compounds has resulted in an estimated 20 000 contaminated sites nationwide. The high contamination of the sites has been ascribed to the extensive use of arsenical pesticides in orchards, and in sheep and cattle dips for the control of ticks, fleas and lice. The use of sodium arsenite ($NaAsO_2$) to control aquatic weeds has also contributed to the arsenic burden of some New Zealand lakes.

Because of the concern about the environmental impact of dipping, especially soil contamination, the Waikato Pesticides Awareness Committee (WPAC) undertook a study in 1994 to determine the level of soil contamination created by the use of sheep dips. Soil samples from seven sheep dip sites in the Waikato and Taranaki regions were tested for residues of arsenic, organochlorides, organophosphate, and synthetic pyrethroid classes of insecticides. The study found that all sites had moderate to high arsenic contamination. The results were of considerable concern as compounds such as arsenic and dieldrin are carcinogenics that impact on immune systems (McBride, 1998). The end product of this research was the development of a guideline to raise awareness among Waikato Council staff and landowners about the risks associated with former sheep dip sites (New Zealand Ministry for the Environment, 2006). The aspects that are addressed in the guideline are about identifying, investigating, and managing risks associated with former sheep-dip sites.

Cases of high levels of arsenic contamination have also been observed in the southern states of the USA, namely Texas and Florida. The occurrence of the chemical is also traced back to the history of its extensive use of in cattle dipping, especially towards the end of the nineteenth century. Evidence of high arsenic contamination include places that were developed for residential and business purposes, which were developed without the developer knowing that they were previously used as cattle and sheep dip sites. These are examples of places that can present hidden, but serious, contamination (Sarkar et al., 2007).

In a similar vein, the findings of a study of 12 dip sites conducted by the Department of Environmental Protection (DEP) of Florida State in the USA indicated a very high concentration of arsenic residues in underground water below dips. In addition to arsenic, other compounds that were found included DDT residues, toxaphene, benzene and chlorodane (www.doh.state.fl.us/Environment/).

The comments by Thomas et al. (2011) link soil and underground water contamination by arsenic around many dip site areas in the state of Florida, USA, to the uncontrolled disposal of the old dip solution. They allude to the fact that when dip tanks were cleaned every year, the dirty chemical solution was either allowed to run into the nearby pit where it eventually seeped into the ground, or arsenic was precipitated out of the solution with iron sulphate plus quicklime, and the sludge was buried in a pit. The subsequent use of other compounds such as DDT, DDE, toxaphene and BHC also increased the amount of chemical contamination.

Because of the intrinsic danger of arsenic to society the World Health Organization expresses the safe maximum permissible value (SMPV) for drinking water as 0.01 mg/l or parts per million.[4] The fatal human dose for indigested arsenic is between 70 and 180 mg (WHO, 1981). Human consumption of arsenic contaminated foods over a long time can lead to arsenocosis, a chronic illness that produces skin disorders, gangrene and cancer of the kidneys and bladder (Huang et al., 2006).

4.5.2.2 South African review

Research about arsenic contamination in South Africa is limited to the contamination in mining operations, and some chemical manufacturing operations. Manufacturing operations in this regard include the manufacture of explosives, fertilizers, acids, and agrochemicals. The chemical compounds occur as arsenic acid, lead arsenate, copper arsenate and calcium arsenate (Holliday et al., 2007). Although it is acknowledged that arsenic is poisonous, the extent of poisoning is not well-documented.

With regard to cases of arsenical poisoning resulting from cattle dipping tanks, concerns about poisoning to humans were raised as early as the 1940s (Clark, 1946). Other concerns were from environmental pressure groups. For example, the Endangered Wildlife Trust Poison Group alleges that the arsenicals that were used in the cattle dips had a huge impact on the population of Yellow and Red-billed Oxpeckers (Verdoorn and Marais, 2004), while it is postulated that the Yellow-billed Oxpecker became extinct in South Africa during the first half of the 20^{th} century, with the birds allegedly being poisoned as they fed on ticks that engorged on cattle. Also, arsenic kills other beneficial creatures in the ecosystem such as earthworms, flies, and dung beetles.

Information about the arsenic status and distribution in soils at disused cattle dip tanks is limited, except for an isolated study conducted by Moremedi and Okonkwo (2007) around a cattle dip site at Ka-Xikundu village, next to the Kruger National Park in the Limpopo Province. The study detected a high concentration of arsenic levels in the soil around the Ka-Xikundu dipping site. The Ka-Xikundu dip tank is located outside the Venda territory, and it is one of the oldest dip tanks in the area. In the analysis of the findings they argued that the accumulation of arsenic and other elements in water and soil might have led to the entry of such toxic elements into the food chain, affecting both plant and animal species. Humans may be affected directly, as in the case of drinking polluted water or indirectly via ingestion of animal products.

This part of my study was conducted around the dip tanks that were established in the communal villages of the former Venda territory. The way that spent dipping solution was disposed of in the past usually involved pouring the effluent into either a poison hole, or direct disposal on surface adjacent to the dip trough. The poison holes were disposal pits dug out to about 2- 2.5 m deep and filled with rocks – similar to french drain pits (Fletcher, 2000) and these pits were seldom lined or reinforced, especially in Venda. This study assumes that the dip sites could be contaminated by the chemical and such sites need to be identified for future environmental planning and management. The study by Moremedi and Okokwo (2007) referred to above reports of a considerable amount of arsenic concentration in one communal dip tank which is outside the Venda territory. Results from one site, however, cannot show a bigger picture of the extent of contamination and further investigations from more and varied sample cases is therefore necessary. In addition, the identification of sample cases should consider the various characteristics of ecological regions such as soil types, rainfall, vegetation, and topography since they have an influence in the concentration and movement of arsenic.

4.6 METHODOLOGY

4.6.1 Distribution of Sample Sites

Data for this study were obtained from soil samples that were collected from ten identified dip sites and constitutes a representative sample of the dip tanks in the study area. The choice of sites was based on the ages of the dip tanks, with the respective dip sites all belonging to the group of 54 tanks that were established in the study area between 1915 and 1955, and as such some of the oldest in the study area (Sefara, 2010).

The study was conducted at the dip tanks of Khubvi, Mukula, Rambuda, Sambandou, Thengwe, Tshandama, Tshifudi, Tshikuwi, Tshituni and Tshivhulani, as displayed in Figure 4.2. Table 4.1 presents the latitude and longitude of each site, along with other descriptive data.

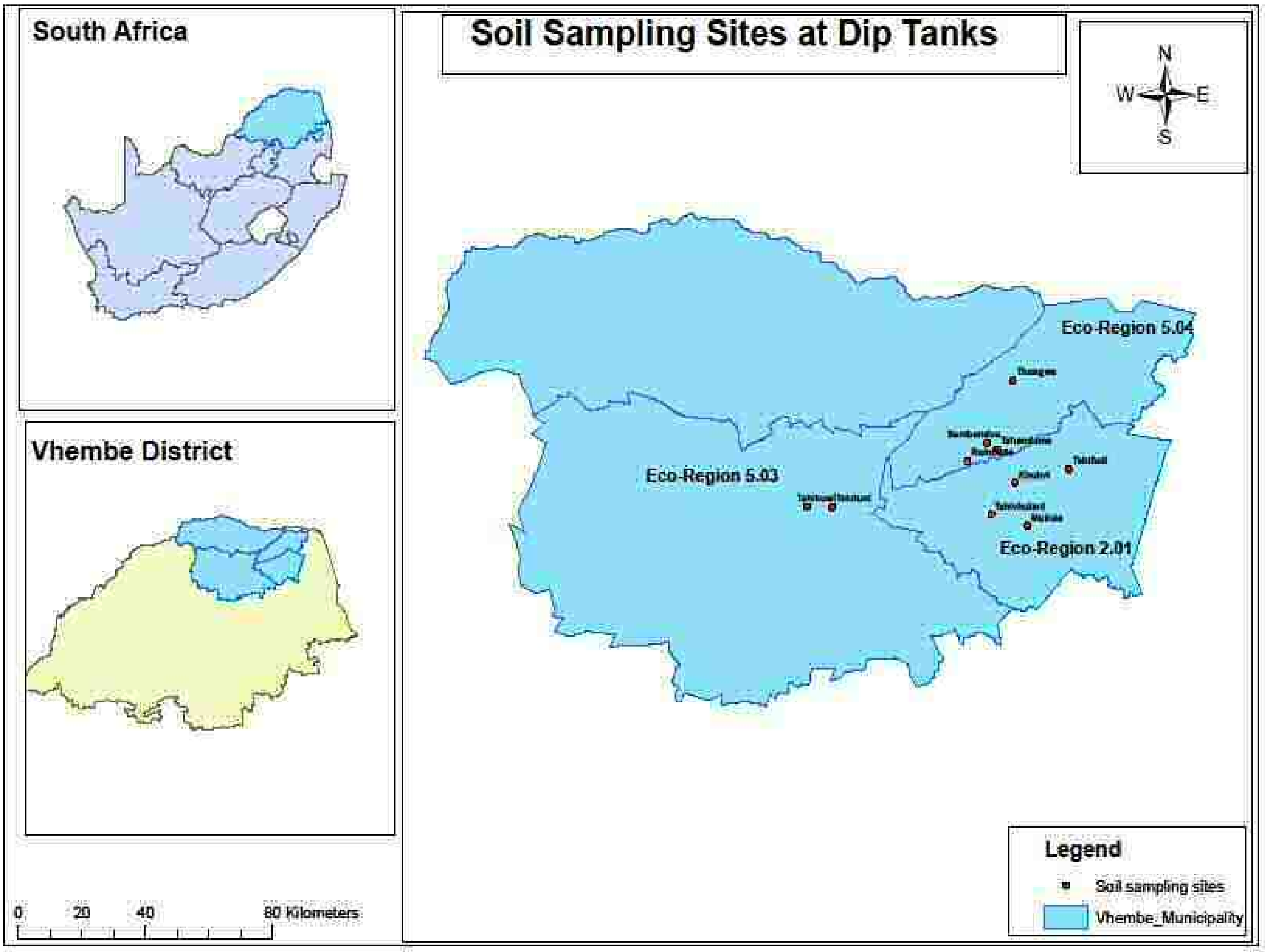


Figure 4.2 Dip sites where soil samples were taken

4.6.2 Description of the Sampled Dip Sites

Much of the surface area of the former Venda territory is taken up by the Soutpansberg mountain range. Its variation in topography, geology, drainage, micro climate, soil and vegetation has a bearing on the regional division of the former Venda area. The ten dip sites where soil samples were taken are situated in three different regions, namely the central highlands area (Eco Region 2.01), North Eastern area (Eco Region 5.04), and the Western region (Eco Region 5.03) (WRC, 2001).

The physical condition of the environment at different dip tanks is described according to the conditions of the eco regions and soil characteristics of each dip site. The tanks are distributed among the three eco regions as follows:

- *Central area (Eco Region 2.01):* Khubvi (established in 1923), Mukula (established in

1948), Tshivhulani (established in the early 1920s) and Tshifudi (established in 1948)

- *North east area (Eco Region 5.04):* Rambuda (established in 1940), Sambandou (established in the late 1920s), Thengwe (established in 1950) and Tshandama (established in the 1950s)
- *Western region (Eco Region 5.03):* Tshikuwi and Tshituni (both established during the 1940s).

Table 4.1 groups and summarises the dip tanks in terms of their date of establishment, along with their Eco Region classification and soil description. A more detailed description of each of the three Eco Regions and soil types follows, where the names of features like mountains correspond to local vernacular names.

Table 4.1 Location of dip tanks selected, with ecological and soil characteristics of surroundings

Site	Latitude	Longitude	Date built	Eco-regions and soil characteristics
Established before 1948				
Tshivhulani	22º55.35' S	30º30.12' E	Early 1920s	ER 2.01 (Central Highland): Deep red clays predominate
Khubvi	22º49.52' S	30º34.03' E	1923	ER 2.01 (Central Highland): Heavily weathered, compacted red clay
Rambuda	22º47.05' S	30º27.06' E	1940	ER 5.04 (North-Eastern area): Red loam with high organic matter content
Tshikuwi	22º53.83' S	29º58.91' E	1940	ER 5.03 (Western area): Heavily weathered, compacted red loam
Tshituni	22º56.82' S	30º02.57' E	1940	ER 5.03 (Western area): Gravelly with traces of brown clay
Established from 1948				
Sambandou	24º 49.59' S	30º39.33' E	1948	ER 5.04 (North-Eastern area): Sandy loam with very high organic matter content
Tshifudi	22º 48.24' S	30º43.27' E	1948	ER 2.01 (Central Highland): Sandy loam with prevalent organic matter
Makula	22º 51.00' S	30º36.59' E	1948	ER 2.01 (Central Highland): Weathered, compacted red clay
Thengwe	22º 49.59' S	30º32.58' E	1950	ER 5.04 (North-Eastern area): Sandy with little organic matter
Tshandama	22º 30.07' S	30º45.05' E	1950	ER 5.04 (North-Eastern area): Sandy with little organic matter

In Eco Region 2.01 (Central Highland area) the soil around the Khubvi and Mukula dip tanks is highly weathered and consists of compacted red clay; around the Tshifudi dip tank sandy loam with organic matter is prevalent, while around the Tshivhulani dip tank deep red clays predominate. In Eco Region 5.04 (North-Eastern area) the soil around the Rambuda dip tank is red loamy with a high content of organic matter. Around the Sambandou tank soils are sandy loam with more organic matter; while the Thengwe and Tshandama dip tanks areas are characterised by sandy soils with limited organic matter. In Eco Region 5.03 (Western area) red loam soils, heavily weathered because of compaction, are found around the Tshikuwi dip tank. The soil at the Tshituni tank is gravelly, with traces of brown clay

4.6.2.1 Eco Region 2.01 - Central Highland area

The central area is characterized by undulating landscape, hills and low mountains with moderate relief which are elongated and north facing. The altitude of this area ranges between 500 and 800 m above sea level. The hills are separated by a series of perennial and periodic streams. The main rivers adjacent to the sampled dip tanks in the central area are Mbwedi, Mutshindudi and Lwandevhe. Khubvi dip tank lies on the southern foot slopes of Khubvi hill at an elevation of 590 m; Mukula on the eastern foot slopes of Mukula ridge at a height of 563 m; Tshivhulani tank on the eastern side of Sibasa highlands at elevation 701 m; and Tshifudi on the southern foot of Tshifudi mountain at a height of 593 m.

The vegetation of Eco Region 2.01 is diverse; it is generally comprised of Sour Lowveld-Bushveld, Soutpansberg Arid Mountain Bushveld and patches of Afromontane Forest (Acocks, 1988). Where the natural vegetation is not disturbed, the area has a fairly extensive tree cover made up largely of Bush Willow (*Combretum krausii*), Cabbage Tree (*Cussonia spicata*), Red-Bush Willow Tree (*Combretum apiculatum*) and Round-Leaf Kiaat (*Pterocarpus rotundifolius*), and the dense undergrowth of subtropical shrubs and creepers (The Republic of Venda, 1979). The common vegetation closer to the sampled dip tanks appears as an open parkland with large trees.

Eco Region 2.01 is situated in a summer rainfall area with an average of 300 mm to 2025 mm annual rainfall. Temperature ranges from a minimum of 2^0C to a maximum of 44^0C, with the mean annual of 20^0C.

The soils are relatively deep and fertile. The dominant types are sandy to sandy loamy soils in the uplands to red clay soils in the lower lands. There is, however, a variation in soil types around the respective dip tanks. Soil around Khubvi and Mukula dip tanks is highly weathered and compacted red clay; around Tshifudi dip tank sandy loamy with organic matter; and around Tshivhulani dip tank deep red clay.

4.6.2.2 Eco Region 5.04 - North-Eastern area

Eco Region 5.04 where the Rambuda, Thengwe, Tshandama and Sambandou dip tanks are situated is also characterized by undulating landscape, hills and low mountains with moderate relief. The altitude of this area ranges between 450 m and 1300 m above sea level. The rivers that flow through the region are the Mutale and the Luvuvhu. The sampled dip sites in the area are all situated along the wide Mutale River Valley. Rambuda dip tank is situated along the southern footslopes of Rambuda mountain at an altitude of 720 m; Sambandou along the eastern Tshitavha range at an altitude of 630 m; whilst Thengwe and Tshandama are situated along the wide Mutale River flood plain at an altitude of 659 m and 670 m, respectively.

The vegetation of Eco Region 5.04 generally comprised of Sour Lowveld and Bushveld on the western part, and patches of Afromontane Forest mainly along the ravines (Low and Rebelo, 1996). Where the natural vegetation has been destroyed by overgrazing and deforestation, vegetation comprises mostly of short grass.

This region also lies in a summer rainfall area; with an average of 425 mm to 1875 mm annual rainfall. The type of rain the area receives is mainly of the orographic type. Temperature ranges from a minimum of 2^0C to a maximum of 34^0C, with the mean annual of 20^0C.

The soil type in this area is sandy to sandy loam. Loamy soil is mainly found along the foot slopes of the mountains and the floodplains. The type of soil around Rambuda dip tank is red loamy that is full of organic matter; it is sandy loamy with more organic matter around Sambandou tank; and sandy with little organic matter around Thengwe and Tshandama dip tanks, respectively.

4.6.2.3 Eco Region 5.03 - Western area

Eco region 5.03 is situated along the western part of the Soutbansberg. The region is characterized by flat to undulating landscape, plains with low to moderate relief, and hills with high relief on the northern side. The area is drained by the Nzhelele River system. Its altitude ranges between 450 meters and 1300 meters above sea level. The region borders the southern part of Limpopo Highlands. Tshikuwi dip tank lies at an altitude of 963 m while Tshituni tank is at an altitude of 906 m.

This is also a summer rainfall area. Because it is on the lee side of the Soutpansberg, rainfall is generally low, with the annual average rainfall ranging between 350 mm in the west and 1050 mm on the east, closer to the mountains. Temperature ranges from a minimum of -4^0C to a maximum of 45^0C, with the mean annual of 21^0C.

The vegetation in this area is comprised mainly of mixed lowveld-Bushveld. The western part of the region shows some element of aridity and it is covered by Mopani trees (*Colophospermum mopane*) and scattered baobabs (*Adansonia digitata*).

The soil type in this area is acidic sandy, gravelly to sandy loamy. Loamy soil is mainly found along the river valleys. The type of soil around Tshikuwi dip tank is red loamy. It, however, appears heavily weathered due to compaction. That of Tshituni tank is gravelly with traces of brown clay.

Figures 4.3 – 4.12 present the location and general physical characteristics of the dip sites sampled.

Figure 4.3 Sambandou

Figure 4.4 Tshivhulani

Figure 4.5 Tshifudi

Figure 4.6 Khubvi

Figure 4.7 Rambuda

Figure 4.8 Mukula

Figure 4.9 Thengwe

Figure 4.10 Tshikuwi

Figure 4.11 Tshituni

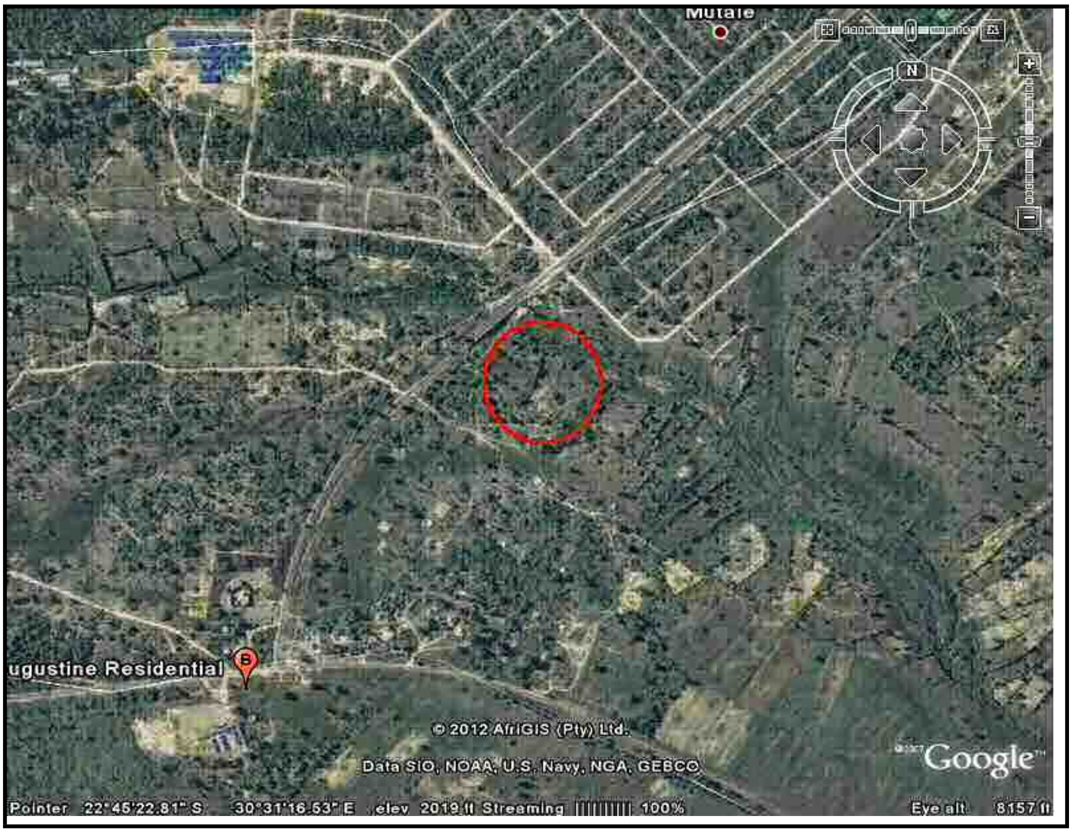


Figure 4.12 Tshandama

4.6.3 Collection of Soil Samples

To investigate the horizontal distribution of arsenic, the points where soil samples were collected were within an area of 100 m radius from each tank because a normal dip site in communal areas covers an area of approximately a hectare. The possible horizontal migration of arsenic tends to follow the direction of cattle movement during and after dipping. It also follows the direction of dirty dip effluent that flows into the adjacent poison hole. This the structure into which dirty dip effluent flows when the tanks are cleaned. Cattle assemble in the forcing yard, and are then channeled to the tank through the crush; after swimming through the tank they emerge into the draining area, or draining pen, where the dip solution is supposed to drip from their bodies; thereafter they scatter to different directions.

The samples were therefore taken at the following distances from each dip tank: at the splash and dip sludge disposal areas (5 m); the drain or drip pen area (20 m); and a dispersal area (100 m), respectively. Figure 4.13 provides a diagrammatic and pictorial representation of the points where the soil samples were collected around each dip site area.

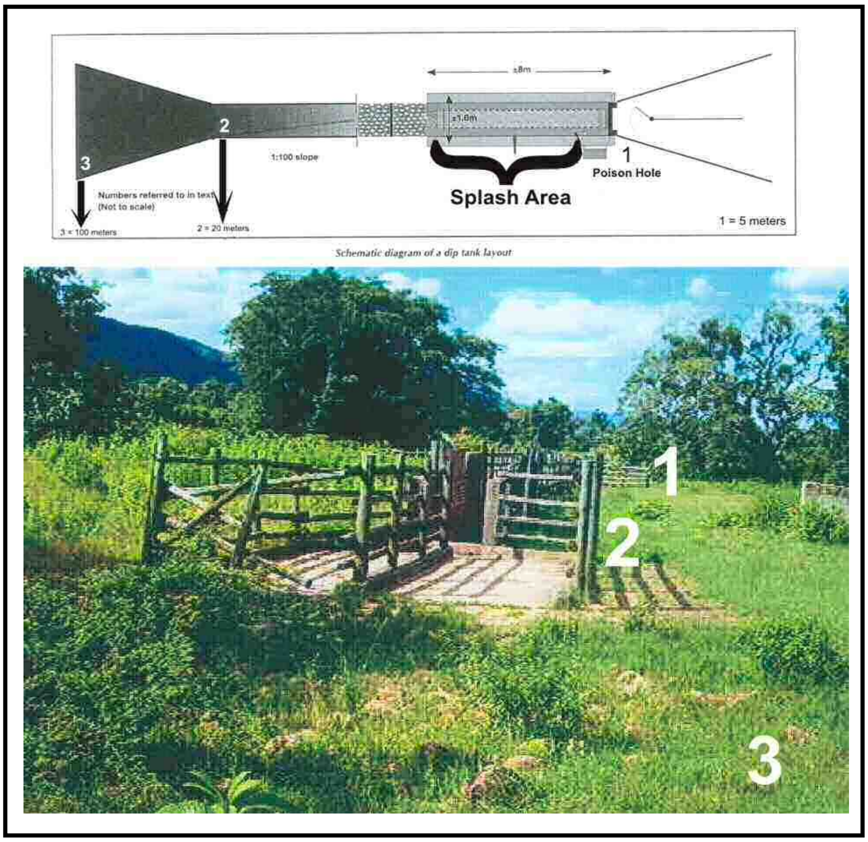


Figure 4.13 Diagrammatic representation of where samples were taken around dip tanks

The splash area is the nearest distance from the wall of the dip tank. The 20 m distance covers a draining pen where the cattle congregate whilst they are still wet with dip solution. The solution that drips from their bodies can be channeled by a furrow back to the tank if it is lined with concrete. The 100 m distance covers an area around the tanks from where cattle disperse to different directions. This was perceived to be the control site which was chosen for the purpose of determining the natural occurrence of arsenic in the areas around the dip sites.

In order to demonstrate the distances from the dip tanks where soil samples were taken, the buffer tool in Arc Map 10 was used. The buffer tool creates a buffer polygon around input features to a specified distance. In this instance, three individual buffers were created in order to show 5 m, 20 m, and 100 m around each dip tank site (Figure 4.14).

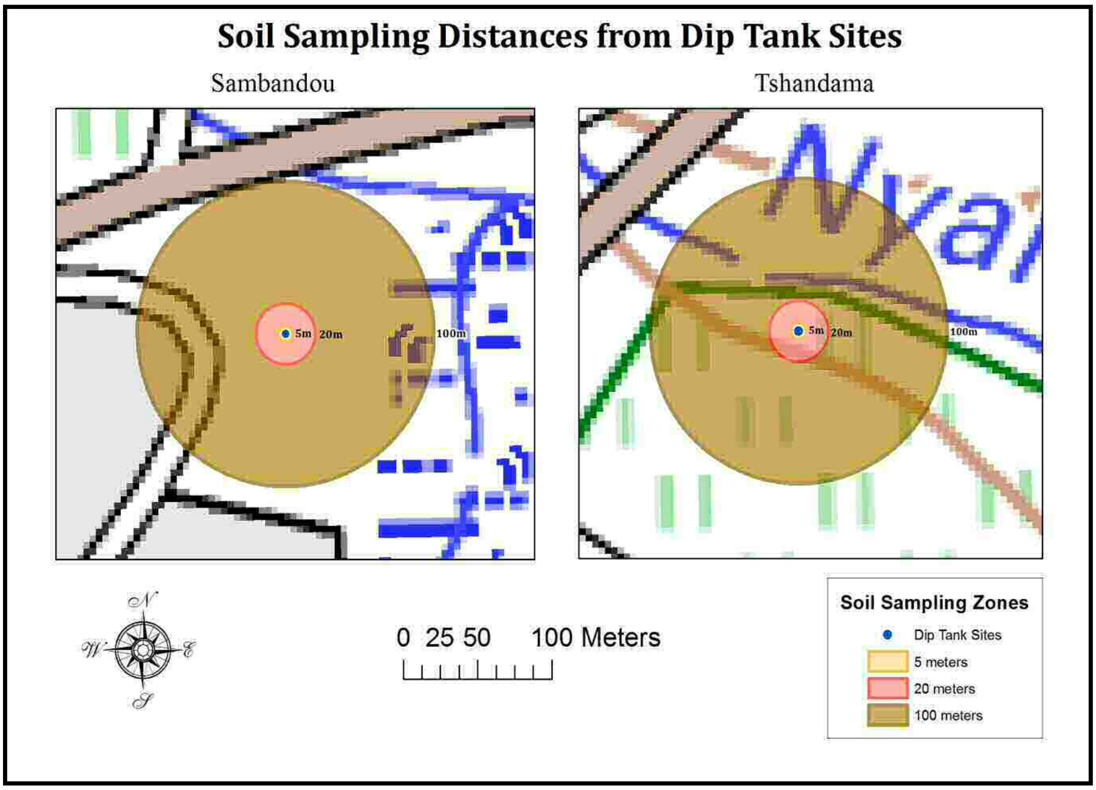


Figure 4.14 Buffer areas showing the distances of the sample points

Linear, single point soil samples were taken according to the distances mentioned above at the sampled dip sites. The samples were taken from the depth of 30 cm in each sample point by using a soil auger, as opposed to the 10cm depth preferred by Moremedi and Okonkwo (2007) in their study. This depth was chosen to make provision for the expected deeper penetration of the As residue over the average 50-year period since the commissioning of the dip sites, as well as to make provision for potential loss of topsoil due to erosion from runoff and animal disturbance. A consistent selection method was therefore employed in choosing the sampling locations at each site: both the depth of sampling and the distance from the source of the contaminant (As) was controlled by taking into consideration the layout and slope at each sampling site.

The samples from each dip site were placed in clean sandwich plastic bags and labeled accordingly, for despatch to the soil laboratory for analysis.

4.6.4 Laboratory Analysis

The packaged soil samples were subsequently sent to the Agricultural Research Council's soil laboratory in Pretoria for chemical analysis. The analysis was done by using Semi Quantitative Scan of an Ammonium EDTA extract. Individual soil samples were dissolved in an Ammonium EDTA solution, and the solution was filtered to determine the chemical composition of each sample (Locke, 2008).

4.6.5 GIS Methods Used in Generating Maps

All data were created and processed using Arc-GIS 10 by ESRI (Google Earth, 2012). The coordinates for the dip tank sites and soil sample sites were collected using Google Earth.

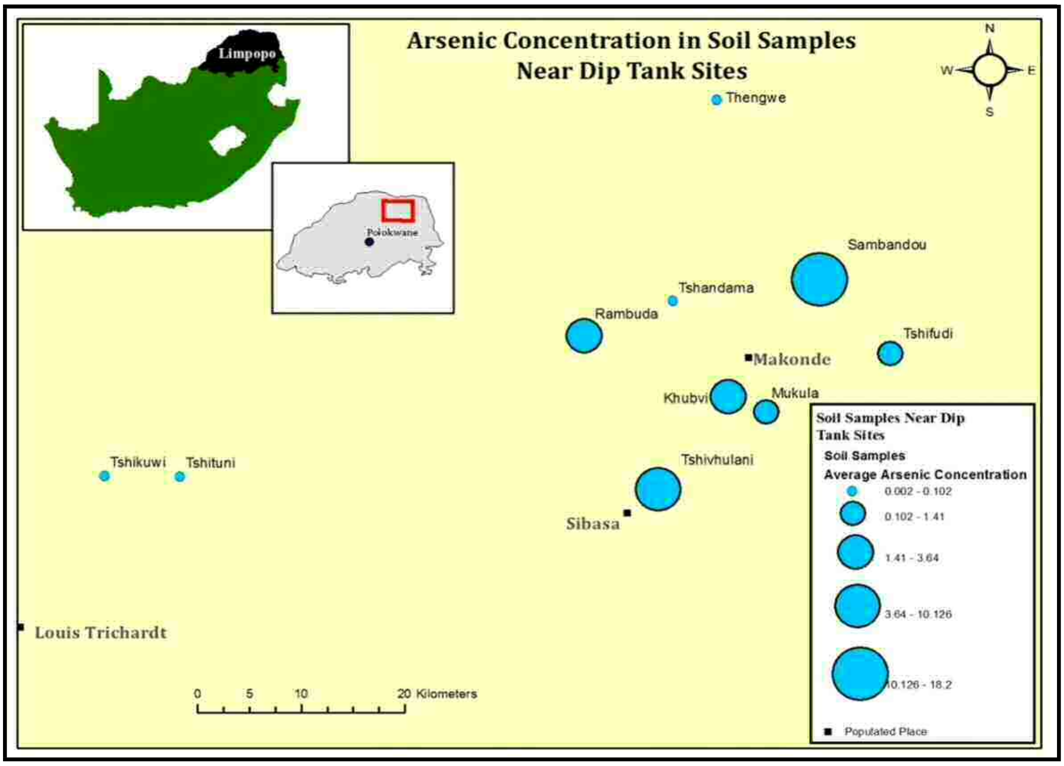


Figure 4.15 The concentrations of arsenic in soils around the sampled dip tank sites

Latitude and longitudinal coordinates were then recorded in an excel spreadsheet and converted to decimal degrees. This excel spreadsheet was then added to a geo-database in Arc Catalog 10 to confirm Arc10 compatibility. After the table was imported to the geo-database, it was used to create a feature class shapefile based upon the latitude and longitude; this shapefile of dip tank sites and soil sample sites was then added to a world layer base map provided by ESRI for reference (ESRI, 2012). The As concentrations were then mapped with symbology of graduating symbols, with areas of higher concentrations mapped as larger circles than lower concentrations, as displayed in Figure 4.15.

4.7 RESULTS AND DISCUSSION

The results of the arsenic concentrations in soils at the ten dip sites, as displayed in Figure 4.15. are discussed in more detail below.

4.7.1 Absolute Concentration of Arsenic Residues in Soils

Table 4.2, below, lists the results from the highest to lowest As concentrations at 5 m distance from dip tanks.

Table 4.2 Concentration of arsenic residues in soils at dip tank sites in mg/kg

Dip sites	Concentration (mg/kg)				% Decrease		Comments
	5 m	20 m	100 m (Control)	Mean	5m - 20m	5m – 100m	
Sambandou	46.760	6.882	1.085	18.242	85.3	97.7	No poison hole
Tshivhulani	30.180	0.187	0.011	10.126	99.4	100.0*	Dip tank in depression
Tshifudi	3.853	0.225	0.150	1.409	94.2	96.1	Steep slope
Khubvi	3.653	3.688	3.595	3.646	-1.0	1.6	Maize field
Rambuda	3.529	3.627	3.699	3.618	-2.8	-4.8	Brick yard; poison hole at 20m
Mukula	2.302	1.200	0.084	1.195	47.9	96.4	Steep slope
Thengwe	0.142	0.073	0.091	0.102	48.6	35.9	Sandy/rocky soil
Tshikuwi	0.084	0.122	0.019	0.075	-45.2	77.4	Sandy/rocky soil
Tshituni	0.017	0.057	0.013	0.029	-235.3	23.5	Gravelly, sandy soil; traces of clay
Tshandama	0.002	0.003	0.002	0.002	-50.0	0.0	Sandy/rocky soil
Mean As concentration	**9.049**	**1.606**	**0.875**	**11.53**			

* Actual percentage: 99.96; rounded off. ☐ Concentrations >WHO SMPV of 0.01 mg/kg

Absolute As concentrations observed

Surface soils around the 10 dip sites show arsenic values which ranged from 0.002 mg/kg to 46.76 mg/kg at a 5 m distance from the tanks. An immediate observation is that the arsenic concentrations measured by this study are significantly lower than the findings of the 2007 study at the Luvuvhu river (Moremedi and Okonkwo, 2007). Other factors aside, the difference in arsenic concentrations could be the result of the depth at which soil samples were extracted. While Moremedi and Okonkwo (2007) took their samples at a maximum depth of 10 cm, samples for this study were extracted at a depth of 30 cm.

Sambandou recorded the highest mean concentration (18.24 mg/kg) in the current study, and Tshandama the lowest mean concentration (0.002 mg/kg), while both these sites also had the same ranking in terms of concentrations at 5 m distance from tanks. Five of the 10 dip sites (Sambandou, Tshivhulani, Khubvi, Rambuda and Tshifudi) showed moderate to high concentrations (>3 mg/kg) of arsenic residues at the 5 m distances.

World Health Organisation's (WHO) safe maximum permissible value (SMPV) of 0.01 mg/l

Most observed As concentrations are far in excess of the World Health Organisation's (WHO) safe maximum permissible value (SMPV) of 0.01 mg/l or parts per million (WHO, 1981). The shaded values in Table 4.2 indicate As concentrations that exceed the WHO SMPV limit – and Table 4.3 sheds more light on the extent of variation. Tshandama, where the lowest As concentrations were recorded, is noteworthy in that it showed constant, low As concentration of 0.002 mg/kg at 5m, 20 m and at 100 m; this concentration falls within the WHO safe maximum permissible value.

The extent to which the concentration of arsenic around the respective tanks differs from the WHO SMPV standard of 0.01 mg/kg is indicated in Table 4.3.

The dip sites that stand out are Sambandou, Tshivhulani, Khubvi, Rambuda and Tshandama. At Sambandou the concentration is 1800 times higher, Tshivhulani 1 010, and Khubvi and Rambuda 360 and 350 times higher.

Table 4.3 The extent of As concentrations compared to the WHO maximum permissible limit

Dip tank	**Mean As concentrations around100 m at each dip site** (mg/kg)	**Order of magnitude from WHO's SMPV (0.01 mg/kg)**
Sambandou	18.242	1800
Tshivhulani	10.126	1010
Khubvi	3.646	360
Rambuda	3.618	350
Tshifudi	1.409	140
Mukula	1.195	120
Thengwe	0.102	10
Tshikuwi	0.075	10
Tshituni	0.029	3
Tshandama	0.002	0.2
Mean	**11.53 mg/kg**	

4.7.2 Decrease of As Residues in Soils with Distance

The high levels of contamination closer to the tanks could be attributed to three factors: firstly, the practice for many decades of disposing spent dip sludge by discarding it onto the ground or into the nearby 'poison holes' when the tanks were cleaned; secondly the splash of dip solution over the sides of the dip tanks every time cattle jump into the tanks; and finally the fact that when cattle emerge from the tank, they assemble at the draining pen nearby the dip tank, before they disperse.

The two sites where significantly high As concentrations were observed, are those at Sambandou and Tshivhulani, both of which also decrease very rapidly from 5 m to 20 m distance from the dip tanks. Both these sites have consistently serviced very high volumes of cattle, which explains the absolute values. Sambandou furthermore has no poison hole and the spent dip effluent is spread manually with buckets around the dip tank, which could explain the higher concentrations at 20 m – as most migration would be via infiltration and surface runoff.

Absolute decrease in As concentration with distance from source

On a normal scale according to the highest and lowest values, there is a relative high change in arsenic concentration from the dip trough (measured at 5 m) to a distance of 100 m for all sites except Tshituni and Tshandama, the two sites where the lowest 5m and overall As concentrations were recorded. For example, the situation at the Tshivhulani dip tank shows that the As concentration 5 m from the tank is 2743.6 times higher than the concentration at 100 m; the corresponding value for Sambandou is 43.1 times, while other sites display a more gradual drop in concentration between the respective two points.

At some sites, particularly Khubvi, Rambuda and Sambandou, high levels of contamination were measured up to 100 m away from the tanks. These relatively high concentrations could be explained by the drip of dip solution from the treated cattle which congregate in the unpaved drip yard before they disperse. Overflowing of dip tanks due to flooding after rainfall events, as well as the overland flow of dip solution could also have contributed to the phenomenon of elevated As values at distance from the tanks. In addition, Khubvi and Rambuda's high As concentrations far from the source can also be explained in terms of specific anthropogenic activities – see later explanation.

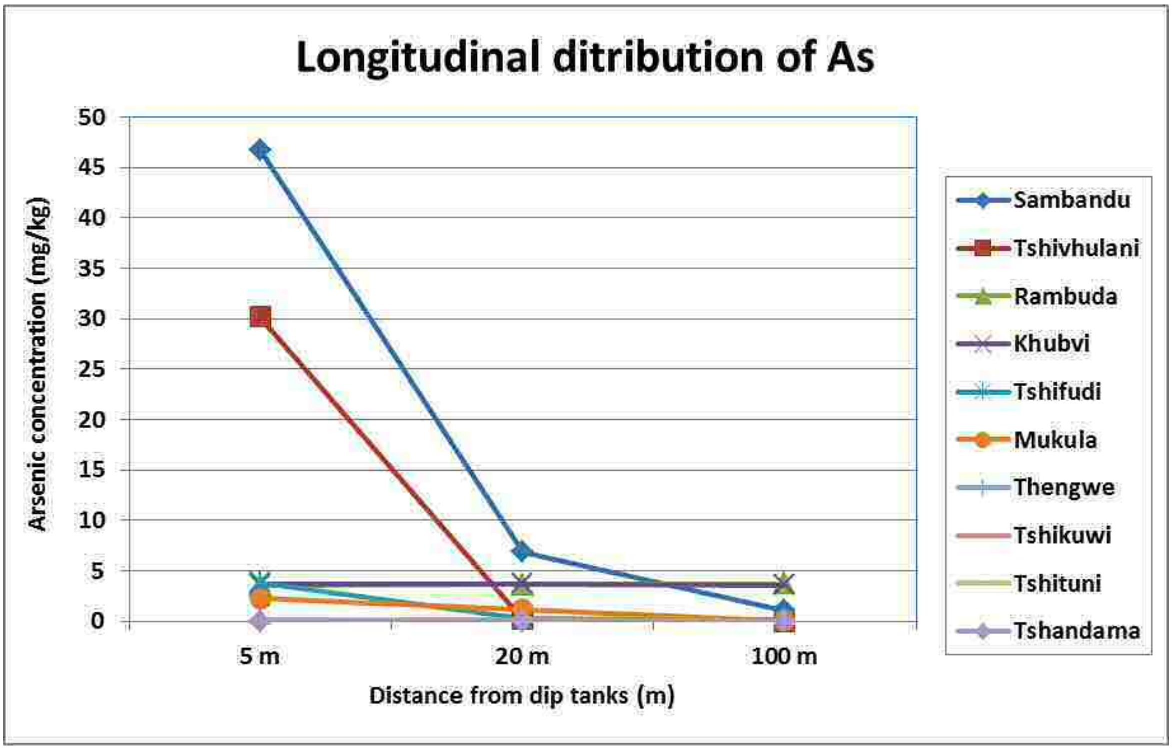


Figure 4.16 Longitudinal distribution of arsenic concentration

<u>Percentage decrease in As concentration in soils with distance from source</u>

Table 4.2 also shows the percentage decrease in concentrations of arsenic against distance, measured as the percentage change in concentration in As from 5 m to 20 m and also from

5m to 100 m using the formula:

$$\% \, Decrease \quad = \quad \frac{Actual\ decrease}{Initial\ value} \times 100\%$$

(where the actual decrease is represented by the highest value minus the lowest value, with the initial value being the highest value).

The results reveal the general trend that As contamination in soils is high closer to the tanks, and decreases with distance from the source of contamination; this was observed for seven of the ten cases (see Figure 4.16). This decline in contamination varies, however. The values of Sambandou and Tshivhulani show a much bigger difference between sampled points at 5 m and at 20 m, compared with the other eight sites.

The arsenic concentration of sample points in soil from 5 m to 20 m distances from the source at Sambandou decreases by 85.3%, and those of Tshivhulani by 99.4%. The percentage decrease from 5 m to 20 m is also high in respect Tshifudi (94.2%). Making a similar comparison in respect of percentage change from 5 m to 100 m, the following sites record the highest decrease: Sambandou (85.3%), Tshivhulani (99.96%), Tshifudi (96.1%) and Mukula (96.4%). However, the relatively low absolute values of As concentration at 5 m in respect of Tshifudi (1.409 mg/kg) and Mukula (1.195 mg/kg) to some extent mask this significant trend. It nevertheless implies that the As in the soil profile is leached or washed away very rapidly.

4.7.3 As Concentration Observed in Soils as Explained by Soil Properties

The loamy and clay rich soils at Khubvi, Mukula, Rambuda, Sambanou, Tshifudi and Tshivhulani had higher arsenic concentration levels than Tshandama, Thengwe, Tshikuwi and Tshituni, where sandy and rocky soils are more dominant**.** Refer to Table 4.2 and Table 4.4 .

Arsenic is easily adsorbed by soil particles (Goldman, 2012) and it is accepted worldwide that relatively higher arsenic concentrations are positively correlated with clay, silt and organic matter and specifically with Fe, Mg and Al oxides in soil (Smith et al, 1998; Sheppard, 1992; Huang et al, 2006; ATSDR, 2007). Therefore, the high concentration of arsenic is mainly found in the top soil layers in areas with clayey soils. By contrast, the arsenic is easily leached or washed into the deeper layers where large-grained sandy soils occur, due to lower adsorption capacity of these soils. Flooding and weathering also appear to enhance the horizontal distribution of arsenic in soil, with both these processes contributing to the deeper penetration of arsenic into the soil profile (Mandal and Suzuki, 2002).

Table 4.4 As concentrations and soil types observed at dip sites

Dip site	**As concentration(mg/kg)**			**Soil description**
	at 5 m	**at 20 m**	**at 100 m**	
Sambandou	46.760	6.882	1.085	Sandy loam with very **high organic** matter content
Tshivhulani	30.180	0.187	0.011	Deep red **clay**
Tshifudi	3.853	0.225	0.150	Sandy loam with prevalent **organic** matter
Khubvi	3.653	3.688	3.595	Heavily weathered, compacted red **clay**
Rambuda	3.529	3.627	3.699	Red loam with high **organic** matter content
Mukula	2.302	1.200	0.084	Weathered, compacted red **clay**
Thengwe	0.142	0.073	0.091	Sandy with little organic matter
Tshikuwi	0.084	0.122	0.019	Heavily weathered, compacted red loam
Tshituni	0.017	0.057	0.013	Gravelly with traces of brown **clay**
Tshandama	0.002	0.003	0.002	Sandy with little organic matter

Also Mukula's relatively high As concentration at 5 m of 2.302 mg/kg can be explained in terms of its clay content; however, Tshituni's 0.017 mg/kg appears somewhat anomalous as its surrounding soil also has traces of clay.

4.7.4 As Concentration in Soils as Explained by Topography and Slope Characteristics

Closer inspection of the Tshifudi and Mukula dip sites reveal that they are both situated on or near steep slopes – at any rate, the exit sides where cattle emerge after dipping slope rapidly downhill. The prevailing soils present are sandy loam with significant organic matter at Tshifudi and weathered, compacted red clay at Mukula. While one would expect the adsorbing qualities of these soils to predominate, it appears from the data that the slope characteristics at these two sites have a stronger influence on the dispersal of As from the sites. It would therefore be carried away mainly as surface runoff over the steep slopes, leading to the expectation that there will be relatively higher As concentrations further away from the source. In comparing the data to the other dip sites, these two sites have significantly higher As concentrations than the other clay and/or organic content soils at 100 m from As source. It can therefore be deduced that slope plays a significant role in overland As dispersal, mainly as runoff.

4.7.5 As Concentration in Soils as Explained by Anthropogenic Activity

A deviation from the trend of a marked decrease in As concentration with distance from the dip tanks was observed at Khubvi, Rambuda and Tshandama. At both Khubvi and Rambuda tanks, where instead of decreasing with distance from the tanks, the concentration of arsenic at a distance of 5 m is slightly lower that at 20 m. This could be linked to other human activities, as the area around Khubvi tank has since been turned into a maize field, whilst an area adjacent to the Rambuda tank is used for mud brick making. Continuous ploughing and brick making would have mixed the top layers of the soil and might have shifted the soil downslope, thereby promoting the migration of arsenic horizontally in the soil profile. The relatively high As concentrations at 100 m away from the dip tanks at both these sites (3.699 mg/kg and 3.595 mg/kg respectively for Khubvi and Rambuda) relative to all other sites' observed values at 100 m distance support the inference that the ploughing and/or levelling and working of the soil for brick production added to the horizontal spread and migration of As in their soil profiles.

Furthermore the poison hole of Rambuda dip tank is situated on the downslope side of the tank, approximately 20 m away from the tank and is joined to the tank by a narrow lined furrow. As a result, dip effluent during cleaning could not soak into the ground before it reached the poison hole, which partially explains the higher concentration at 20 m, near the poison hole, than at 5 m.

As already discussed, Tshandama is significant in that its observed concentrations remained constant and also that it is very low at 20% of the WHO's SMPV.

4.7.6 As Concentration in Soils as Explained by Duration of Exposure to Arsenite Soda

Duration of exposure only partly explains the difference in arsenic concentrations. If 1955 is taken as the year when the use of arsenic-based dipping compounds was discontinued, the average exposure of dip sites where the lowest five concentrations was detected is 9.4 years (σ = 4.63) and that of the tanks where the highest five concentrations was found 18.6 years (σ = 11.32). At Sambandou, where the highest readings were recorded (46.76 mg/kg at 5 m and 6.88 mg/kg at 20m), the dip was only in use for 7 years before 1955 compared to the approximately 32 years of the second highest ranking site, Tshivhulani. However, the tanks constructed up to 1940 rank second, third and fourth in As concentrations at a 5 m distance.

The age of dip tanks therefore do not show a very significant correlation with As concentrations in this study.

4.8 CONCLUSION

The purpose of this chapter was to investigate the occurrence, distribution, concentration and contamination of arsenic in soils surrounding cattle dip tanks in order to determine the ecological sustainaility of past dipping practices in the former Venda area in South Africa. The investigation began with the review of general background of the firstly agrochemicals in general and then DDT and specifically arsenic used for dipping, followed by a review of arsenic contamination and its impact. To this end three soil samples were collected from each of ten different dip tank sites, which were Sambandou, Tshivhulani, Tshifudi, Khubvi, Rambuda, Mukula, Thengwe, Tshikuwi, Tshituni, and Tshandama.

Varied traces of arsenic were found around all the tanks. The sites with high contamination are Sambandou, followed by Tshivhulani, Khubvi, Rambuda and Mukula. At the respective sites the concentrations are significantly higher than the safe maximum permissible value (SMPV) of 0.01mg/kg prescribed by the World Health Organisation.

The observed general pattern of arsenic occurrence in soils in the study area is that high concentrations occur closer to the dip troughs, and the concentrations drastically decrease with distance from the tanks. This observation can be explained by the splashing of dip solution outside of the tanks as cattle jump into it; the manual cleaning of dip tanks whereby dip effluent is discarded on the surface close to the tanks; and the assemblage of cattle at the draining pen close to the dip trough after they emerge from the tank following dipping, before they disperse.

Soil properties, specificlly its clay content (due to Fe and Al minerals especially), and also its natural organic matter content (humus, manure and plant matter) result in higher As adsorption, thereby immobilising but retaining As in loco. The presence of clayey soils and organic matter therefore causes local immobilisation, causing elevated levels near the source, but reduces the further horizontal migration through the soil profile, as well as its downward percolation to groundwater. Therefore, the high concentration of arsenic is mainly found in the top soil layers in areas with clayey soils. Another observation made is that the bulk of higher arsenic contamination has been found at sites where red clays and loamy soils full of organic matter dominate.

Topography and slope also influence the migration of arsenic, with more surface runoff due to steeper slopes causing lower As concentrations near the source, relative to flatter terrain, but higher levels further away, thereby posing a risk to nearby watercourses and aquatic ecosystems. A steep slope has a more pronounced effect on As dispersal than what clayey or orhanic-rich soils has in retaining or adsorbing As. Further research would be necessary to determine the breakeven point between the effect of slope in dispersing As and the role clay content to fix As in situ.

Anthropogenic influences, especially the utilisation of soils for agricultural cultivation and also for brickmaking activities, influence the distribution of arsenic in the soil profile. The effect of this is that there is a more even or uniform spread of As present, with relatively high concentrations occurring even at 100m from the source, while the values near the source are generally lower than corresponding observations without substantial human interference. The use of clay or cement for bricks would result in fixing or adsorbing As locally, while cultivation would inlcude the buildup of organic matter which would likewise fix As locally.

Although arsenic contamination decreases with distance, all values are high enough to be of concern because even at 100 m distance from the dip tanks, nine of the ten sites sampled display arsenic concentrations higher than the WHO safe maximum permissible value (SMPV) of 0.01 mg/kg. Therefore all the dips where arsenic was used as a pesticide from 1915 to 1972 are contaminated by the chemical. The dip tank sites should furthermore not be taken as only the visible part of the rural landscape were cattle used to gather, and still gather for the control of ticks and tick-borne diseases, but it should also be noted that such sites pose potential risk to the natural environment and to human health. As arsenic is highly mobile in soil, it may move down the soil profile and contaminate underground water, soil and plants in areas closer to the tank sites. This fact may have long term impacts if the extent of contamination is not thoroughly addressed.

There is a strong likelihood that the health of people who have been exposed to the chemical for a long time, for almost a century in this case, has been endangered. This could have happened when people worked with soil in the areas adjacent to the dips. The chemical can be inhaled as soil dust, ingested with food or directly ingested. Furthermore, although the extent of underground water contamination was not determined in this study, it is very likely that arsenic could have leached into the underground water from the areas sample, due to the high concentrations that were recorded, given the high mobility of arsenic in soils and effluent disposal practices which included direct disposal on surface or into poison holes.

The persistence of arsenic in high concentrations near the dip tanks of the communal areas, and its subsequent potential of poisoning the surrounding soils, vegetation, microbes and water resources, leads to the conclusion that although the purpose of eradicating East Coast Fever was realised, the use of arsenic as a pesticide has not been ecologically sustainable.

The presence of dip tanks as part of the rural landscape must not be looked at in isolation; they must also be looked at as areas with a potential of endangering human health, and also areas that require proper management. The extent of arsenic contamination around the dip tanks in the Venda area should therefore be investigated in association with the social implications; this aspect is addressed in more detail in Chapter 6, which investigates social sustainability.

CHAPTER 5

THE ECONOMIC SUSTAINABILITY OF CATTLE DIPS

5.1 INTRODUCTION

This chapter examines the meaning of economic sustainability in relation to the introduction of the plunge cattle dip initiative to control ticks and the associated tick-borne disease of East Coast Fever in the former Venda area of South Africa during 1910- 2013. The research focuses on the economic viability of the dips as they are explained in terms of market conditions, as expressed in costs and benefits, and also in terms of the non-tangible benefits that accommodate the creation of broad conditions for the realization of human potential. The economical sustainability investigative view is therefore on the economic practices, opportunities and customs that evolved as part of the practice of cattle dipping.

There has been a shift in the explanation of economic growth and efficiency since the publication of the Brundtland Commission Report (WCED, 1987), which identified long term environmental strategies for the environmental community. Instead of relating economic growth only to the maximization of output or monetary returns per unit cost of production, the focus has shifted towards the perspective of economic sustainability. From this viewpoint, economic efficiency is associated with objectives such as poverty reduction, enhancing equity and increasing the output of useful goods and services (Harvey, 1996; Hugo, 2004; Elliot, 2008, Pearce et al., 2013). Holling (2001), in his theory of panarchy, presents sustainable development as fostering adaptive capabilities of both physical and socio-economic systems, while simultaneously creating and maintaining social opportunities.

The view of creating opportunities is also espoused in the theory of new economics by Seers (1972) and Robertson (2005). This theory is based on an economic system promoting people and earth-centredness and reflects the growing global demand for new ways of economic life and thought that will conserve the earth and its resources, and empower people to meet their own needs and those of others. Lafferty, cited by Dryzek and Schlossberg (1998), describes sustainable economic development as a normative concept prescribing and evaluating changes in living conditions with which development programmes should identify.

The following aspects are considered in this chapter:

- Historical overview of plunge dipping economies.
- Present day economic efficiency of plunge dips.
- The economic benefits to farmers associated with dip tank operations.
- Cattle dipping and associated business enterprises.
- Livelihood value of cattle.

5.2 HISTORICAL OVERVIEW OF PLUNGE DIPPING ECONOMIES

The cost effectiveness of the introduction of cattle plunge dipping is best understood from the premise of the occurrence of the cattle diseases rinderpest in 1897 and East Coast Fever in 1901. The outbreak of the two diseases was of great economic concern to the South African cattle rearing industry. Besides their impact on the farming community *per se*, the loss of cattle was also felt by the transport industry of the time since cattle were used to pull the transportation wagons, while the mining sector also demanded large numbers of cattle as meat supply in the emerging mining settlements in Kimberley and the Witwatersrand.

Although data on cattle losses and on the costs of controlling the diseases are fragmentary, it is estimated that the two diseases virtually wiped out all the cattle in southern Africa (Cranefield, 1991). Rinderpest in particular killed over 4.5 million cattle in South Africa before a vaccine was produced to end the pandemic. The extent of the destruction of rinderpest, between 1896 and 1900, is illustrated in the report by the famous late 19th century hunter and cattle inspector, Frederick Courtney Selous (Farmers Weekly, 23 December 2003) where he is quoted as saying:

> "*One might as well have tried to stop the rising tide on the seashore, as prevent this dreadful disease from travelling down the main roads, leaving carcasses and ruined men behind it. Nothing stopped the spread of the rinderpest through the Transvaal. Over a million cattle and immense numbers of game died. Not an ox survived in the Zoutpansberg. In Waterberg, people starved or died of fever by the score.*
>
> *Khama's people lost everything and postponed death by eating caterpillars, bark, roots and long-decayed corpses. In colonial Bechuanaland the situation was soon equally as critical as in Mafeking and Vryburg, where 97% of the cattle herd died. Further south in Barkly West 26 000 cattle succumbed – 62% of the total.*

With regard to transport, the rinderpest brought havoc to the transport industry. In January 1896 the cost of ox-wagon transport for the 500 miles between Mafeking and Bulawayo was 14 shillings. By July the transport had risen from £6 to £60. Transvaal stock farmers and transport drivers were ruined, became "poor whites" and drifted into Johannesburg".

The outbreak of the rinderpest also dented the cultural life of black communities. This is because black communities used cattle for ploughing, for buying brides (payment of *lobola*), paying fines, offering sacrifices, and settling tribal disputes. The Berlin Missionary Society reports as presented by Giesekke (2004) indicated that the disease swept into the Transvaal like a whirl-wind in the last weeks of 1896, and reached the Venda area by the end of 1896. Phoofolo (1993) stated that while the rinderpest epidemic caused the cattle herds of both black and white farmers to be decimated, the predominant role played by cattle in the black communities (as economic and political assets) meant that the epidemic radically altered the social and political structures within the communities. Also, lack of information on the rinderpest, as well as the inability of the government authorities to control the disease then, led to the misconception among black communities that their cattle were being poisoned by the governments and the white people in their regions.

Control measures to prevent the spread of rinderpest included: stringent quarantine methods, fencing off of areas as well as the killing of healthy cattle belonging to blacks. Later on, a veterinary scientist by the name of Robert Koch produced a vaccine that eventually helped in controlling the plague. Since cattle stocks were virtually wiped out, the country embarked on a serious restocking campaign by importing cattle from India, Australia and Europe (Cranefield, 1991).

Whilst the country was still licking its wounds inflicted by rinderpest, East Coast Fever struck at around 1901. As stated in Chapter 2, the veterinary success by Arnold Theiler in discovering the protozoa responsible for the disease as well as the tick responsible for the disease transmission led to the government of the Union of South Africa to embark on a drastic campaign to get rid of the disease. The campaign was implemented under the legislative framework of Ordinance No 38 of 1904 and the Diseases of Stock Act of 1911 (Linington, 1949), as well as the Animal Disease and Parasite Act of 1956 – all of which were subsequently redrafted as the Animal Diseases Act of 1984.

Combined measures that were introduced to control and eradicate East Coast Fever included: fencing off of infected areas; curtailing of animal movement; impounding of stray and suspected animals; pasture spelling; quarantine procedures; slaughtering of infected animals; and regular dipping. Any cattle which were found infected with East Coast Fever or had been in contact with suspected infected cattle, or had been on any infected or suspected area had to be slaughtered and destroyed (Norval, 1983). Cattle from the suspected areas were not allowed to be taken to the market without authorization from the resident magistrates. No person could move any cattle except if he was in possession of a permit from the Commissioner of Lands, who would only grant permits for cattle from non-infected farms or herds. Before movement cattle had to be washed, dipped or sprayed with arsenical sheep dip, or with a solution made of one part paraffin oil, four parts water, and a little soap to remove ticks.

According to Ordinance No 38, farms had to be fenced to prevent the spread of the disease. The Commissioner of Lands could enforce that fences be erected along the boundaries of any farms within infected or suspected areas or any native locations or any town lands within the infected area (Linington, 1949). The cost of erecting fences along the boundaries of commercial farms was borne by the individual farmers and defrayed out of moneys voted by the Legislative Council (Cranefield, 1991). Individual farmers were, however, expected to repay the cost together with interest at the rate of 3 percent per annum by equal yearly instalments commencing two years after the fencing was completed. As early as 1907, for example, fencing material to the value of £40 000 was purchased in the Zoutpansberg area (Gray, 1908).

Whenever the Commissioner of Lands had incurred any cost in respect of the fencing of native locations, the occupiers of huts in such locations were liable to contribute *pro rata* to the cost as if such occupiers were owners of the farms, and the amounts were due by way of yearly instalments. This was payable under the provisions of the Native Tax Ordinance 1902 (Cranefield, 1991).

When plunge dipping was found to be the most effective method of controlling ticks, the earlier dip tanks, known as Conquest Cattle Tanks, could be erected for £95 sterling. The chemicals that were used were Arsenical Cooper's Dip, Methyl Arsenate of Soda, and Quibell's Powder Sheep Dip (National Archives of South Africa, TAD-A1813/06). Most of the chemicals were initially imported from Britain and it required an effort to obtain them. In the marketing of their product, William Cooper and Nephews, the first providers of commercial dip chemicals in South Africa, were once known for the slogan:

> "*We unhesitatingly state from our wide experience and observation, that, at the lowest figure, from one to three pounds sterling actual cash value will be put on to every head of cattle on the farm by dipping regularly, say once a fortnight. If therefore a farmer has over a hundred head of cattle and horses, the actual capital cost per head necessary to erect a tank cannot exceed £1, and may be only a few shillings if he has 200 head, while the actual cost of dipping once a fortnight will be at the maximum*".

Their common advertisement expression was: "ONE SHILLING AND THREE PENCE per annum; DOES DIPPING PAY?" (National Archives of South Africa, TAD-A1813/06).

Expenditure was incurred for the construction of dip tanks, buying of chemicals, and paying the dipping personnel. The personnel responsible for dipping comprised of European veterinarians, stock inspectors and assistant stock inspectors. These were assisted by cattle guards, Veld Cornets, Native Constables and dip assistants who were associated with and responsible for operations at individual dip tanks in the villages. It is recorded in the Tomlinson Commission Report (Tomlinson et al., 1955) that on the 31st of December 1953 there were 2 166 black (Bantu) dipping personnel in the Bantu Areas, of whom 2005 were in the service of the Department of Native Affairs. The report also showed that during the financial year 1952-1953, the expenditure on veterinary services in the Bantu Areas was about £430 000 sterling. During the 1951 census the Venda area (Sibasa District -210) had 52 dip tanks (National Archives of South Africa, NTS 10751- Native Affairs 1951).

While the commercial farmers bore the cost of dipping their cattle, the responsibility of providing dipping in the communal areas was a combined effort carried by the Department of Native Affairs, the Tribal Territorial Local Councils, Mission Stations, private mining companies and private commercial farmers (National Archives of South Africa, NTS 10751 - Native Affairs 1951). The Department of Native Affairs took on the task of building the tanks in some areas, and also of providing the chemicals, as well as supervising the whole dipping system. The other role players assisted in providing the physical infrastructure. An oral account by Fletcher (2008) asserts, for instance, that private farms rendered help with dipping to the villages in the far northern areas of Venda (Mutale region) because dip tanks were established there only later, as initially there were no cattle in that area as a result of stock losses from East Coast Fever. Cattle were introduced to the area by commercial farmers who constructed their own dips.

The government authorities used the provision of the tanks as an incentive to lure people to move to the villages, and cattle dipping tanks in the black rural areas became a symbol of a major governmental programme that impacted South African society.

Compulsory dipping in South Africa led to the complete eradication of East Coast Fever in 1954. The activity ceased to be compulsory among commercial farmers in 1960, but they were encouraged to continue with it because of the prevalence of other tick borne diseases (Coetzer et al., 1994). It, however, continued to be compulsory in the communal areas as the threat of stock diseases prevails in these areas since the grazing areas are not paddocked. Diseases could therefore be transmitted easily in such free rangelands, and in addition, cattle owners do not have their individual dip tanks in communal areas.

The task of building and maintaining dipping tanks in the communal/tribal areas was given to the then Native Affairs Department (NAD), and the technical service was handled by the Division of Veterinary Services of the Union of South Africa (Fletcher -oral account, 2004; Sefara, 2010). The Veterinary division liaised with the Native Affairs Commissioners, resident magistrates who were in charge of black areas (Native Affairs), and tribal chiefs. These were assisted by Territorial Councils in the respective districts (National Archives of South Africa, TAB A341/15a). Important role players regarding stock dipping in communal areas were: the Secretary of Agriculture, The Chief Native Commissioners, Native Commissioners, Government Veterinary Surgeons, Animal Health Inspectors and dipping assistants (National Archives of South Africa, TAB PS 73/13/07). Extension services came later after the introduction of the betterment system. Dip sites were initially located at central places that were accessible to cattle farmers from several chiefdoms. The numbers of dips increased when chiefs requested for more dipping sites in their respective areas. This became a common practice in all communal areas. The management of dipping service was transferred to the respective Departments of Agriculture in the black communal areas, both self-government and independent national states. The provision and implementation of dipping practise in the homelands continued to be governed by the earlier mentioned South African stock disease legislation.

In Venda cattle dipping was administered by the Veterinary Division of the Department of Agriculture which was located at Sibasa. The main office worked with the district offices of Dzanani, Mutale, Tshitale and Vuwani. The district offices were divided into wards, and each ward had its own health inspector as well as several dip tanks. When Venda became independent in 1979, approximately 127 dip tanks had already been established in the villages.

Cattle dipping was conducted as an extensive and systematic programme in Venda. The programme was run weekly during the summer season and fortnightly during winter (The Republic of Venda, 1979; Mafhara, 2004). Actual dipping was done in association with other supplementary measures, which mirrored the general practices in all the communal areas of South Africa. These measures included the official registration of cattle with the veterinary division, in order to monitor the number of cattle owned by each subsistence farmer; the impounding of stray animals in the official pounds; regulation and control of the transport of livestock based on their health, as well as restricting animal movement through the erection of fences in communal areas; and the compulsory reporting of cattle deaths to the Veterinary Research Institute at Onderstepoort (north of Pretoria) for disease monitoring.

While there is physical evidence of dipping in the Venda area, information of the actual cost of dipping could not be found during the research. The main reason for this was that information was lost after the withdrawal of the service in 1994. Nonetheless, information from key informants was found helpful. Their account is that throughout the dipping programme everything was provided for by the government, except that cattle owners were expected to pay a nominal dipping fee. The fee was calculated according to the number of cattle one possessed, and it was payable annually. It is suspected that the money that was contributed by farmers was used to help in the buying of dip chemicals. Assertions by Mukhuba (2010) and Nekhavhambe (2010) indicate that the fee started from 5 cents per animal in the 1920s and 1930s, and increased to R10.00 in the 1980s. This fund was locally known as “Springbok” (Thagisi, 2007; Sefara, 2010).

The actual financial returns in association with cattle dipping in Venda could also not be established because this activity was not run as a business with its associated financial records. However, the returns could be related the realization of the broader objective. That is, after the heavy investment by the government, East Coast Fever as the main causative factor was controlled and subsequently eradicated in 1954. In addition, the dip tanks were continuously used to handle other low scale tick bite related problems. Information about cattle dipping as presented by Talbot and Talbot (1960) can be used as evidence to show the broader objective of establishing dip tanks as a measure of controlling and eradicating East Coast Fever was eventually realized (Figure 5.1).

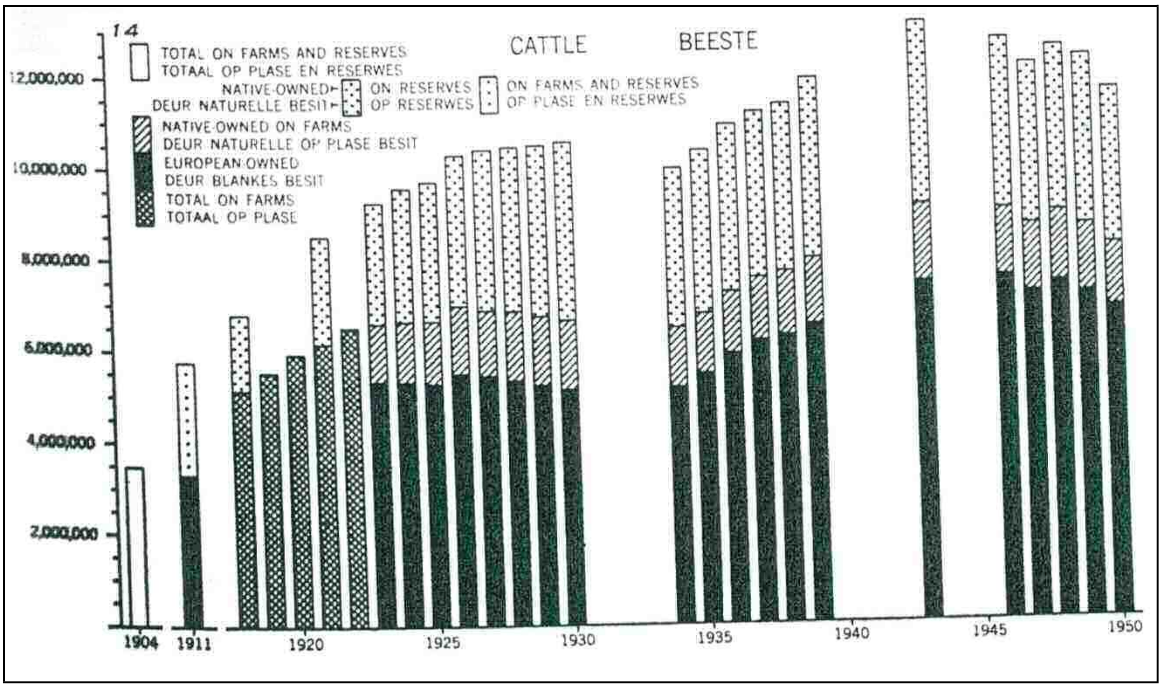


Figure 5.1 Composite graph showing the number of cattle in South Africa between 1904 and 1950 (source: Talbot and Talbot, 1960)

It can be read from the graph that in 1904, there were only approximately 4.7 million cattle in the whole country. As from the time of the introduction of dips, the number of cattle in commercial farms and communal areas/native reserves started to increase significantly. From 1911 to the 1950s cattle numbers in the country increased from 4.7 million to more than 12 million; the increase peaked between 1945 and 1950s.

5.3 RESEARCH FINDINGS AND DISCUSSION

5.3.1 The Economic Efficiency of Plunge Dips

The economies of scale model describes the association between the input costs and the production output in an economic system, where "economies of scale" refer to the cost advantages that a system or a business obtains as it produces and sells more product. The model considers a project efficient when it produces higher quantities of product at a minimum cost (Berry and Kim, 1993), from where it follows that increased production reduces unit cost.

The fixed input costs with regard to the operation of the cattle dipping programme are the actual costs of construction of the dip tanks, and the operational costs are those for dip chemicals, water, cleaning and labour. Oberem et al. (2006) estimated the 2006 building cost a plunge dip from between R30 000 and R150 000. The cost of chemicals and human resources constitutes perennial overhead costs. Dipping outputs, on the other hand, refer to the number of cattle that each dip tank handles over a given time period. For the dip tank to be regarded as economically efficient, it must be used to its maximum capacity, which Oberem et al. (2006) calculated for a 15 000 litre tank to be no more than 2 000 cattle per one dip session. Linked to the dip tank capacity is the cost of dipping per animal. Dip chemicals have to be replaced continuously during the dipping sessions, irrespective of the number of cattle that are dipped (Sefara, 2010), because the effectiveness of some chemicals is short; and because each animal carries out roughly 2,8 litres of dip wash after being dipped. The concept that is used is called Total Replacement (TR). If a tank is used for fewer cattle than its optimum capacity, dip chemical goes to waste since the mixture cannot be used for the next session, and its use is regarded as inefficient.

A plunge dip tank is therefore regarded as economically efficient if it handles a large herd of animals, for instance if a 15 000 litre tank is used for 2 000 cattle or more per dip session. The dip tanks in the study area were all found to have a capacity of 15 000 litres. The chemical compound that is currently administered in the tanks is Amitrax (Sefara, 2010), which has a relatively short life span, and as such should be added to the dip solution during every dip session. The dip concept that is used in this regard is Total Replacement (TR), meaning that the chemical has to be applied in full before the cattle are dipped. For the standard 15 000 litre volume of dip tanks found in Venda, 1.5 kg of Amitrax is required for a single dip mixture which costs R376.20 at current subsidized prices.

For the dip tanks in the communal areas, there are on average 40 dipping sessions per year. Considering the replenishment of dip chemical for each dip session, an amount of approximately R15 000 per dip facility per annum is spent (R15 048-00 p.a., to be exact) for buying chemicals every year. More dips in an area therefore require more funds for buying chemicals.

The data that were used to examine the economic efficiency of the dip tanks in this study was obtained from Mutale (Figure 5.2) and Malamulele regions (Figure 5.6), which are the current dipping administrative regions of Vhembe District Municipality. These two areas fell under Sibasa district before the new 1994 South African political dispensation and were purposively selected mainly because they fall under the red line zone of Animal Disease Management in the district.

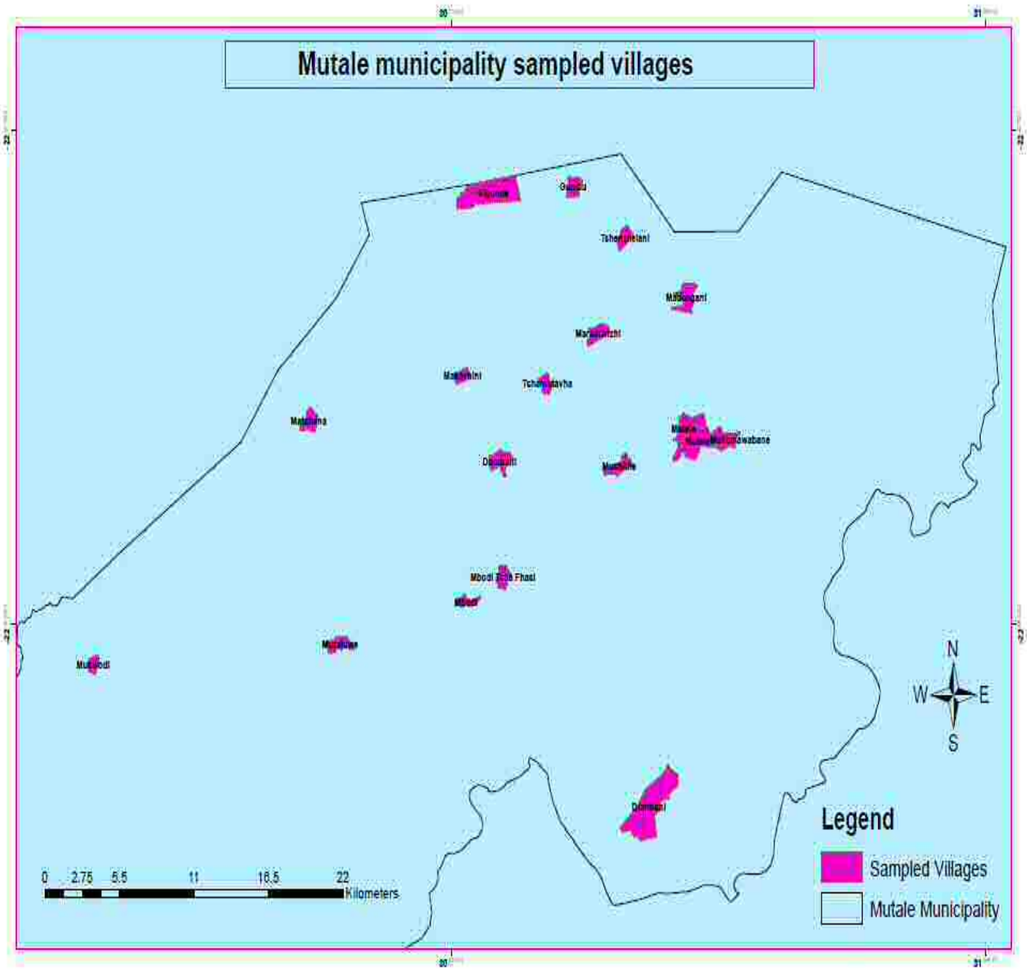


Figure 5.2 Mutale villages (ESRI, 2012)

This zone is an area prone to the outbreak of Foot and Mouth Disease (FMD) and where the government started to reintroduce cattle dipping in 2003after a new outbreak of the disease (Fletcher, 2008). This recent transmission of FMD was linked to wild animals from the neighbouring Kruger National Park and the north-eastern neighbouring countries of Zimbabwe and Mozambique. Even though the disease is under control at the time of writing, it always poses a major threat to the cattle industry in the area as sporadic outbreaks can occur.

Data from Mutale has been divided into two categories i.e., from the whole region between 2003 and 2008, and current data from 1/3 dip administrative ward (Tshamutumbu area) in the region, while data from Malamulele area covers the period from 1987 to 2008 (Malamulele Veterinary Division, 2008).

5.3.1.1 Mutale district data

Mutale district has thirty four plunge dips. The area is divided into five administrative wards which are numbered from 1/1 to 1/5. The dip tanks are located in almost all the villages. All the plunge dip tanks have a capacity of 15 000 litres. The number of cattle in the district hovered around 29 000 and 35 388 between 2003 and 2008. There was a small increase in the number of cattle between 2003 and 2008. The only exception occurred in 2005 and 2006 respectively. Instead of maintaining a slight yearly increase in the number of cattle, the number of cattle in 2006 was lower than in 2005. The total number dropped from 32 989 in 2005 to 31 681 in 2006, respectively (Table 5.1 and Figure 5.3).

Table 5.1 Number of cattle in Mutale area: 2003-2008 (source: Mutale Veterinary Section, 2008)

YEAR	Number of cattle	Number of dips	Number of cattle per dip	Number of cattle owners	Per capita ownership	Required number of dips
2003	29 000	34	853	2 640	11	15
2004	30 511	34	897	2 643	12	15
2005	32 989	34	970	2 752	12	16
2006	31 681	34	932	2 582	12	16
2007	33 850	34	996	2 488	14	17
2008	35 388	34	1 040	2 715	13	18
			Av: 948	Av: 2 637	Av: 12	16

Reasons for the decrease could not be determined during the research.

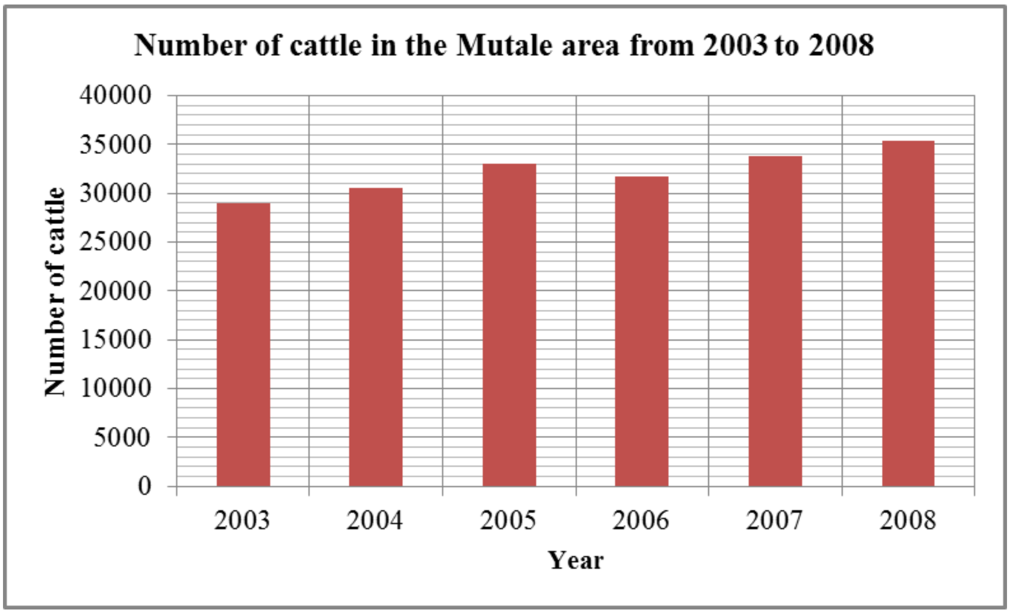


Figure 5.3 Number of cattle in Mutale area: 2003-2008 (source: Mutale Veterinary Section, 2008)

The general picture of cattle ownership in Mutale shows very small herds per kraal. The number of animals per kraal ranges from eleven to fourteen, with the average per capita cattle ownership of twelve animals. This situation of small herds echoes the findings by Tomlinson Tomlinson et al. (1955), where it was reported that small cattle kraals in the communal areas was common.

The number of cattle that one dip tank served at Mutale varied from 853 to 1 040. When this is related to the maximum carrying capacity of 2 000 animals which each tank is expected to handle, the findings indicate that the number of cattle each dip tank used in the area was lower than the maximum number that should be served. The utilization of the tanks between 2003 to 2007 was at 50 percent capacity. It was only in 2008 that the utilization capacity of Mutale dips increased to slightly above 50%. The figures suggest that the dip tanks in Mutale area operated at low capacity. From the basic economic perspective therefore, the cattle dipping situation in Mutale suggests a diseconomy of scale. This appears so because: 1) Each dip tank handles fewer cattle than the maximum number it is supposed handle and; 2) Even though there are few cattle per tank, the dipping overheads like the provision of chemicals, maintenance of infrastructure, and the payment of officials should always be accommodated. In the case of chemicals for example, their administration and application should always be in accordance with the correct specification of total replacement during every dip session. Because fewer cattle are dipped, the chemical that is supposed to be used is instead being wasted.

If the economic effectiveness of dip tanks were to be examined by only considering the relationship between inputs and outputs, it could be suggested that the appropriate number of tanks in Mutale area should be 17 instead of 34. This, however, cannot be the case since there are other underlying factors that might have contributed to the situation.

5.3.1.2 Findings from Ward 1/3

This is a health inspection ward that lies on the far north-eastern plains of Mutale in the former Venda area. It falls between the Limpopo River in the north and the veterinary red line of Foot and Mouth Disease control in the south. The area is ideal for cattle ranching and it is traditionally known as Madangani, (perceptual Venda name for kraals which refers to the place of cattle rearing). The ward has 10 dip tanks that are located in the respective villages. The dip tanks in the ward were established between 1948 and 1975, with Malongana dip tank being the oldest (Table 5.2). Similar to the whole Mutale region, all the plunge dip tanks in ward 1/3 have a capacity of 15 000 litres.

Table 5.2 Number of cattle in Mutale Ward 1/3 (source: Mutale Veterinary Section, 2008)

Dip Tank	Village	Year of establishment	Total number of cattle	Number of cattle owners per tank	Average individual kraal sizes
Mutele A	Mutele	1975	268	26	10
Maramanzhi	Maramanzhi	1971	550	60	20
Matatani I	Mbodi 1	1953	424	28	15
Matatani II	Mbodi	1953	1 323	82	16
Malongana	Mukununde	1948	1 013	53	19
Mushithe	Mushithe	1954	541	56	10
Bale	Bale	1956	688	62	11
Matshena	Matshena	1949	1 838	101	18
Makavhini	Makavhini	1973	1 479	90	16
Tshamutavha	Tshamutavha	1969	509	30	19

Data in Table 5.2 show a variation in the number of farmers who use the respective dip tanks and the number of cattle per dip tank respectively. The total number of cattle per dip tank ranges from 268 to 1 838; with the lowest number at Mutele A (268) and the highest number at Matshena (1 838). Also, Mutele A is used by few farmers (26) and Matshena by more farmers (101). With regard to the number of cattle per farmer there is a pattern of small kraals sizes in the ward, with cattle ownership per capita (kraal size) ranging between 10 and 19.

With regard to the percentage of dip capacity used, data from ward 1/3 shows that only four dip tanks in the ward are utilized at 50 percent and above (see shaded entries in Table 5.3). The tanks are Matatani II (66,15 percent), Malongana (50,65 percent), Matshena (91.90 percent), and Makavhini (73,95 percent). The other tanks, namely Mutele A, Maramanzhi, Matatani I, Mushithe, and Bale are utilized at very low capacities (Table 5.3 and Figure 5.4).

As is with the whole Mutale region, this situation is explained by the small herds that are kept by farmers.

Table 5.3 Dip tank capacity utilization in Ward 1/3 (source: Mutale Veterinary Section, 2008)

DIP TANK	VILLAGE	Dip Capacity in litres	Maximum number of cattle	No of cattle / dip	% dip capacity used
Mutele A Crush	Mutele A	15 000	2 000	268	13.40
Maramanzhi Crush	Maramanzhi	15 000	2 000	550	27.50
Matatani I	Mbodi	15 000	2 000	424	21.20
Matatani II	Mbodi	15 000	2 000	1 323	66.15
Malongana	Mukununde	15 000	2 000	1 013	50.65
Mushithe	Mushithe	15 000	2 000	541	27.05
Bale	Bale	15 000	2 000	688	34.40
Matshena	Matshena	15 000	2 000	1 838	91.90
Makavhini	Makavhini	15 000	2 000	1 479	73.95
Tshamutavha	Tshamutavha	15 000	2 000	509	25.45

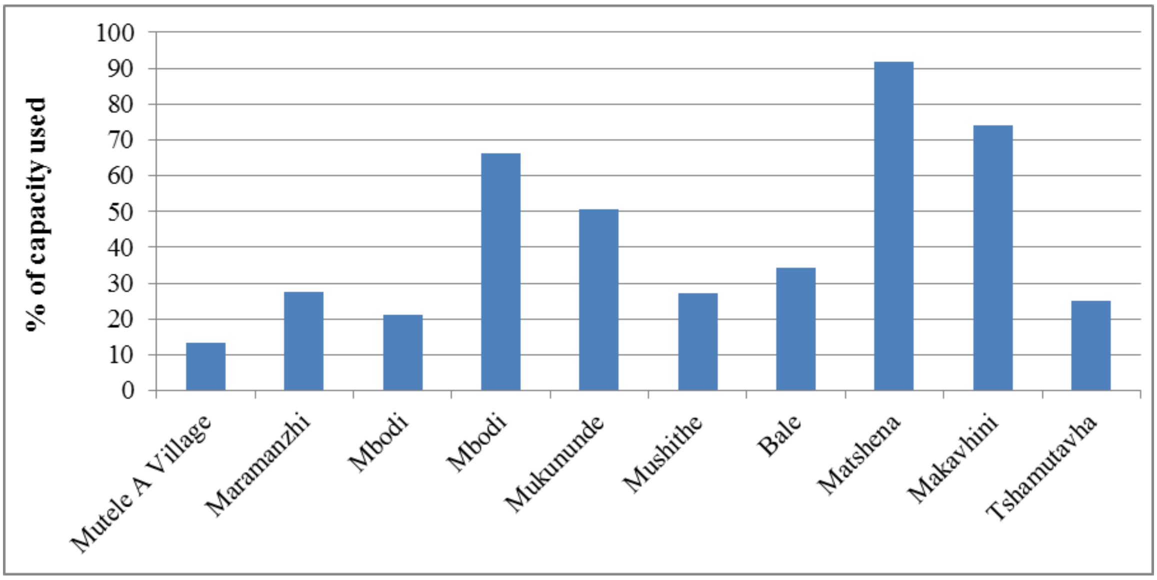


Figure 5.4 Percentage of dip tank capacity used: Ward 1/3 (source: Mutale Veterinary Section, 2008)

The calculated cost per unit of livestock (head of cattle) in the ward, which is determined by dividing the cost of chemicals spent in each dip tank per year by the total number of cattle dipped at that dip tank, shows that the unit cost is high for low numbers of cattle treated and decreases with increasing numbers of animals treated (Table 5.4 and Figure 5.5). Table 5.4 reflects that it costs R55.97 to dip one animal at Mutele A tank, compared to R8.16 at Matshena tank. Therefore there is a greater capacity of dip use where there are more cattle, and less capacity where there are fewer cattle. A situation where more funding is used on fewer cattle is uneconomical.

Table 5.4 Dipping cost per unit of cattle: Ward 1/3 (source: Mutele Veterinary Section, 2008)

Dip tank	Village	No. of cattle owners	Total No. of cattle	Dipping cost per unit (R)
Mutele A Crush	Mutele A Village	26	268	55.97
Maramanzhi Crush	Maramanzhi	68	550	27.27
Matatani I	Mbodi	28	424	35.38
Matatani II	Mbodi	82	1 323	11.34
Malongana	Mukununde	53	1 013	14.81
Mushithe	Mushithe	56	541	27.73
Bale	Bale	62	688	21.80
Matshena	Matshena	101	1 838	8.16
Makavhini	Makavhini	90	1 479	10.14
Tshamutavha	Tshamutavha	30	509	29.47

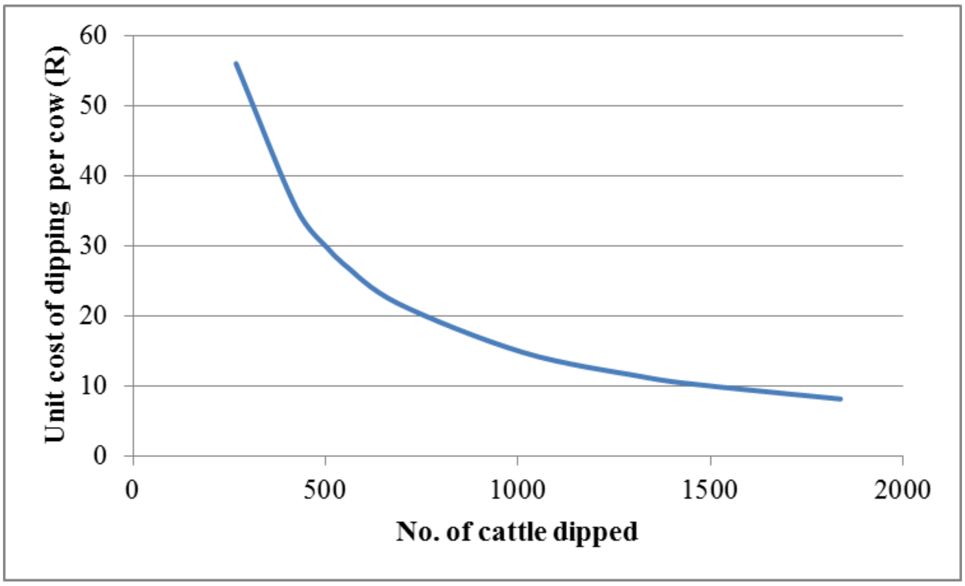


Figure 5.5 The cost of dipping one livestock unit as a function of total number of cattle dipped

An observed pattern from ward 1/3 shows a situation that resembles the general pattern in the whole Mutale district. There are dip tanks that are supposed to cater for large numbers of cattle. However, farmers in the area keep small herds. Owing to the fact that there are fixed costs associated with the running of dipping irrespective of the lower number of cattle, cattle dipping in the area is a costly exercise.

According to Mugwedi (oral evidence, 2012), the Animal Health Inspector of Ward 1/3, low cattle numbers are attributed to the devastating droughts that struck the area in 1991 and 2002, respectively. As a result of great losses, many people lost interest in animal husbandry and those who keep cattle now prefer to keep smaller herds. The present herd sizes represent the limit of cattle which farmers can afford to raise and keep (Mugwedi, 2012). In addition, Nempumbuluni (oral evidence, 2008) noted that the interest of rearing cattle is also dwindling in the area as a result of stock theft, which is compounded by the porous northern border with Zimbabwe. He pointed out that that there is a likelihood for one to lose a whole kraal or herd in one cattle raiding strike.

5.3.1.3 Findings from Malamulele

As stated earlier, Malamulele is part of Vhembe District that previously fell under the former Venda area. It also falls within the red line area of stock diseases control.

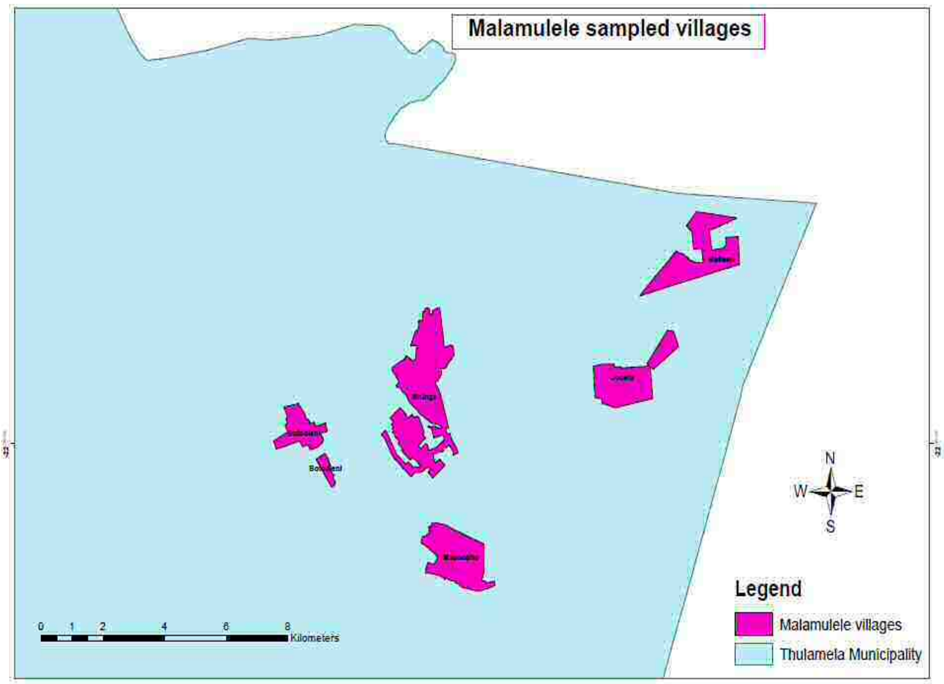


Figure 5.6 Malamulele villages (ESRI, 2012)

The cattle records situation in Malamulele is based on cattle records from five dip tanks, namely, Botsoleni, Josefa, Maphophe, Matiyani, and Mhinga (Table 5.5), displaying data that were collected from 1987 to 2008, a period of 22 years.

Table 5.5 Number of cattle at five Malamulele dip tanks from 1987 to 2008 (source: Malamulele Veterinary Section, 2008)

Year	No of cattle	Number of dip tanks	Average No of cattle / dip tank	% dip capacity used
1987	1 520	5	304	15
1988	1 961	5	392	20
1989	1 961	5	392	20
1990	2 500	5	500	25
1991	2 929	5	585	29
1992	2 189	5	438	22
1993	1 500	5	300	15
1994	1 885	5	377	19
1995	2 109	5	422	21
1996	2 618	5	524	26
1997	3 119	5	624	31
1998	3 119	5	624	31
1999	4 108	5	821	41
2000	4 314	5	863	43
2001	4 458	5	892	45
2002	4 315	5	863	43
2003	4 285	5	857	43
2004	4 474	5	895	45
2005	4 786	5	957	48
2006	4 240	5	848	42
2007	3 369	5	674	34
2008	4 051	5	810	41
Average:			**635**	**28%**

The average number of cattle that were dipped in each of the respective five dip tanks had never been above 1 000 for any of the years recorded, as shown in the fourth column of Table 5.5. The average number of cattle handled per dip tank for the year are far below the maximum number a dip tank can potentially handle, ranging from a minimum of 304 cattle in 1993 to a maximum of 957 recorded in 2005, for the period 1987 to 2008. Because of low cattle numbers, the percentage of dip capacity utilization is also low, being between 15% and 41% for all of the tanks. These results indicate the general uneconomic utilization of dip tanks in the Malamulele area.

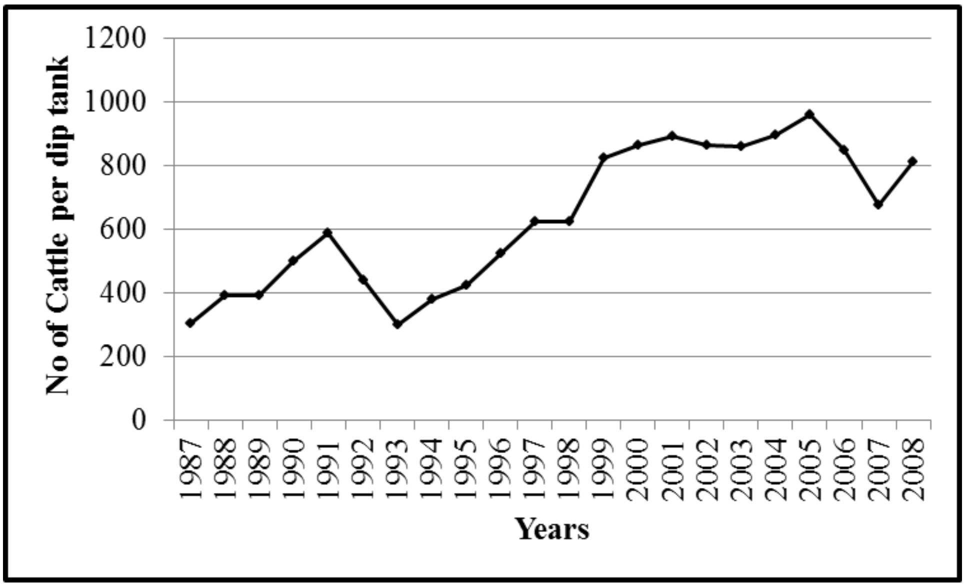


Figure 5.7 Number of cattle dipped in Malamulele area: 1987-2008 (source: Malamulele Veterinary Section, 2008)

A conclusion that can be made from the data of the two areas is that although the plunge dips are the most cost effective method of controlling ticks in the communal areas as asserted by (Oberem et al., 2008), without knowing the past information of cattle numbers when the dip tanks were established, the current use of dips in the three areas is not economically efficient.

As stated earlier the reason that informs the continuation of dipping in the area is the bigger picture of controlling Foot and Mouth Disease.

5.3.2 Livelihood Roles of Cattle

Information about the livelihood roles of cattle was obtained from scheduled interviews with the representatives of Cattle Owners Associations. Cattle Owners Associations are organizations that were established by communal farmers of different dip tanks in the area. Fletcher's (2008) oral account stated that the associations started after the government withdrew the provision of free dipping in the communal areas. Farmers organised themselves for the purpose of pooling financial resources in order to buy dip chemicals. The respondents for the interviews were from Mutavhanani/Rambuda Association Mutale with 36 members; Mbahe-Tshamutilikwa Association in Thulamela with 30 members; Valdezia Association in Greater Hlanganani with 51 members; and Tswera Association in Thulamela, respectively.

Figure 5.8 shows the members of Mbahe-Tshamultikwa Cattle Owners Association. The respondents from all the association were not prepared to provide the number of cattle each owner possessed.

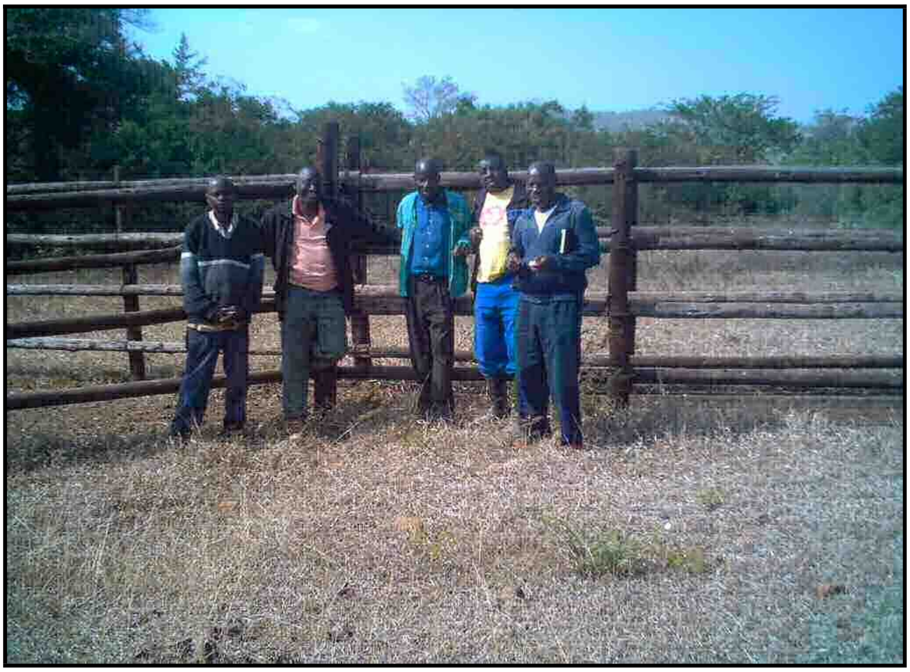


Figure 5.8 Committee members of Mbahe-Tshamutilikwa Cattle Owners Association. The gentleman second from the right is the headman of the village

The findings concerning the livelihood roles of cattle indicate that livestock ownership have profound importance as cattle are used for many purposes, and are considered an important part of day to day lives of people and their culture. When asked to provide the reasons for owning cattle, the farmers raised the reasons that were observed by Dovie et al. (2006) and Randela (2003). These reasons included: 1) selling of cattle to the local communities during the performance of social functions such as ritual and wedding ceremonies; 2) selling of cattle to the local butchers; 3) slaughtering cattle for selling meat to the locals; 4) selling of cattle by-products such as milk and green manure, and 4) use of cattle as a source of draught power for village agriculture and transport.

Although cattle sales from which the conventional economic value can be derived was found to be irregular and limited, all the interviewed cattle owners indicated that they sometimes sell their cattle. The number of animals sold depends on the needs of individual cattle owners. The selling of cattle augments the flow of cash during the time of need. A farmer could sell cattle when he or she needs money for buying household utensils, or paying children's school fees. The proceeds that farmers get from selling cattle vary per household. This is because of the fact that the selling of cattle by individual farmers is irregular. In this regard, Mr Thagisi (2008) from Mutavhanani Cattle Owners Association, for example, indicated that he had sold three animals in 2007 at R4 000 per animal, for which he received R12 000. He indicated that he used the money to supplement the household requirements such as ploughing implements and paying school fees.

In supporting the point that cattle sales enable communal farmers to invest in the education of their children, Mr Nekhavhambe (2012) of Tswera Cattle Owners Association indicated that he used to keep a herd of an average of 40 cattle. He would sell one or two animals early in the year when he needed money for school fees and is the proud father of five children who all went beyond the first academic degree. He attributes this to the selling of his cattle, and he now still retains a small herd which he keeps out of personal affection (Figure 5.9).

Concerning the use of cattle as a source of draught power the respondents indicated that they use cattle in ploughing and drawing scotch cars and sledges. A ploughing service is also extended to the locals who do not own cattle. Community members are charged when they hire cattle owners to plough their fields and transport their goods.

Figure 5.9 Mr Nekavhambe's cattle kraal – Tswera, 2012

The ploughing service is more lucrative in summer when there is a high demand of ploughing resources. Each cattle owner generally has at least one span for ploughing purposes. This has been identified amongst the members of Mbahe-Tshamutilikwa Association. When prompted to quantify the monetary value that they derive from ploughing, it was found during the interview that farmers charged an amount of R170 per acre (1 acre = approximately 4047 m^2). When relating this figure to the findings by Lubbe, cited in Randela (2003), that the average number of days Venda cattle owners spend ploughing during the ploughing season is 50, one can deduce that if a person has one ox and ploughs only one acre per day, such a person may make an income of R8 500 (R170 x 50) in a season. The amount is valuable since it supplements the owner's income. Therefore, the more cattle spans one has, the more money one gets during the ploughing season. The farmers could, however, not recall the number of acres they plough during the ploughing season.

In addition to cattle sales and their use for draught power, it was found that cattle ownership also generate social capital. This occurs through cultural values that are bestowed on cattle. The most common values that the farmers pointed out are social standing that is expressed in the number of cattle one has; the slaughtering cattle during the performance of social functions such as ritual, burial and wedding ceremonies; and also the use of cattle as a means of bride price – the payment of bride price is called (*u mala*) in Tshivenda. The standard practise about the payment of the bride price is that one should pay a minimum of eight (*malo*) cattle for the bride. In this regard, Mukhuba (2012) pointed out that all mature men strived to raise this number when they were about to get married.

5.3.3 The Economic Benefits that Farmers Associate with Dip Tanks

In a beef production enterprise, the condition of animals is a decisive factor in determining income. By improving the condition of animals, the farmer can create a buffer against low profitability. The farmers in this regard indicted that the issue of cattle health has been the main aspect why the farmers take their cattle for dipping. In their view dipping helps in keeping the cattle in good condition because the ticks could not damage the hides and sensitive organs such as ears, adders and scrotum. Females with undamaged udders are able to suckle their calves for a long time before they are weaned; this reduces calf mortality. There is also a perception that as cattle swim through the dip trough, they sip little dip. The solution is perceived as a remedy for cattle rumen infection (Mukhuba, 2012). Rumen infection causes the bloating of the rumen, which reduces the appetite of cattle which may subsequently lead to death. The explanation about the infection is that it mainly occurs when cattle feed on maize and legumes.

When farmers were asked to explain what healthy cattle translates to, they indicated that it translates to good prices when the owners intend selling cattle. Reflecting on the issue of cattle health and quality, Mr Masithi (2008) of the Mbahe-Tshamutilikwa Cattle Owners Association commented:

> *"Cattle dipping used to help in producing healthy strong bulls that were jewels of the eyes of the owners. When they bellowed as different kraals (heads of cattle) gathered in the plains, one could feel that the animal was healthy".*

Linked to the issue of cattle health was the aspect of respect that cattle owners who owned strong bulls commanded within the community. According to the respondents, farmers who had strong breeds were given the accolades of being experts in cattle breeding.

Veterinary officials also emphasised the issue of cattle health of cattle was also by. The respondents in this regard included a Senior Manager, a Manager for Animal Health, and two Animal Health Controllers, being the Veterinary Division officials of Vhembe District. Additional information was obtained from the veterinary chemical sales representatives of Afrivet Company.

Veterinary officials indicated that the worth of cattle dipping should not be viewed directly from the actual monetary perspective alone, but that communal dipping be regarded as a community or social service that was, and is, extended to cattle owners. This is because the majority of communal farmers cannot afford to generate income that can financially sustain dipping. It was pointed out that the bigger picture of cattle dipping in the communal areas is about the control of animal diseases; the diseases are viewed as having the potential of negatively affecting cattle productivity for both local consumption and exports. Local officials report that cattle diseases spread easily in communal areas owing to uncontrolled grazing, unlike the case for commercial farms. Because the export of cattle and their products need to meet certain local and international standards, the outbreak of diseases can tarnish the image of the country's cattle producing industry. Consequently this impacts negatively on issues such as pricing and employment (Mahafha, 2008).

Although the service is an expensive exercise, plunge dip tanks are considered to be the most cost effective method of controlling ticks in the communal areas. Veterinary officials regard dip tanks as suitable central areas where they are able to extend and provide veterinary knowledge and services to the communal farmers. It is at the dip sites where veterinary officials are able to monitor the health of animals and the outbreak of stock diseases such as FMD; to vaccinate animals; to disseminate veterinary knowledge; and monitoring the cattle herd sizes. The explanation about this is that due to the fact that grazing in communal areas is not confined to individual farms, it can be a difficult task to reach the farmers all over the villages. It is at the dip sites where cattle from different kraals can assemble at one point in time for veterinary services. The accrued benefits that are derived from such agglomeration are in terms of time, labour, and cost convenience (Mahafha, 2008).

5.3.4 Cattle Dipping and Business Enterprises

Apart from the benefits that relate to the health and quality of cattle, dipping sites as central points offered some opportunities in a form of informal economic spin-offs. Cattle dipping was perceived to be an important activity that facilitated the development of small scale and informal business enterprises. Dip sites became market areas for local craftsmen and vendors. Wares that were sold during dipping days included whips, yokes, straps, skeis, ploughs, and identity bells. The castration and dehorning of bulls were also done at the dip sites. People with the castrating tools and dehorning tools used to come to the dip sites to offer the services to the farmers. Mr Nempumbuluni (2010) indicated that cattle owners were charged 50 cents in the 1970s for the use of a *Burdizzo* castrating instrument (Nepumbuluni, 2010).

Dip sites were also suitable places for advertising and marketing when farmers intended to sell live animals or to slaughter animals for selling meat in the village. Potential buyers mainly came to the dip sites to negotiate the prices with the individual farmers. With regard to slaughtering, the message was easily spread to the surrounding communities by farmers who brought their cattle for dipping.

5.4 CONCLUSION

I have demonstrated in this chapter that the past cattle dipping practice in the former Venda area was economically sustainable. The evaluation focused on the economic efficiency of the tanks in terms of the conventional model of inputs and profit, and also addressed the intangible economic benefits derived from dipping, including the business enterprises that have been created, and those which have benefited in response to the dipping practice. Information for this research was obtained from historical records through archival search, as well as interviews with veterinary officials, cattle owners associations, and representatives from sellers of veterinary chemicals.

Several conclusions can be drawn from the findings of this research on the economic significance of the establishment of cattle dipping and its future economic sustainability:

Firstly, before the introduction of cattle dipping in the early 20th Century, the economies of Southern Africa, including Venda, were severely handicapped by the outbreak of FMD and ECF, as they were based heavily on cattle husbandry. The introduction of dipping convincingly saved the cattle industry of South Africa, and Venda in particular. From Holling's (2001) panarchy perspective, the dipping initiative can be viewed as an important cushion that protected the collapse of the cattle industry. As dipping contributed to the eventual eradication of the disease by 1954, I contend that the service was economically effective and therefore contributed to economic sustainability. The continued provision of dipping for another four decades up to 1994, when the new democratic government abandoned this practice, provided a public service of curbing and controlling animal disease outbreaks in a region prone to such epidemics, a prophylactic approach with immeasurable economic benefits. On the negative side, however, the provision of dipping in the villages became uneconomic sometime after the 1954 eradication of ECF, as the number of cattle in the villages dropped, which resulted in the dip tanks being underutilised – i.e. not being used to their optimum capacity.

Secondly, the responses by cattle owners from the different associations indicate a positive correlation between dipping and the sustaining of their informal rural economies. Cattle rearing has been perceived as an important activity which facilitated the development of rural livelihoods. This includes the use of cattle as a source of draught power, their use as a source of income as beasts of burden; also the sustenance of the Vhavenda community's social systems in their being used as 'lobola' – the traditional payment for a bride by the groom to his father-in-law; and for the generation of social capital; and the promotion and development of informal rural enterprises, especially those directly associated with dipping days: informal butchery and meat selling, and the vending of vegetables and other goods during dip days. The above attributes are all linked to cattle health that is viewed to be sustained by dipping.

Thirdly, even though there was a time when the veterinary division withdrew the provision of dipping because it was viewed as costly and uneconomic, the recent (21^{st} Century) threat of the outbreak and spread of diseases such as Foot and Mouth Disease from the Kruger National Park and neighbouring countries like Zimbabwe and Mozambique into cattle disease prone areas (such as the Vhembe district), has forced the government to reintroduce the provision of cattle dipping. Apart from the economic benefit of the actual dipping activity with its direct preventive health benefits, the operations during dip days at dip sites make them suitable places where veterinary officials are able to monitor the health of animals, to vaccinate animals, and also to collect and keep animal census records. The early identification of cattle illnesses furthermore enables them to speedily implement the necessary intervention measures, which is an important insurance mechanism for sustaining the region's stock herds and protecting the cattle industry from potential panarchical shocks. Furthermore, the management of cattle data which occurs at the dip sites helps in deterring stock theft.

Finally, a direct cost/benefit analysis of the current status of dipping practice in Venda indicates diseconomies of scale, as the available high volume dip tanks are currently extending services to only small numbers of cattle and are not optimally utilised. The lower rate of cattle ownership in the communal areas compared to prior decades could also be a result of the period of approximately 20 years that the dipping service was discontinued. It could therefore be argued that a more focused dipping service, along with improved facilities, cooperation between government agencies and owners, and targeted marketing should stimulate new interest in the benefits of cattle ownership, and hence improve the economic benefits to the local population, as well as improve the economic efficiency of dipping practice. The means to arrive at a more focused dipping service are addressed in Chapter 7 of this thesis.

The net economic benefit, however, far overshadows current low efficiency of use of dipping facilities. The state of dipping facilities also needs to be maintained and managed, an issue which is also addressed in Chapter 7 of this thesis. Improved quality of facilities would enable better roll-out and efficiency of the dipping service, which should have a positive effect on cattle ownership, as well as other multiplier effects in the local economy of Venda. In this chapter I have therefore shown that the practice of cattle dipping in the former Venda region of South Africa is indeed economically sustainable, but that a few adjustments need to be made in order to improve the efficiency of the service. This relates to the state of the infrastructure, but also to budgeting and promoting the service, which should increase the economic efficiency of the service being rendered by curbing waste of chemicals and the current low levels of utilisation of the service. It was pointed out in this research that the more cattle that utilise the dipping service, the more economically effective the service would be. As a public service for preventing disease, it can be categorically stated that the practice of cattle dipping adds to economic sustainability.

In Chapter 7 a *Sustainable Community Cattle Dipping Model* is developed which addresses the issues of policy, management and implementation of dipping, including the provision of improved dipping facilities, which could render the practice more economically sustainable than its current status. The model also integrates ecological sustainability (as discussed in Chapter 4) and social sustainability requirements.

The next chapter (Chapter 6) investigates the social sustainability of dipping practice.

CHAPTER 6

THE SOCIAL SUSTAINABILITY OF CATTLE DIPPING

6.1 INTRODUCTION

While the two preceding chapters investigated ecological sustainability (found wanting) and economic sustainability (found compliant), the focus of this chapter is on the social sustainability aspect of the establishment of cattle dip tanks and the practice of cattle dipping in the communal areas of the former Venda territory of the Limpopo Province. The social sustainability view stems from the perspective of the Brundtland Commission (WCED, 1987) that instead of only looking at the viability of activities or developments from a profit maximization perspective, they should also not cause environmental harm, and should also consider or incorporate human welfare. Put differently, this means that they must be environmentally (or ecologically) sustainable, as well as socially sustainable – not harming human wellbeing. Variables that are considered in assessing social sustainability include social justice, inclusion or participation in decision-making, sustainable institutions and administration, and cultural diversity (Elliot, 2008).

The viewpoint of social sustainability relates well to the issue of environmental justice. Environmental justice is spelt out as the pursuit of equal justice and equal protection under the law for all environmental regulations without discrimination based on race, ethnicity and socioeconomic status (McDonald, 2002). It also mandates the right to ethical, balanced and responsible uses of land and renewable resources in the interest of a sustainable planet for humans and other living beings. In addition, any form of development should be driven by the spirit of fair treatment and meaningful involvement of all people regardless of race, colour, national origin or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (USEPA, 2004). Fair treatment means that no group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations. Meaningful involvement means that potential affected community residents have an appropriate opportunity to participate in decisions about a proposed activity that will affect their environment or health. Environmental justice is the goal to be achieved when everyone enjoys the same degree of protection from environmental and health hazards and equal access to the decision making process to have a healthy environment in which we live, learn and work (McDonald, 2002; USEPA, 2004).

The social interpretation of sustainability focuses on the reduction of poverty and the maintenance of the health of social and cultural systems. Becker et al. (1999) indicated that social sustainability refers to the viability of socially shaped relationships between society and nature over longer periods of time. The enhancement of the viability of socially shaped relationships refers to the improvements in both individual wellbeing and the overall social welfare. A socially sustainable form of development is therefore one that is just, equitable and provides a decent quality of life for current and future generations.

The notion of social sustainability has as its basis the theory of social capital. Social capital is viewed as the resource which people draw upon in pursuit of their aspirations, and is developed through networks and connectedness, membership of more formalized groups and relationships of trust, reciprocity, and societal exchanges. The term was coined to describe the substances that count for most in the daily lives of people. Such substances are those that cultivate goodwill, fellowship, sympathy, and social intercourse; and they collectively make up a social unit. The theory was introduced into academic and research debates by scholars such as Bourdieau (1983), Coleman (1994) and Putman (2000).

Putman (2000) contends that social capital refers to connections among individuals, i.e. social networks and the norms of reciprocity and trustworthiness that arise from them. It is thus closely related to civic virtue. He further asserts that social capital promotes greater coherence of action due to shared understanding, and also allows communities to resolve collective problems more easily. Not only does its existence promote cohesion, it also greases the wheels that allow communities to advance smoothly. Where people are trusting and trustworthy, and where they are subject to repeated interactions with fellow citizens, everyday business and social transactions are less costly. Trust always parallels security, and levels of trust in individuals or groups provide an indication of the extent of cooperation. Better knowledge sharing is based on trust, a common frame of reference, and shared goals. Where networks are weak, people generally have lower levels of trust (www.eoearth.org). Social capital improves our lot by widening our awareness of the many ways in which our fates are linked. When people lack connections to others, they are unable to test credibility of their own views. Networks that constitute social capital also serve as conduits for the flow of helpful information that facilitates the achievement of set goals. It is suggested that where trust and social networks flourish, individuals and communities prosper economically.

From the World Bank's perspective, social capital refers to the institutions, relationships, and norms that shape the quality and quantity of a society's social interactions (Robertson, 2005). The core idea of social capital is social cohesion, and this is critical for societies to prosper economically and for sustainable development. In addition, social capital should be viewed as a glue that holds societal institutions together. Not only does it act as a glue, it also helps to mitigate the insidious effects of socioeconomic disadvantage, namely unemployment, poverty, lack of knowledge, and social injustice.

The central thesis of social capital theory is that relationships matter; social networks are a valuable asset; interaction enables people to build communities, to commit themselves to one another, and to knit the social fabric. A sense of belonging and concrete experience of social networks brings great benefits to people in their contexts (Field, 2003). Bourdieau (1983) defines social capital as the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationship of mutual acquaintance and recognition. Coleman (1994) describes it as a variety of entities that is characterized by some aspect of social structure which facilitate certain actions of individuals who are within a structure.

6.2 FINDINGS AND DISCUSSION

The social sustainability with regard to cattle dip tanks was examined in terms of the following:

1. their location in relation to water courses and surrounding settlements.
2. the physical state of dip tanks, including safety measures around the tanks.
3. social justice of dipping, including the safety of dip operators; and
4. the existence of the elements of social capital and social cohesion.

These aspects are each discussed and analysed in the sections following.

6.2.1 Safe Location of Dip Tanks in Venda - Proximity Analysis

The basis of this proximity analysis is linked to the guidelines for the location of dip tanks in relation to water courses and settlements. Cattle dipping good practice includes the siting of dip tanks in a way that human or animal life is not endangered, while also reducing the risk of polluting the environment, especially the surrounding soil resources and the receiving water ecosystems, to a minimum. Human or animal life can be endangered through physical injury, drowning, drinking of polluted water, and eating polluted plants and animal food products (Latif et al., 2001). Dip tanks should be located away from residential areas, ideally in an open area which has already been cleared. At the same time the removal of large trees and forested areas should be minimized in order to reduce soil erosion and evaporation. In addition, dip chemicals should be kept out of the reach of people and in communal areas they should be kept safely in a chemical house only accessible to dipping operators.

Dip chemicals can pollute surrounding soils, with likely risk of exposure by communities near the dip tanks to polluted soil, while the percolation of water through the soil profile adds to groundwater pollution risk. Also, the location of dip tanks closer to the residential areas increases the risks of communities, children in particular, to be exposed to health and safety dangers. Children may easily stray to the tank sites, where they are likely to fall into the tanks and drown; such accidents are especially likely in places where dip tanks are not fenced. Chemicals from dip effluent or solution can also pollute surrounding water resources and aquatic ecosystems, including watercourses, fountains, underground water and wetlands. The risk of this occurring is especially in situations where dip tanks are cleaned manually and dip effluent from the tanks can then easily flow into nearby aquatic systems. Another likely pollution occurrence is where dip chemicals on the cattle skins is washed off from the animals when crossing a stream after being dipped, in the case where dips are located very close to streams. Thirdly, when the tank floors and walls develop cracks, the dip solution is likely to leak into the ground and eventually find its way into underground water. Finally, there is also risk of contamination of watercourses where dip facilities are located close to streams, when these facilities are flooded during extreme rainfall events when streams overflow their banks.

Therefore communities near a stream which do not have access to piped potable water would rely on the stream for their daily water needs, and could be exposed to chemically polluted water. In Limpopo most settlements rely on boreholes for drinking water, thus avoiding groundwater contamination is even more important.

Dip tanks should therefore not be established too close to watercourses and settlements. Various norms for safe dip locations occur in the literature; for instance dip facilities are deemed safe when sited at a minimum distance of 100 m from watercourses and 50 m from wells, springs and boreholes (US Department of Agriculture, 1967; SEPA, 2006; New Zealand Ministry for the Environment; Oberem et al., 2006). Dip tanks should also be constructed in such a way as to prevent easy entry by stray animals and humans.

The distance of dip tanks to the villages and watercourses was determined in this study by applying proximity-based measurement, which is a method applied by geographers to establish relationships between objects. This is one way to measure environmental equity, which is based on people's proximity to facilities that pose environmental hazards (Glickman, 1994). Determining questions in this regard are: How close is object A to object B? What is the distance between two locations? What is the nearest feature from something? In the analysis of determining the relative location of dip tanks to watercourses and villages, two approaches were applied, namely, the Arc-GIS Near Tool Model, and field observations.

6.2.1.1 Use of the Arc-GIS Near Tool model

The Arc-GIS Near Tool Model is a tool that determines distance from each point in the input features to the nearest point, polyline and polygon in the Near Features within the search radius. It calculates distance from each point in one feature class to the nearest point or line feature in another feature class. The software then searches for the nearest neighbour and calculates the distance. It then computes all the calculated distances into an average.

The data layers that were overlayed in this study comprised of the streams, villages, and the dip tanks of the whole Venda. The nearness index was created by beginning with base data or a base map provided by the Council for Scientific and Industrial Research (CSIR). The base map provided river coverages, town or village coverages and border coverages of the Venda area. The layer for the dip tank locations was recorded in their coordinates obtained through the use of a Global Positioning System (GPS). The distances that were calculated were from object A (dip tank) to object B (river or settlement). Using Arc-Map 10, the proximity of dip tanks to rivers and streams and to towns was determined using a tool called "proximity" in the Arc Toolbox. Using a function named “near”, the distance of each dip tank from the closest stream and town was calculated. Any error in the original coverages has been inherited into this analysis.

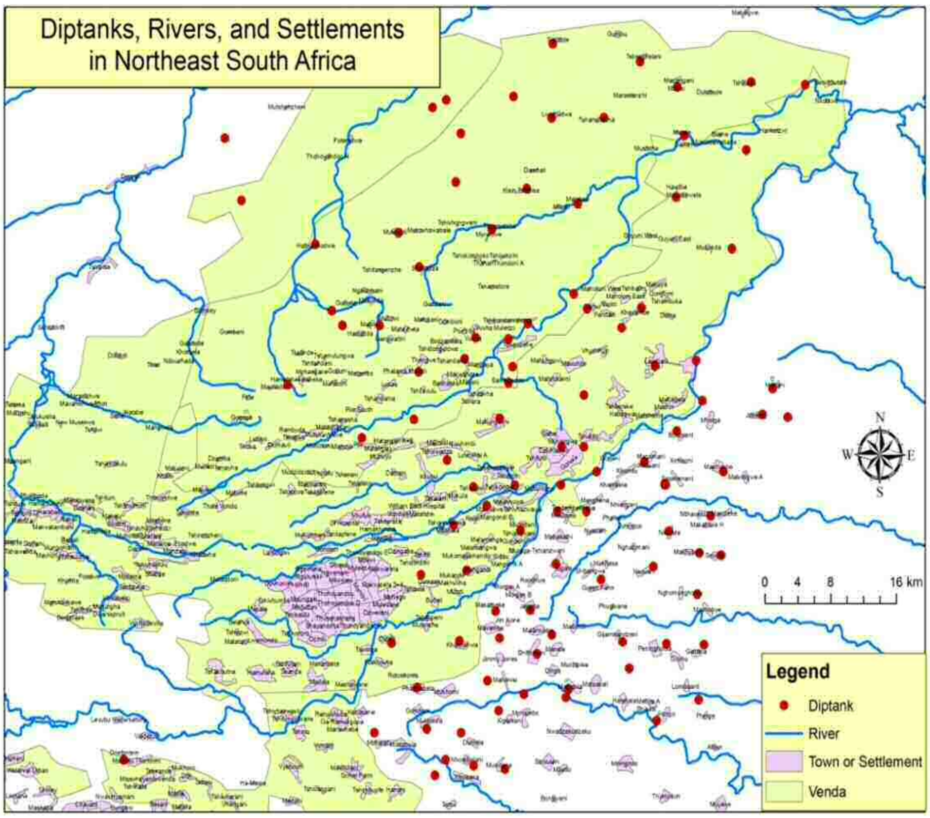


Figure 6.1 The distribution of dip tanks in Venda

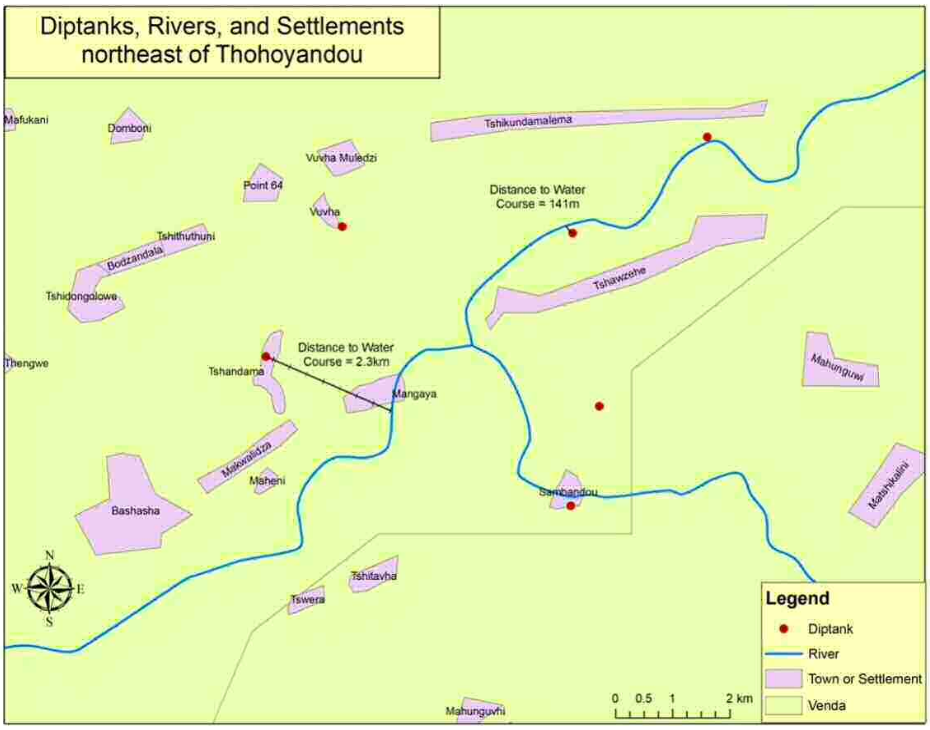


Figure 6.2 Dip tanks in the northeast in relation to settlements and watercourses

The obtained average dip tank distance to rivers or streams is 4.4 km, while the dip tank average distance to a settlement is 5.66 km. Figure 6.1 shows a wide variation in the distribution of streams in the Venda area, with the density of streams and villages in the eastern part of Venda being higher on than in the west. Figure 6.2 shows six dip tank positions relative to nearest watercourses and settlements typical of the eastern part of the study area. Figure 6.3 is the layout of the ten dip tank sites that were used in this study.

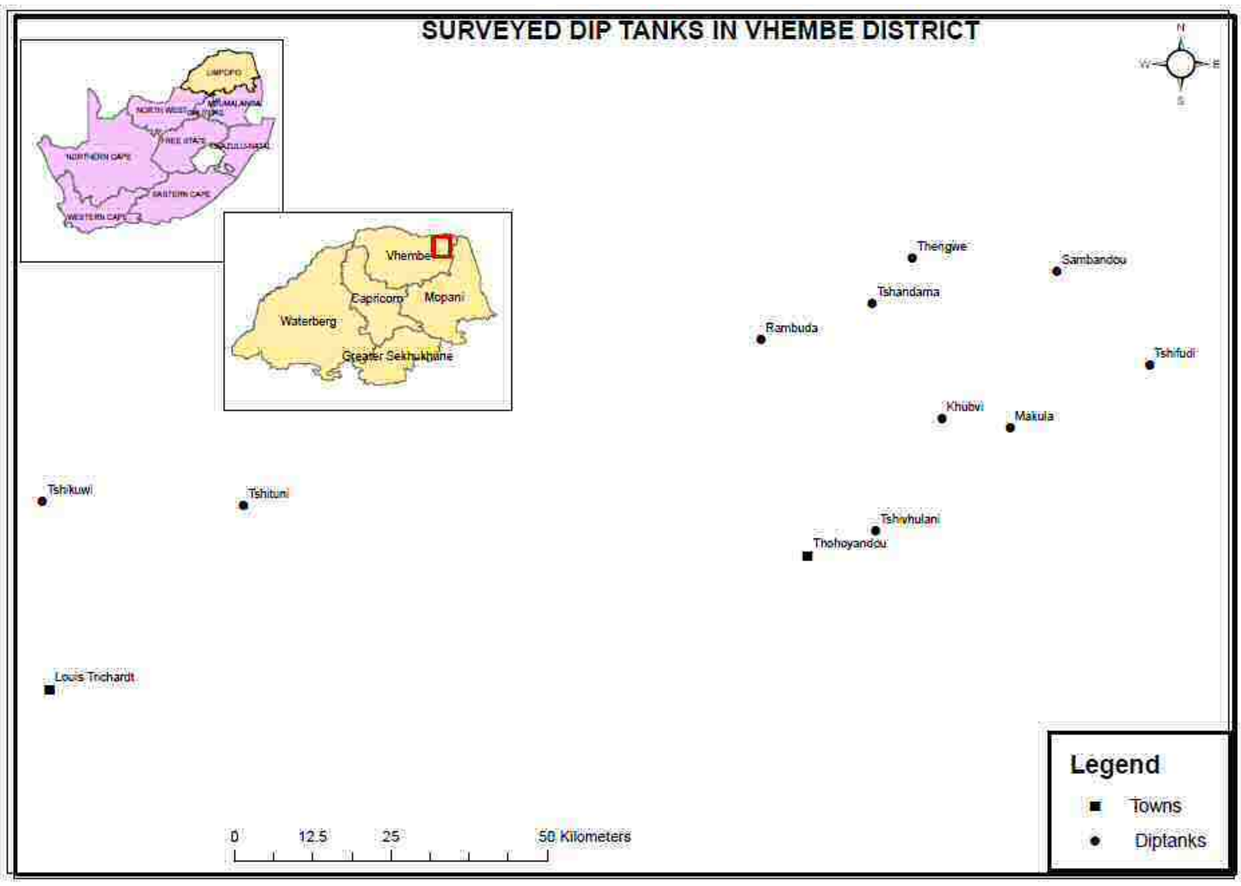


Figure 6.3 Villages where dip tanks were surveyed

6.2.1.2 Field observations and measurements

A field observation or ground-truthing excursion was undertaken in October 2008 to verify information about the distances from dip tanks to residential areas and watercourses at each of the ten sample sites used in the ecological and economic analysis (Chapters 4 and 5). Distances between the dip tanks and watercourses and settlements were measured manually (Table 6.1) using a measuring tape and car odometer. The average distance to rivers was determined at 258 m and the average distance to settlements at 316 m. The tanks that are situated very close to water sources are at Tshivhulani (20 m) and Tshifudi (40 m). These short distances are of concern because nearby streams are likely to be polluted by dip effluent during the cleaning of dips. Also, dip chemicals are washed off into the water from the animals as they cross the streams after dipping (Figure 6.4).

Table 6.1 Distances (m) of dip tanks to adjacent watercourses and settlements

Dip sites	Latitude (˚ S)	Longitude (˚ E)	Distance from watercourses (m)	Distance from settlements (m)
Sambandou	22˚ 49.591' S	30˚ 39.330' E	140	70
Tshivhulani	22˚ 55.350' S	30˚ 30.120' E	20	1 000
Tshifudi	22˚ 48.240' S	30˚ 43.270' E	40	70
Khubvi	22˚ 49.522' S	30˚ 34.029' E	100	582
Rambuda	22˚ 47.052' S	30˚ 27.057' E	200	40
Mukula	22˚ 51.000' S	30˚ 36.590' E	100	2 000
Thengwe	22˚ 49.591' S	30˚ 32.580' E	1400	300
Tshikuwi	22˚ 53.826' S	29˚ 58.906' E	300	100
Tshituni	22˚ 56.822' S	30˚ 02.570' E	130	100
Tshandama	22˚ 30.070' S	30˚ 45.050' E	150	30
n=15		**Mean distance**	**258**	**316**

Figure 6.4 Cattle crossing a watercourse after being dipped

The direct use of river water by the local citizens can expose them to contaminated water.

This has unfortunately been a common phenomenon for many communities in the Venda area. In this research, all the villages adjacent to the dip sites that were visited were found not to have access to piped water and thus rely on water from nearby streams and fountains. For instance, Figure 6.5 shows that the communities next to Tshifudi tank, including the local Tshaulu Police Station, rely on the nearby Lwandevhe stream for their daily water supply. When disused dip flows to the stream during cleaning, all the communities are likely to be affected.

Figure 6.5 The multiple uses of water of the stream next to Tshifudi dip tank. Note the borehole pump housing at the river next to Tshifudi tank

With regard to the proximity to the villages, four dip tank sites are situated very close to the villages. They are in order of closeness: Tshandama (30 m), Rambuda (40 m), Sambandou (70 m), Tshifudi (70 m), and also both Tshihuwi and Tshituni (100 m). The other four sites are located relatively further from the settlements.

The proximity of dip tanks to the villages is of concern because people from nearby homes are exposed to the dangers of falling into the tanks. Such dangers are more likely where there is a high volume of pedestrian traffic, especially school children. Tanks that have a high potential of such accidents in this study are Rambuda and Tshandama.

The Rambuda tank (Figure 6.6) is found within the agricultural section of the Rambuda Village. The closest homestead to the tank is only 30 meters away. The structure for storing dip chemicals is right at the boundary of the nearest homestead. The place next to the chemical storage structure is used by the local children as a playground.

The Tshandama tank was found to be surrounded by several homesteads and is being encroached by expanding settlements. Most of the newly established homesteads nearby the tank were not fenced.

Figure 6.6 Rambuda dip tank

The issue of life dangers that are associated with the relative location of dip tanks could not be looked at in isolation. The other related aspect is the issue of their physical condition.

6.2.2 The State of Cattle Dip Tanks in Venda

For dip tanks to be safe to the communities, they should be well maintained. Some of the measures which can be deployed to minimize risks to humans, animals and the environment in the case of existing and disused dip tanks are: 1) putting physical barriers such as fencing around the tank; 2) capping and sealing the tank by placing thick soil, rocks, and impervious pavement over the dip facility; 3) removing and treating (by means of bio-remediation) the contaminated soil; 4) setting aside the disused site as reserve land for which less exposure can be expected; and 5) implementing *in-situ* phyto-remediation whereby tolerant plants that concentrate soil contaminants in their above ground tissues are cultivated in the contaminated sites (SEPA, 2006; USEPA, 2004). In addition to the above, there should be a perimeter fence around the dipping area that reduces access into the dip sites (Fletcher, 2000).

The following section presents the state and condition of the sampled dip sites, which was determined by undertaking visual inspections. Addendum 02 is the matrix wherein the parameters of the condition of the visited dips were recorded. The main parameters include: 1) there has to be a perimeter fence around the dip area, 2) the poles that protect the entrance and exit areas must be kept in good condition, 3) the construction of the dip tank itself must be from strong reinforced concrete, and its condition should without cracks so as to minimize the rate of seeping of the chemical solution into the ground. The results of these inspections are reported under *state of fencing of dip facilities* (1 and 2 above), and the *physical condition of the dip tanks themselves* (3 above) in the sections following.

All the dip tanks in this research are plunge dips, of which two were found to be disused, namely Khubvi and Thengwe.

6.2.2.1 Fencing around plunge dip facilities

Observations regarding perimeter fences around the visited tank sites revealed that all the sites were not fenced. The tanks are easily accessed from different directions, mainly through foot and cattle paths. This appears so because most of the dips were initially established in central localities to serve cattle farmers from different villages. When enquiring from the veterinary personnel and local cattle farmers as to why there are no fences around the tank sites, the dominant answer was the one about the mass movement of cattle from different villages. Mr Mukhuba (2012), an elderly resident from Khubvi village pointed out that during the earlier years of cattle dipping, Khubvi dip tank served several villages from within a radius of twenty kilometers. Dipping used to be a whole day activity. To enable an earlier position in the day's dipping line-up, cattle owners from far away villages used to bring their animals to the dipping site for overnight camping. Herds had to be separated and they were spread over the whole area closer to the respective dip tank. A similar historical backdrop of dipping was also confirmed by Mr Nekhavhambe (2012) of Sambandou dip tank.

6.2.2.2 The physical condition of dip tanks

The physical state of most of the dip tanks is one of disrepair. The low concrete walls around the dip tanks and poles for dip site kraals are not well maintained, and are old and in a dilapidated state. Where corrugated iron sheets were used to protect the tanks, they have been vandalized. Most of the dip tanks observed also show a heavy development of cracks along their side walls. Cattle owners who regularly use the tanks try to patch the cracks on the sides, but the patches do not last long. The development of cracks likely leads to a heavy loss of water and dip chemical solution through seeping; and as a result an increase in the rate of refilling the tanks, and also chemical replacement (Ndengeza, 2008) and soil pollution. Only a low level of water can be sustained in the tanks during dipping, as they leak rapidly, which makes them shallow, exposing the animals to the danger of injury when they jump into the shallow water.

Evidence of poorly maintained tank sites was observed at Tshifudi and Tshivhulani dip tanks (Figures 6.7 and 6.8).

Figure 6.7 Tshifudi dip tank

Figure 6.8 The physical condition of the Tshivhulani dip tank

The kraals around Tshifudi dip tank have been removed and only the tank area is protected by make-shift poles. The vandalism of infrastructure is evident at Tshivhulani, where the tank also shows evidence of heavy cracks along the tank walls. Cattle owners at the respective dip sites blame the government for the collapse of infrastructure. They pointed out that the responsibility of maintaining dipping infrastructure was carried by the previous government, and after the current government withdrew its services in 1994, the farmers did not have the financial means to continue maintaining the dipping infrastructure; and no-one is prepared to contribute towards the repair of the dips.

There are also disused tanks in the area, situated at Khubvi (Figure 6.9), Mukumbani, Muswodi and Old Thengwe, and were all found to be in a bad state. Common characteristics around the tanks are broken troughs, lack of physical barriers, and tanks that are filled with litter and dirty rain water. It is also not easy to identify some from a distance since the original structures have been destroyed, are filled in with rubble and soil, and are often covered by vegetation.

Figure 6.9 Disused Khubvi dip tank

In general, the state of some of the visited tanks mirrored the report on the conditions of the dip tanks in Venda that was compiled in 1951. The 1951 report stated that conditions of dip tanks like Folobodwe (No 448), Matsheka (No 861), Makula (No 417), Makuya (No 867), Paswane/Tshifudi (No 432), Tshibulane/Tshivhulani-Sibasa (No 427), Ramputa/Rambuda (438), and Sambandou (No 390) were so bad that they needed urgent repairs (National Archives of South Africa, 10751 - Native Affairs SE/N/7 1951).

What is of concern regarding the physical state of the above dip tanks is that there is a high potential of exposing community members and animals to the risks of physical injury as well as drowning. The danger of falling and drowning into the tanks in villages may be more apparent at night since the villages do not have street lights; young children can also be at a higher risk. Coincidentally, there was a report of a drowning accident during the time of the investigation. Two five-year old children from the school near Tshimbupfe dip (Figure 6.10) tank fell into the dip tank and drowned as they were playing (Tshikhudo, 2008). The dip where the children drowned is located close to the school. The two boys apparently decided to play at the dip tank on their way home from school.

Figure 6.10 The life dangers related to unfenced dip tanks (source: Tshikhudo, 2008)

Besides the issue of falling and drowning in the dip tanks, there are other dangers that communities may face. Amongst others, 1) criminal elements within society may find these facilities as ideal places to conceal stolen, illegal or contraband goods, 2) where there is an easy access to the chemical dip solution, people may use it for wrong motives such as poisoning, and 3) the abandoned deep tanks that are filled with water during the rainy seasons can attract breeding mosquitoes which are vectors of malaria.

6.2.3 Dipping Operations and Social Justice

The promotion of equity through job creation, knowledge dissemination, community participation in decision making, protecting society from exposure to pollution, and social interaction are some of the characteristics of sustainable social development. These aspects were also examined in relation to the cattle dipping tanks in the communal areas of Venda. Information about these aspects was obtained by conducting face to face interviews with different cattle dipping stakeholders who included officials from Vhembe District Veterinary Division, dipping assistants, and cattle owners.

The respondents who were interviewed were the top managers of the Vhembe District Veterinary Division; the Animal Health Inspector, Dip Tank Assistants, and cattle owners of Khubvi, Mbahe-Tshamutilikwa, Valdezia and Tswera dip tank associations respectively. The interviews were done by open ended and structured questions around the issues of: 1) the involvement of various dip stakeholders with regard to decision making about the establishment of dip tanks; 2) the consideration of expertise in dipping operations; 3) the consideration of using protective clothing; 4) the cleaning of dips and the disposal of dip waste; 5) opportunities that are associated with dips, and social cohesion issues linked to cattle dipping. The findings from the interviews follow below.

6.2.3.1 Decision-making and knowledge about dipping operations

The analysis of archival records and interviews with dipping role players indicated that in terms of the Stock Disease Act of 1911, the Animal Disease and Parasite Act of 1956, and the Animal Disease Act of 1984, that the running dipping operations in the communal areas was the responsibility of two parties, namely the government administrators and the dipping operators on the ground. The main decision maker was the Secretary of Agriculture who was assisted by the Government's Veterinary Surgeons and the Chief Native Commissioners. Together with the Department of Native Affairs, the state bureaucrats provided scientific information of cattle diseases and also provided the funds necessary for the construction of the dip tanks (National Archives of South Africa, TAB PS 73/13/07). The task of building and maintaining dipping tanks in the communal/tribal areas was given to the technical division of the local Veterinary Services. These were assisted by Territorial Councils, Mission Stations and Private Mines in the respective districts (National Archives of South Africa, TAB A341/15a).

Territorial Chiefs and their subjects did not play any substantial role in the decisions regarding the provision of dip services. Information and decisions were disseminated to them from central government. The roles that chiefs played were secondary, and they included the identification of suitable places for the location of tanks; the provision of manual labour through their subjects; and identifying local dip assistants (*Zwibika mushungo*; medicine preparer) who helped the Animal Health Inspectors (known as *Ramadipe* in Venda). Through their subjects, they provided necessary manual labour for the digging of the dip troughs, filling the tanks with water, and cleaning the dip tanks. Manual labour was mainly provided in a *dzunde* system. This is a compulsory system whereby subjects are expected to provide certain tasks to their chiefs (Phophi, 2007).

The actual dipping operations were directly run by the Animal Health Inspectors who were helped by dipping assistants. The dipping assistant was the one most involved with the day to day running of a dip and had as his main duties the administration and preparation of dip chemicals before the cattle were dipped, checking cattle registers during dip days, collecting blood samples of dead animals for the Animal Health Inspectors, and organising the cattle owners for dip maintenance duties. Because of their direct involvement with dipping, dip assistants were called by the perceptual name *Tshibikamushonga*, literally meaning somebody who prepares medicine (Nempumbuluni, 2010).

A dip assistant generally did not have scientific knowledge regarding the administration of dip services *per se*. Usually he would only be given basic knowledge on how to prepare the dip chemicals before the cattle were dipped, to facilitate the dip cleaning programmes, and also to collect blood samples from the spleen of slaughtered cattle or cattle that had died of suspected infections. When enquiring about their knowledge of cattle diseases, it was found that the assistants were not well informed; they only knew that dipping tanks were there to control ticks which were a menace in cattle. Commenting on the issue of knowledge about cattle disease and the application of dip chemical, Mr Thagisi (2008), a dip assistant of Rambuda dip tank, stated:

> "*I became interested in cattle dipping because I like cattle. When the old dipping assistant of our area died, I volunteered to be an assistant. The animal health inspector demonstrated to me how to mix chemicals and pour into the dip. I use a 20 litre bucket whereby I do it half chemical solution and half water. I then pour the mixture into the dip and stir using the bucket. The smell from the mixture gives me some form of flu. The smell was worse with the old Double Bennex (DDT). We used to scoop it with our hands into the dip and stirring was done by cattle as they jumped into the tank. The smell would remain on the cattle for seven days and people who were closer to cattle developed flu-like symptoms".*

Thagisi's comment suggests that dipping assistants were inadequately trained. The only type of competency was that they could only do what they were instructed to do, and they therefore regarded the smells or fumes they encountered as part of the job. As a result, the safety of the assistants was compromised, with possible consequences like health risks, especially the flu symptoms he felt whenever he administered and handled the dip chemicals.

The lack of proper training for the dipping assistants was echoed by the manager and animal health inspector of Veterinary Division of Vhembe district, Messrs Mafhara, and Ramuntshi (2007). They pointed out that the handling of dipping operations should be done by individuals who received the necessary academic and technical training. However, on account of the fact that the job at hand was vast, the animal health inspectors were overburdened and they were thus compelled to use the services of dip assistants from the villages. The assistants are only given hands-on training. The fact that they were not properly trained suggests that they were exposed to the health risks associated with various toxic chemicals. For instance, for Cooper's dip to be administered, the powder had to be boiled for a long time in open containers before it was poured into the tank. Cooper's dip is an arsenical compound that is highly volatile and one who prepares it must be well experienced.

The issue of limited knowledge with regard to the dipping operations also became evident when cattle farmers had to run their own dipping operations after the state withdrew the dip services in 1994. In certain areas, some cattle owners clubbed together in order to buy dip chemicals as groups (Cattle Owners Associations). Though the system worked, it was not as properly controlled compared to when dipping was handled by the state. When asked about how they dipped their cattle, cattle owners indicated that they did not follow the organised dipping programme similar to the one followed by veterinary division, but rather only dipped their cattle when they observed a visible increase in the number of ticks on cattle. Safety measures were not considered essential. Cattle farmers indicated that they handled the chemicals without using safety equipment including masks and gloves. Everything was done manually, as long as the chemicals were administered. There was no supervision when it came to cattle dipping; any person, including children, could take cattle to dip tanks at a time convenient to them. This issue was observed at Tshivhulani dip tank during the site visit in 2007. A group of herd boys brought a herd of cattle one afternoon and let them plunge into the dip tank without the supervision of a dip assistant or any adult (Figure 6.11). A situation such the one in Tshivhulani dip tank left many people exposed to the dangers of chemical poisoning, physical harm and death through accidental drowning.

Figure 6.11 Unsupervised young boys dipping cattle

6.2.3.2 Safety of dip handlers

It is imperative that everyone involved in dipping operations should be properly trained and competent in performing their duties. The safe management of dipping operations include the correct handling and mixing of chemicals, and the disposal of unwanted or dirty dip concentrates and dip containers. Incorrect mixing of dip chemicals may either directly affect the health of animals or lead to ticks building up resistance to the dip chemicals. Cattle dipping guidelines require that for human and environmental safety, all dipping operators should have protective clothing; the containers and contaminated clothing should be disposed of properly; and effluent of dirty dip solution should be discarded into the holding sump next to the tank, and that the disposal of waste should be done by a licensed waste disposal contractor.

Protective clothing refers to the use of breathing masks, latex gloves and water proofed boots during dipping operations and the cleaning of dip tanks. An observation made during the site visits on dipping days was that the operators did not use any protective clothing.

On this issue Mr Ramuntshi (2007) stated that:

> "*The animal health inspectors and dip assistants were not protected at all. Even today there is no protection. When we inoculate cattle for instance, we do not even have masks and gloves. We always raise this issue with the higher authorities to no avail. Blood that one draws from cattle, or chemicals we inject to cattle may accidentally spill onto the operator. This could be dangerous to human health. It is more dangerous to the cattle owners who are just given chemicals without knowing the dangers associated with them. Imagine if one is mixing a powder chemical on a windy day*."

Mr Ndengeza (2008) also said:

> "*We do not use protective clothing at all. We sometimes improvise by wrapping our hands with pieces of cloth when we smear the chemical creams in the tick infested cattle ears. We call this method 'Dozha' - to smear*".

Mr Nekavhambe (2012) of Tswera supported the issue of not applying safety measures by recalling the time when they cleaned their local dip tank. Everything was done manually; village women used to use buckets to scoop the dip solution out whilst men got into the tank to remove mud. Dip effluent was always thrown to the surroundings of the tanks and it easily seeps into the soil. In cases where there were poison holes adjacent to the tanks, the effluent flows into the holes. Figure 6.12 is an example of a poison hole.

Figure 6.12 Poison hole at Tshituni dip tank

Oberem et al. (2006; 166) indicate that the poison hole should be at least 100m from boreholes, streams, houses and public thoroughfares. The area should also be fenced off and should be marked "DANGER SABS WW5" and "KEEP AWAY" in all local languages. It is customary to provide a holding sump or poison hole to prevent the discarded dip wash from flowing into the surrounding water and soil.

Dip cleaning was always done without any protective clothing. Mr Nekhavhambe (2012) indicated that community members had breathing difficulties every time they cleaned the dip tank. With regard to the handling of used containers, Mr Phophi (2007) indicated that it was done through burning and burying them next to the dip sites. This was, however, not easy to adhere to because the containers were perceived to be valuable utensils by the community. Since the dip chemicals came in containers of 20 litres, they were mainly used for water storage (*magokoko* in Venda). Therefore, there was always a temptation on the side of the dip assistants to hide the containers and use them in their households, or to sell them to community members (Fletcher, 2004; Nempumbuluni, 2010). The cleaning of the containers was also very basic; ordinary powdered soap was used as a cleaning detergent, and therefore chemical residues were not completely removed (Thagisi, 2007). This suggests that there was a high potential for the users of the containers to ingest chemical residues from stored water. Even if the containers were cleaned, the detergents used were ordinary powdered soaps. This suggests that the residues of some chemicals were not completely removed.

6.2.3.3 Keeping of dip tanks database

It is essential to keep a database of dip tanks. The database normally is a record of information that may be required in future land-use planning and development. A need for residential areas may arise, for example. If information about the past dip is available, areas where there were dips may be avoided or rehabilitated before an area is developed. The database should contain information about their location, their age, the chemicals that have been used, and their physical condition. An attempt to find information about Venda dips in this regard has been made in this research. Their locational information was sourced through the Veterinary Division of the Vhembe District, and through field visits. Information that is available is about the location of the existing tanks and is kept because the location of the tanks is associated with the villages where they are located. However, information on the location of discontinued dip tanks and on the ages of several tanks could not be found. Archival records, though helpful, also have numerous voids in this regard. One interesting aspect about the records of dip tanks is that their information, especially their location and the type of chemicals used, seems to be only the custody of the Department of Agriculture. Records about dip tanks were not available in the respective municipalities.

6.2.4 Cattle Dipping and Social Cohesion

This aspect was examined by investigating the supportive and cohesive social environment that might have emerged as a result of the establishment of dip tanks. The social environment referred to here is the one that Holling (2001) regards as being supposed to build a strong social capital by striving to foster adaptive capabilities of both physical and socio-economic systems, whilst in the meantime creating opportunities that empower groups, develop a more open and reliable policy environment, develop self-reinforcing relationships amongst groups, and also improve the internal function of groups and employment opportunities.

The responses from the various dip stakeholders pointed to some social capital advantages that they associated with the establishment of dip tanks in the communal areas in Venda. What the veterinary officials credit cattle dipping with, is that its introduction led to the eradication of East Coast Fever. Added to the eradication of this disease is the fact that dips are used by the state to perform cattle inspections for the outbreak of other stock diseases, such as Foot and Mouth Disease. Dipping at communal dip tanks was and is also seen as an opportunity for effective extension, education, training, practical demonstration and collection of census data. Dipping attendance is also viewed as an important forum for interface between cattle owners and government veterinary officials. Through this interface, veterinary officials are able to perform cattle inspection for the surveillance of the outbreak of diseases and also to conduct cattle censuses.

The discussions with the cattle farmers showed that cattle dipping in communal areas promoted the spirit of collectivism and camaraderie amongst cattle owners. Dipping sites were previously regarded as meeting places for cohorts from different villages who met to share matters of tribal importance. This mainly happened during the earlier times of dipping when one dip tank served several villages. During that time cattle dipping took almost the whole day. As mentioned before, for one’s cattle herd to be dipped earlier, cattle owners used to gather their herds around the tanks from the communal rangelands a day before the dip day and the herders would spend the night at the dip site awaiting the arrival of the Animal Health

Inspector the following day. It was during those nights that cattle owners exchanged traditional knowledge on securing their kraals from evil by using the best *mushonga/muthi* (medicine), and also how to improve the quality of their cattle (Mukwevho, 2008).

When the government withdrew the dipping service from 1994 onwards, cattle farmers survived by forming associations. It was through these associations that the farmers could help one another with matters such as the purchasing of dip chemicals, and also the identification of animals belonging to individual farmers. As a result, stock theft and potential physical conflicts among cattle owners were minimised.

One of the traditional tribal systems among Venda people was that the chiefs and headmen were provided for by their subjects. People with cattle herds were expected to provide spans of oxen during the ploughing season. Since the dip tanks were established in the villages through the influence of the chiefs and headmen, they were suitable information centres for the chiefs and traditional leaders to know the possible number of spans of oxen at their disposal.

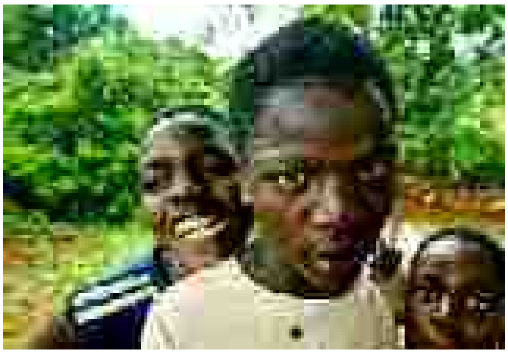
Cattle dipping promoted an element of responsibility among the livestock owners. The owners were expected to account for all their livestock. Before their animals were dipped, they presented their cattle register, and they were expected to report the animals they sold, those that died, and also the new-borns (Mukwevho, 2008).

The most notable social aspect associated with dip days that still exists today is the one of recreation. Dipping sites were known as centres of bullfight tournaments. Cattle owners who have bull champions commanded a lot of respect. The other recreation activity was the one of bare-knuckled traditional boxing bouts or tournaments (*musangwe*) as portrayed in Figure 6.13. Men of different ages, from different villages gathered after the dipping and participated in the tournament. This traditional sport has existed since the 1930s, and is practiced by men and boys from the surrounding villages. Men and boys challenge one another and engage in boxing under strict traditional rules and codes. For example, no kicking, biting and/or hitting of the fallen opponent is allowed. Men and boys emerging from the tournaments as champions command respect in all the villages, but they are also expected to be role models.

An old champion

Medicinal Divination

Contestants exchanging blows during the bare-knuckled boxing tournament



Young spectators

Figure 6.13 Bare-knuckled tournament at Tshifudi dip tank site

The sport is steeped in traditional beliefs and most fighters consult the traditional diviners and ancestral spirits before fighting. The bare knuckled tournaments were attractive to boys and able-bodied men to such an extent that schooling was affected during dip days: many boys, even those whose parents who did not have cattle, could not afford to miss the tournaments from a social perspective. Sessions of this activity still exist today in certain villages, and it has assumed the status of holiday events.

The social capital associated with dips is evident when the activity also addresses societal issues such as the acquisition of knowledge and information dissemination, generation and provision of employment, poverty alleviation, decision making and social injustice, public participation, creation of opportunities, societal cohesion, improved social equity and social progress, and environmental justice.

6.3 CONCLUSION

The above discussion evaluated the perspective of social sustainability with regard to past cattle dipping practices. The social sustainability measuring parameters that were used in the research considered the relative location of cattle dip tanks, the state of dip tanks in the study area, the management and administration of the dipping process, and the issue of social interaction and cohesion associated with livestock dipping.

In terms of the relative location and conditions of dip tanks, the sites are socially unsustainable. Most of the dip tanks are located very close to watercourses and villages, where they pose a potential hazard to watercourses and aquatic ecosystems, as well as to human health. The dominant factor regarding the choice of location was the availability of water. The need for water seemed to have made the then planners of cattle dipping in the communal areas to lose sight of the bigger picture, and therefore the communities did not have access to piped water and they also relied on water from adjacent watercourses. As such there was always a likelihood of compromising the health of communities. An opinion that can be made about the proximity of dip tanks to the residential areas is that even though the tanks were initially situated away from the residential areas, the issue of the future expansion of settlements was overlooked and many settlements have subsequently grown to closer proximity of these facilities.

The dip sites are not secured to prevent easy access to the tanks by people and animals. There are no perimeter fences around the tanks. The dipping structures also appear poorly maintained. The walls and protective poles along the tanks are old and broken and in some cases the protective poles have been vandalized. In many cases the dip tanks rthemselves are cracked and leaking, thereby exposing soil and groundwater resources to chemical contamination. Even though dipping is perceived to be helpful, there is lack of ownership and responsibility amongst the farmers when it comes to maintaining these facilities. Where there is some form of maintenance, it is patchy, and the expectation is for the government to help. This state of affairs appeared to have encouraged and perpetuated the dependency syndrome to such an extent that when the provision of dipping facilities by the government was discontinued between 1994 and 2003, cattle owners in the communal areas could not maintain and sustain the continued operation of the dips. As a result, the current poor state of dip tanks exposes the surrounding communities to health and life risks, which include the dangers of physical injury, drowning, breeding of mosquitoes in dip tanks, and the risk of poisoning to the community or their pets and livestock.

As for the expertise about the dipping operations, and the safety of dipping operators, the findings suggest an element of social injustice. The dipping assistants who are directly involved with dipping seem not to be properly trained on the handing, storage and safe disposal of chemicals, or aware of the hazards of the chemicals that they are working with – neither to themselves, nor the community or the environment. They are also not provided with protective clothing, and are as a result constantly exposed to the dangers of chemical contamination. In this regard the communities are also not informed or trained abpout the potential hazards of existing or redundant dip facilities

In terms of social unity and cohesion, the introduction of dipping in the communal areas mainly helped in the establishment of an important forum for interface between cattle owners and government veterinary owners. It also eased the facilitation of the extension of knowledge about cattle diseases, since cattle owners were scattered over wide areas. Cattle owners benefited by receiving education and training on how to monitor and identify cattle diseases. The coming together of cattle owners led to the formation of associations; some of the associations sustained the cattle owners during the time when there was a breakdown in service provision by the government between 1994 and 2003.

The communities surrounding livestock dip facilities also benefited from dipping practices in a social sense. Men-folk gathered at dip tank sites prior to dipping and shared and exchanged tribal issues and there was also the development of bare-knuckled boxing tournaments after dipping that were good for recreation. Besides recreation, such tournaments promoted social respect amongst the cohorts from different villages.

On the balance then, I must conclude that the social aspect of sustainability of past cattle dipping practices in the former Venda area is found wanting. Although there are many social sustainability benefits associated with this practice, the current and previous lack of information disseminated to the communities and dip operators about the associated risks surrounding the practice of dipping, the neglected physical condition of the dip facilities, and the lack of maintenance of these facilities over time has created risks that are a serious detriment to human health and to sustainability in general.

Therefore the past practice of cattle dipping practices in the former Venda area are not sustainable because only the economic aspect of sustainability is positive, while both the ecological and the social dimensions are not sustainable.

A thorough re-look at dipping practice is therefore necessary to address this unfavourable situation. Whereas these last three chapters have researched the sustainability of past dipping practice in Venda, Chapter 7 addresses sustainability by evaluating the current Draft Limpopo Cattle Dipping Policy, i.e. it gives an indication of how present policies and practice will affect the sustainability of dipping practice into the immediate future.

CHAPTER 7

THE LIMPOPO DRAFT CATTLE DIPPING POLICY AND DEVELOPMENT OF A SUSTAINABLE COMMUNITY CATTLE DIPPING MODEL

7.1 INTRODUCTION

The Veterinary Division of the Limpopo Department of Agriculture produced a Draft Dipping Policy Document in 2004 with the aim of providing guidance on the implementation of a new/revised cattle dipping in the communal areas of the province. The 2011 update of this 5-page policy document is applicable to all the communal areas in the province, including the former Venda – which is now contained within the Vhembe District; this document is attached to the thesis as Annexure A.

This chapter presents a synopsis of the Draft Dipping Policy Document (Mampane, 2011), with the principal aim of analysing it in terms of sustainability perspectives in order to provide recommendations on the future management of cattle dipping.

Whereas the preceding three chapters researched the three pillars or constituents of sustainability, namely the ecological or environmental aspect, the economic, and the social dimensions respectively, this chapter provides context in analyzing how policy and implementation affect the actual roll-out of dipping in Venda. The dipping policy has implications for all three of the sustainability pillars, or in the sustainability model developed by the South African Department of Agriculture and Tourism (DEAT, 2008), governance is indeed regarded as a fourth element of sustainability which encapsulates or underpins all of the other three elements, as illustrated in Figure 7.1.

DEAT regarded the three pillars model of sustainable development, as discussed in previous chapters, as insufficient to explain sustainability, and have replaced the concept by a 'cascade of dependencies' of the familiar three spheres, which are dependent on a fourth element of 'governance' to contextualize these, and also to develop and enforce policies. The cascade of dependencies is represented in the tiering or 'nesting' of economy within socio-political systems, and likewise these two dimensions are contained within the overall ecosystem services component, which are necessary to support it. Governance can then be seen as the necessary policy, legislative, administrative and management systems underpinning the other spheres of sustainability (DEAT, 2008).

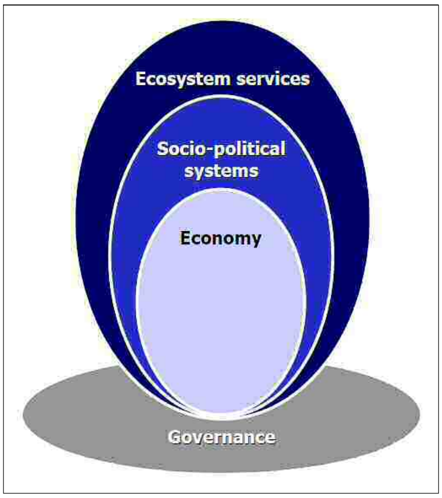


Figure 7.1 The four dimensions of sustainability (source: DEAT, 2008)

There have been various management and implementation constraints encountered by officials throughout the different political dispensations applicable to the Venda area from 1910 to the present day, especially given the many politico-administrative, or governance, changes that have occurred. A brief discussion of the history of dipping in South Africa, and thereafter the governance of cattle dipping in Venda through different administrative and political regimes is therefore provided to contextualize the relevance of the Limpopo Draft Cattle Dipping Policy of 2011, and to facilitate a better understanding of the issues at hand. Hereafter the current policy is assessed, and its shortcomings in meeting sustainable outcomes are identified. The chapter then presents the *Sustainable Community Cattle Dipping Model* which I have developed to address the identified deficiencies in current policy.

Therefore, this chapter comprises five main sections: the first briefly provides an of overview of cattle dipping in South Africa (7.2), the second presents the governance and administration of dipping in Venda (7.3), the next poses an overview of the Limpopo Draft Cattle Dipping Policy of 2011, that also covers the former Venda area, which focuses on the purpose and scope of the policy, as well as its strategies and programmes; the chapter also addresses the significance and the management of cattle dipping services in the communal areas (7.4). Section 7.5 identifies the limitations of the policy, demonstrating the need for a sustainable community cattle dipping model. Finally the section thereafter (7.6) presents a comprehensive model which was developed to facilitate the development of a sustainable dipping policy for the Limpopo Province. The final section (7.7) concludes the chapter.

7.2 THE INTRODUCTION OF DIPPING IN SOUTH AFRICA

The outbreak of Rinderpest in 1886 was responsible for decimating cattle populations in southern Africa, but was already successfully under control by the end of the 19th Century (Cranefield, 1991). The South African War of 1899-1902 disrupted, among many other things, a potential natural recovery of the cattle population, as cattle were required by the military for transport oxen and meat (Norval et al., 1992). Cattle were subsequently imported from Australia and India to meet the demands of the army and also to rebuild the cattle population as hostilities drew to a close.

The first outbreak of East Coast Fever (ECF) in South Africa is linked to imported cattle travelling via the east African port of Mombasa, where they were temporarily off-loaded to graze. East Coast Fever is carried by the micro-organism *Theileria parva,* endemic to East Africa, using the brown ear tick *Rhipicephalus appendiculatus* as vector. In the process the cattle contracted the disease and after subsequent re-boarding, were off-loaded at the ports of Beira, Lourenço Marques (Maputo) and Durban (Cranefield, 1991). From here ECF spread with the trekking of the imported cattle along the various transport routes from the coast inland to Rhodesia and South Africa (Walker, 2011).

Cranefield (1991) contends that ECF first occurred in South Africa near Komatipoort and Nelspruit around 1902, after entering via Delagoa Bay in Mozambique (Portuguese East Africa). It had occurred a year earlier already in the Umtali (Mutare) region of Rhodesia (Zimbabwe) and by 1903 the disease was well established in the Transvaal where over 40 000 cattle had died (Norval et al., 1992). ECF also spread through Natal in 1904, and crossed into the Transkei in 1910. In total approximately 1.4 million cattle died from ECF in South Africa between 1902 and 1945, while 100 000 more were slaughtered to prevent the spread of the infection (Norval et al., 1992).

Dipping, a practice borrowed from Australia, was first introduced in South Africa in Natal in

1902 (Bekker, 1959; Fletcher, 2000), and while its early practice was not meant to control ECF, it began to play a significant role in the control and eradication of the disease by 1909. Veterinary services were well established in most of the territories of South Africa by the beginning of the 20th century, as their capacity to control epidemic diseases had developed as a result of their experience with the control of rinderpest from 1886 onwards. The initial ECF control measures were similar to those used for rinderpest, resulting in the initiation of a national dipping campaign by virtue of Ordinance No 38 of 1904 (National Archives of South Africa, LC442/05; Wheelright, 1911). This intervention introduced control measures such as the fencing off of infected areas, the rigid curtailing of animal movement, impounding of stray and suspect animals, pasture spelling, quarantine procedures and slaughtering of infected animals (Cranefield, 1991).

Cattle dipping became more intensified after 1910 following Arnold Theiler and colleagues' discovery that the disease was caused by the micro-organism *Theileria parva* which is transmitted by a brown ear tick *(Rhipicephalus appendiculatus)* (Theiler, 1971; Cranefield, 1991; Davies, 2004). The implementation of a national dipping programme was enacted by the Disease of Stock Act 14 of 1911, as well as the Dipping Tanks (Advances) Act 20 of 1911, resulting in compulsory dipping throughout the affected areas (Norval, 1983). This campaign laid the foundation for the policy and techniques for the control of infectious diseases of livestock in southern Africa, and the campaign became the envy of many other parts of the world. In addition to the measures instituted with Ordinance No 38 of 1904, the 1911 Acts also provided for a more effective fencing programme and for compulsory presentation of livestock for inspection by the veterinary authorities (Anon, 1981).

During the earlier years of dipping, intermittent outbreaks of ECF occurred in areas considered to be clean of the disease and necessitated additional measures to supplement the effectiveness of the dipping campaign. It was consequently agreed by the veterinary authorities of the various regions and the national government at the Pretoria Conference of 1929 to run a national programme whereby the entire cattle population would be dipped regularly and effectively. This became known as the ECF control programme, which, along with dipping, intensified inspections and fencing measures already in force since 1911, also included a regime of intensive surveillance and close supervision of stock for early diagnosis, stricter movement control measures, the branding of cattle and prolonged quarantine of infected areas (Anon, 1981). The programme of ECF eradication was pursued for the next 30 years and the disease was finally eradicated in South Africa by 1954, with all of southern Africa becoming clear in 1960 after eradication in its last stronghold, Swaziland. At this stage, over 10 million cattle were being dipped every 7-14 days throughout the year (Norval, 1983).

After 1960 dipping among commercial farmers was no longer compulsory (Coetzer et al., 1994; www.nda.agric.za) with new provisions of the Animal Disease and Parasite Act of 1956 coming into force, but they were encouraged to continue with it because of the prevalence of other tick-borne diseases (Coetzer et al., 1994). Yet, dipping continued to be enforced and practiced in the communal areas because of the constant threat of stock diseases, such as FMD, in these un-paddocked grazing areas. Also, communal cattle owners did not possess individual dip tanks and the government therefore continued accepting responsibility for the construction of dip infrastructure and the administration of the dipping services in these areas, of which many were in ECF infested areas. Tomlinson et al. (1955) reason that the majority of black stock owners was not able to carry the financial burdens and responsibility of efficient dipping. The Tomlinson report also contended that black communities' attachment to cattle was such that they could not easily part with them even if an outbreak of a stock disease occurred, which would cause opportunity for the rapid and uncontrollable spread of the disease.

The most recent national legislation dealing with cattle dipping that was promulgated in South Africa is the Animal Disease Act of 1984 and the Animal Health Act of 2002.

7.3 GOVERNANCE AND ADMINISTRATION OF DIPPING IN VENDA

With the Stock Disease Act of 1911 dipping services were first provided especially in the current Limpopo and Mpumalanga Provinces, where the occurrence of ECF was most severe, partly because of the ecological suitability of these regions for the brown ear tick. This legislation was further supported by the Dipping Tank (Advances) Act of 1911, which provided for the construction of dip tanks by government. In the Venda area the dipping service was provided from 1915 onwards, with the first plunge dip tank being built at Tshivhase location (Marole, 1966; Nemudzivhadi, 1985).

Similar to other communal areas, the initial task of building and maintaining cattle dipping tanks in Venda from the 1910s until 1972 was the responsibility of the then Native Affairs Department (NAD) together with the respective tribal councils, while the technical service was handled by the Division of Veterinary Services of the Union of South Africa (until 1961) and the Republic of South Africa (from 31 May 1961) (Fletcher, 2004; Linington, 1949; Sefara, 2010). The rendering of the dipping service to communal farmers was done by state-employed veterinarians. The Veterinary Division liaised with the Native Affairs Commissioners, who were resident magistrates in charge of black areas (Native Affairs), and with tribal chiefs in these areas. These were assisted by Territorial Councils in the respective districts (National Archives of South Africa, TAB A341/15a).

However, cattle dipping imposed by government in the tribal areas was initially met with some resistance, and their operation was perceived as a political and cultural nuisance (Mbeki, 1964; Beinart, 2003), owing to the resentment by local people of the prior imposition of villagisation, and later also betterment schemes. Another reason was the misconception that cattle diseases were brought in by white settlers, who used them to bewitch black people's cattle so that they could easily take their territory. Consequently, activists of that time threatened communities who accepted villagisation or who complied with the dipping services offered, especially in the Transkei and the former Northern Transvaal's territories of Sekhukhune and Matlalas (Yawitch, 1982).

The government authorities used the provision of dip tanks as incentive to lure people to move to the villages, and cattle dipping tanks in the black rural areas became a symbol of a major governmental programme that impacted South African society. Practices associated with dipping that were particularly resented were the counting of animals during dipping days, penalties associated with non-compliance, and the animal tax that cattle owners were expected to pay. Cattle owners were encouraged, and sometimes coerced by the activists to send fewer registered animals to the tanks during dipping days, a phenomenon known as "ghost herd"; and to alternate the herd of cattle, bringing some one week and others the next. In some instances cattle owners were prevented from bringing their cattle to the dips at all – this interference was also accompanied by intimidation, violent vandalism, and the destruction of dipping infrastructure (www.samilitaryhistory.org; Mbeki, 1964; Yawitch, 1982; Mager, 1999; Ainslie, 2002).

Until 1979 the Venda area sorted under the Vhembe Territorial Council which was stationed at the administrative centre of Sibasa. Important role players associated with stock dipping in communal areas were: the Secretary of Agriculture, The Chief Native Commissioners, Native Commissioners, Government Veterinary Surgeons, Animal Health Inspectors and dipping assistants (National Archives of South Africa, TAB PS 73/13/07). Dip sites were initially located at central places that were accessible to cattle farmers from several chiefdoms. A total of fifty four (54) tanks were constructed in Venda between 1915 and 1955 (National Archives of South Africa, NTS 10751 - Native Affairs 1951). With time, in order to reduce the impact of distance, and also due to an increase in cattle population, chiefs of other villages within the tribal authorities requested for more dipping sites in their respective areas and were allocated these tanks (Mafhara, 2007; Nethengwe, 2013).

As a result of the implementation of the Apartheid policy in South Africa, the management of dipping services was transferred to the respective Departments of Agriculture in the black communal areas, both self-governing and independent national states. The provision and implementation of dipping practise in the homelands continued to be governed by the earlier mentioned South African stock disease legislation. The respective acts were operational from the time when Venda was a Native Reserve (1913-1969), a Self Governing Territory (1969), a Homeland (1972-1978), and a Republic (1979-1994), respectively.

During this era the Veterinary Service stakeholders involved with dipping included the following:

1. The Administrative Division at the central and district offices, which were responsible for general administration and procurement of chemicals.
2. The Technical Division, who was responsible for the administration of dipping and training of farmers, e.g. monitoring of water levels in dip tanks (see Annexure B).
3. The Engineering Division who had as responsibility the construction of new dipping structures and repairing and the maintaining of old dip tanks.
4. Procurement Service, who had to source dipping chemicals from private chemical suppliers, who in turn advised the about the products in the market and supplied the orders directly to Veterinary Service for distribution. The chemical products were mainly supplied by Coopers Limited (Jacobs, 1974) and later Afrivet.
5. Chiefs and headmen acted as a link between the cattle owners and the Veterinary Service.

When Venda became a republic in 1979, approximately 127 dip tanks had already been established in the villages. The Venda Department of Agriculture and Forestry took over this role until 1994, when South Africa was again unified as one territory in a new democracy. Because Venda was contained within the boundaries of South Africa, and was still funded from the South African fiscus, the South African laws pertaining to Animal Health, including the provision and implementation of dipping practise, were still applicable in Venda (as in other homelands, both self-governing and independent) if they so chose, giving them time to create their own laws. What changed was the organizational structure of the state veterinary service that reflected the independence of the region. During this era of 'independence' cattle dipping in Venda was administered by the Directorate of Veterinary Service at Sibasa under the Venda Department of Agriculture and Forestry. The staff was likewise transferred to the Venda government, but in effect it was the same people doing the job, but reporting to superiors in new headquarters. The directorate was in charge of drawing the dipping budget that catered for the construction and maintenance of dipping structures; the hiring, training and remuneration of dip personnel, and the procurement of dip chemicals.

The main office at Sibasa worked with the district offices of Dzanani, Mutale, Tshitale, Thohoyandou and Vuwani. The district offices were divided into wards, and each ward had its own health inspector or Animal Health Technician. Animal health technicians worked under the director of veterinary services, and they were assisted by 'dip boys' or dipping assistants who were stationed at the respective individual dip tanks. The technicians provided technical veterinary knowledge to the cattle farmers. Dip boys were government employees, whose duties included the maintenance of the poison room (dip chemical storage facilities), calibration of dips solution levels, refilling the dip tanks, cleaning of dip tanks, general cleaning of the area around the tanks, and the keeping of cattle records of individual farmers.

Cattle dipping was conducted as an extensive and systematic programme in the former Venda area (The Republic of Venda, 1979). Dip tank sites were regarded as suitable areas for regular inspection of cattle with regard to the occurrence of what were known as 'government proclaimed diseases', which included Anthrax, Foot and Mouth Disease and Tuberculosis (Nethengwe, 2013). The suitability of dip tank sites was based on the trust that developed in cattle farmers regarding the usefulness of dipping to the health and quality of their cattle. The Veterinary Service met the cost of dipping service. Cattle owners, however, paid a levy that was on the basis of an annual rate per head, but this levy was very minimal compared to the cost of the whole dipping system. The levy was imposed on cattle owners primarily to instil a sense of responsibility, rather than it being regarded as a government handout.

Cattle dipping in Venda was referred to as ‘100% dipping’. The programme was run weekly during the summer season and fortnightly during winter (The Republic of Venda, 1979; Mafhara, 2007). Actual dipping was done in association with other supplementary measures, which included disease monitoring and inspection, inoculation of cattle against diseases, extension knowledge dissemination, and recording of cattle census.

After Venda’s reintroduction into the Republic of South Africa and the birth of the modern democratic South Africa in 1994, South Africa was divided into nine provinces with the former Venda now sorting under the Northern Province (later re-named the Limpopo Province), with its administrative capital in Pietersburg (later renamed Polokwane). Again this involved transfer of governance to new premises – from Sibasa to Polokwane. The provision of dipping services by the government to communal areas in South Africa, including Venda, was scaled down after 1994 (Mafhara, 2007; Mampane 2004), and is currently only provided in the areas adjacent to the Kruger National Park (KNP), or the infected zones, and not in all communal areas as before. Areas not adjacent to the KNP are therefore excluded from the free service. The purpose of keeping the government-sponsored service closer to the park is to control the spread of diseases like Foot and Mouth Disease (FMD), which is carried by buffalo.

Figure 3.6 indicates the zones that have been set up to control the spread of FMD. National parks are regarded as Foot and Mouth Disease Infected Zones. Next to the parks are Enzootic (Buffer) Zones; dipping in these areas is compulsory. Adjacent to the buffer zones are Surveillance Zones; farmers in these areas are encouraged to continue with dipping practise, even if only on a limited scale. The former Venda area falls under the surveillance zone. Dipping beyond the surveillance zones is voluntary and farmers do not get any assistance from government there. They continue individually with unsupervised practice. While the main reason behind the curtailing of the programme was a shortage of funds (Mafhara, 2007), other observers believe that a conflict of interest arose in that crop farmers felt that they were given fewer benefits by government than cattle owners (Nethengwe, 2013).

The negative impacts of terminating the dipping service in Venda are the following:

1. Dip assistants who lost their livelihoods.
2. Loss of trust in the system and in government by cattle owners.
3. Deterioration of dipping infrastructure, where structures started to collapse, as no maintenance was done for nearly ten years. Siltation and vandalism of dip tanks also occurred, as well as the alternative and often hazardous uses of these facilities.
4. Loss of income and market by chemical suppliers.
5. Collapse of cattle census records.

After a re-evaluation of the role of dipping in controlling cattle diseases and other negative impacts of ticks, the government through the Veterinary Section of the Department of Agriculture (NDA) has from 2003 slowly reintroduced the dipping system in the communal areas. This re-evaluation was caused by a new outbreak of FMD in 2001 (Nethengwe, 2013). Thereafter the Veterinary Section gradually started supplying communal cattle owners with acaricides that were used in the old dip facilities. During 2004 a policy and regulative processes were started by the NDA, including a call for inputs from the provinces to inform a proposed national cattle dipping policy (NDA, 2005). Even though the South African government has not as yet produced a new policy on stock dipping, it has established a national task team that is currently drawing up a proposal for a new dipping policy (Mampane, 2004; 2011). However, as far as can be determined, the document still has the status of an unofficial internal working document and has not been endorsed or approved through any governance mechanism.

7.4 OVERVIEW OF THE LIMPOPO DRAFT CATTLE DIPPING POLICY

To put the reader in context, the past practice of dipping was discussed in the foregoing sections 7.2 and 7.3. The Limpopo Draft Cattle Dipping Policy of 2011 discussed in this section (7.4) and the next section addressing the limitations identified in the draft policy (7.5), can for all practical purposes be regarded as representing the present practice or status of dipping services, particularly in the Limpopo Province. The section thereafter, (7.6), in which the model to address the shortcomings of the present practice is discussed, can therefore be potentially regarded as the future dipping practice in Limpopo, if it is indeed adopted.

To provide the reader with an overview of the structure of the 2011 Limpopo Draft Cattle Dipping Policy document, its Table of Contents reads as follows:

Figure 7.2 The sections of the 2011 Limpopo Department of Agriculture Draft Cattle Dipping Policy (source: Mampane, 2011)

The full document is annexed to this thesis as Annexure A.

7.4.1 Primary Objectives of the Limpopo Draft Cattle Dipping Policy (2004-2011)

Cattle dipping in the communal areas is premised on the mission of the Veterinary Division of the Department of Agriculture, Forestry and Fisheries (DAFF - formerly the National Department of Agriculture, NDA) which provides services and infrastructure that cover the implementation of health measures for society. Their mission is driven by the need to improve production capacity and trade in animals and animal by-products, as well as to improve public health and consumer food security. The legislation that drives this mission is the Animal Diseases Act of 1984. The Act emphasizes the fact that infectious animal diseases and parasites pose a threat to the agricultural sector in South Africa, and provides for the control of the diseases, the measures to promote animal health, and strategies connected therewith by virtue of the *Primary Animal Health Care Policy – Working Document*. (NDA, undated).

The primary objectives as articulated in the policy are:

1. To broaden access of veterinary services to communal rural communities in a cost-effective manner.
2. To ensure improvement in the health status and production of animals.
3. To contribute to the overall national development.
4. To safeguard public health.

According to the 1984 Act, the National Department of Agriculture (now the national Department of Agriculture, Forestry and Fisheries (DAFF)) is responsible for:

1. Developing programs in consultation with provincial governments and private agricultural stakeholders to contain and eradicate diseases which may pose a threat to the national economy.
2. Coordinating and maintaining a competent epidemiological database and information system of notifiable disease surveillance.
3. Setting standards for routine control measures for those notifiable animal diseases and parasites.

Subsequently, the National Regulatory Services division of NDA has launched a newer initiative to entrench a standing policy on Animal Health, which includes dipping (NDA, 2005). To date no printed policy or regulations controlling dipping have been issued. It is believed that DAFF is consulting at this time with provincial veterinary divisions to get their inputs for a national dipping strategy (Nethengwe, 2013).

7.4.2 The Policy Development Framework

Dipping service is described in the Limpopo Draft Cattle Dipping Policy as an activity that is applied in the form of plunge dipping, spray, or as a pour-on, depending on the prevailing dipping facilities and the support systems in place. It also equally involves the provision of dipping infrastructure, dipping compounds (chemicals), and human resources to dip cattle at the dip tank sites in the communal areas, where these dip tank sites are considered as communal inspection points. The senior manager Veterinary Services in Limpopo will determine the dipping compounds to be used; in his or her discretion he will consult field personnel (especially Animal Health Inspectors), industry, current contracts available, tick resistances against acaricide, statistics and other scientific data available to him.

The draft policy shows a break with the old tradition up to 1994 when dipping service was freely provided to cattle farmers in the communal areas. It is driven by the challenge of managing the occurrence and outbreak of Foot and Mouth and Corridor diseases respectively transmitted by species such as buffalo and brown ear ticks, respectively. To minimize the impact of the two diseases on cattle, the Veterinary Division of the then Venda area, and thereafter the Limpopo Province, has adopted the division of the communal areas into three management zones namely, an infected zone, a protection zone (buffer), and the FMD-free (surveillance) zone.

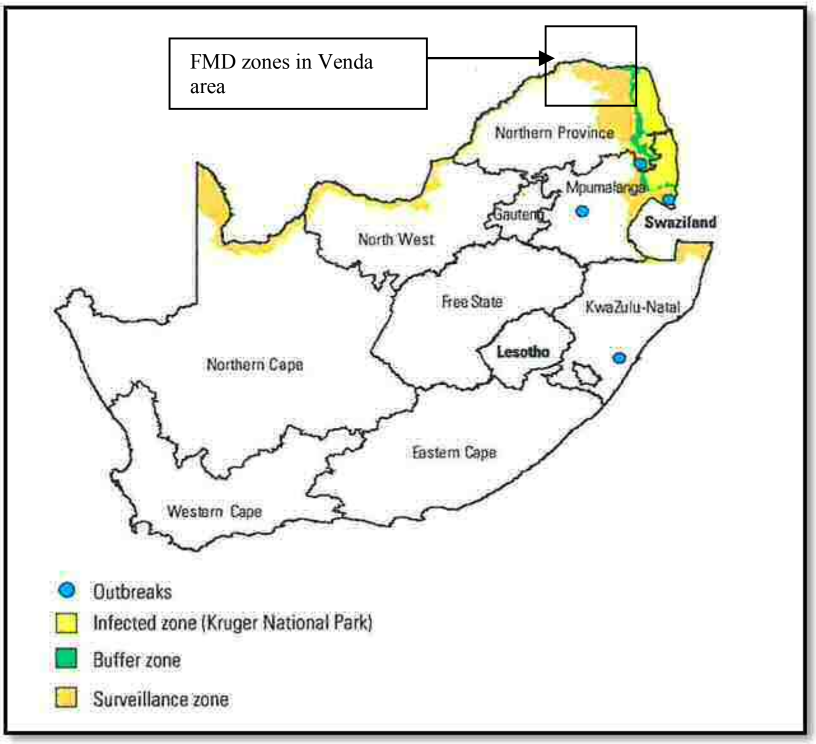


Figure 7.3 Foot and Mouth Disease control zones

The *infected zone* is an area that is adjacent to the Kruger National Park. Because of its proximity to the park, there is a high possibility for cattle to be infected by wild animals that escape from the park. Cattle in this area require regular dipping and dipping is provided free of charge in this zone by the Veterinary Division in order to encourage local farmers to dip their cattle.

The *protection zone* covers an area that borders the infected zone and serves as a buffer area between the infected area and FMD-free area. Cattle farmers in the buffer area are also exposed to FMD and the Corridor disease, and as such, their cattle require regular dipping and this service is provided free of charge.

Dipping is not compulsory in the third zone, the *FMD-free area*. However, cattle owners are encouraged to dip their animals to protect them from the impact of tick bites and other tick-borne diseases. Under current practice the service is not provided for free in these areas.

7.4.3 The Primary Animal Health Care Service Delivery

In so far as the cattle dipping policy in rural communal areas is concerned, the draft policy recommends that the state must play a facilitative role of promoting local initiative. This is because of the view that rural stock farming is characterized by individuals with limited veterinary resources, and poor cattle managerial ability. The strategies of dipping service that are highlighted in the policy document are for both the cattle owners and the government. According to the draft policy, delivery of Primary Animal Health Care (PAHC) shall be based on participatory principles involving the State Veterinarians, Animal Health Inspectors, cattle owners, and Community Based Animal Health Workers (CAHW).

For the cattle owners, the dipping service is supposed to provide resources that are used to control ecto-parasites and the resultant tick-borne diseases and conditions including heart water, redwater, gall sickness, theilerioses, sweating sickness and tissue damage. The dipping service is also supposed to provide regular animal health advice to the farmers at dip tank sites. Dipping sites are areas where communal farmers have contact with extension officers for veterinary advice, which ensures that veterinary services are provided at regular intervals at ground level.

For the government, communal dipping areas are ideal sites for disease surveillance, and to render affordable and effective extension, and veterinary education and training. Dipping is also an opportunity for government to enhance public relations, and a way to improve the natural immunity of cattle to tick diseases. Each of these aspects is next discussed in more detail.

Due to the fact that large herds of cattle assemble at the dip tank sites at one time, the veterinary personnel are able to perform *disease surveillance*. Disease surveillance is mainly linked with the Foot and Mouth Disease (FMD) which invariably poses a threat to the cattle production industry. If FMD is not known and it spreads undetected, no guarantees can be issued to the country's trading partners, and this may result in export bans and subsequently financial losses for the country and farmers. In order to uphold the country's status as a FMD free zone, it is essential to maintain a satisfactory level of disease control. The use of dip tanks for disease surveillance is considered to be more practical and cost effective since the other dip related functions like compulsory cattle inspections, vaccinations, movement control and other disease control practices are also performed on site. Communal cattle owners were keen to come to the dip tank sites for the benefit of the dipping service that they receive, but this also offers an opportunity for the Veterinary Services to perform surveillance of diseases since cattle owners bring their herds to be dipped at regular intervals.

Another aspect of cattle dipping that the Veterinary Services view as important is the one of surveillance of non-controlled diseases. The communal cattle dipping system makes the surveillance of the status of animals with respect to condition, general health, production, reproduction, as well as monitoring mortalities possible. Regular animal inspection gives Veterinary Services the ability to establish an Early Warning System regarding any disease condition and precautionary measures can be activated.

The dipping system also provided an opportunity for rendering *affordable and effective extension, veterinary education and training,* as well as *practical demonstrations* to the farmers. An effective extension service covers all aspects about animal health and production skills, and in the processes veterinary personnel are also able to collect and record accurate animal census data.

The provincial government uses the interaction between the veterinary personnel and the rural farming community to *enhance public relations*, particularly in the FMD control zones, where there is a possibility that farmers could misunderstand and shun the activities of the veterinary personnel. It is of importance from the government perspective that effective animal disease control, and the promotion of animal and human health is difficult to achieve without a positive and sound public relations. Because of the perception and obvious benefits of dipping to cattle farmers, the effect that dipping has on the image of the department is immense. Managed strategic dipping is also viewed as a way of enhancing the natural immunity of cattle resulting from tick infestation.

The 2011 Limpopo Draft Cattle Dipping Policy also considers the impact of overstocking and the poisoning of the environment and animals, especially by using unregistered dipping chemical compounds. The issue of environmental pollution should be considered in the planning and execution of dipping programs. Only dipping chemical compounds without adverse effects to the environment will be used.

7.5 LIMITATIONS OF THE POLICY

The objectives of providing primary animal health in the communal areas as articulated in the 2011 Draft Limpopo Dipping Strategy indicate the concern of the state with regard to the importance of animal health. A deeper analysis of the draft dipping policy however identifies some limitations.

Firstly, the strategy consists primarily of one specific single goal which is giving substantial attention to animal health enhancement. The policy, however, appears silent with regard to other dipping related aspects such as their relative location, the discarding of dip effluent, and the management of disused of dips. In matters related to environmental health, the policy only scantily touches on the use of compounds. From a sustainability perspective, however, the implementation of the dipping system should be multi-faceted. Cattle dipping should not be taken as an end to itself, but rather an implementing strategy that helps to achieve sustainable development goals.

Secondly, the government-sponsored cattle dipping service is currently only provided in the areas adjacent to the KNP or the infected zones, and not in all communal areas as before. Areas not adjacent to the KNP are therefore excluded from the free service. Although the purpose of providing free dipping to cattle owners closer to the park is to stop the spread of FMD, farmers who are supposed to provide their own resources may lose interest in dipping their cattle. On the other hand, the free provision of dipping may perpetuate the element of dependency, as before.

Thirdly, it is mentioned in the draft policy that delivery of PAHC shall be based on participatory principles involving the State Veterinarians, Animal Health Inspectors, Cattle Owners, and Community Based Animal Health Workers (CAHW). The stakeholders however are referred to in isolation and the policy is not clear on how the involved stakeholders should interact. In addition, the policy does not consider the role of municipal bylaws - both district and local municipalities - and how they affect PAHC and the management of dipping systems.

Fourthly, the draft policy does not address the financial failure of the previous policy up to 1994. Issues of finances are central to the success or failure of any project. Since the draft policy does not address financial sources and management, it is possible that the success of PAHC may prove not to be as successful as hoped for by the authorities.

Fifthly, the issue of coordination between Limpopo Province, other provinces with risk areas of outbreak of infectious diseases and the national department (DAFF) are not addressed in the draft policy document.

In order to address the above limitations and shortcomings of the present Limpopo Draft Policy the next section proposes an integrative approach to address these shortcomings.

7.6 THE SUSTAINABLE COMMUNITY CATTLE DIPPING MODEL

Cattle dipping in the communal area of Venda remains the most commonly used and also the most suitable way to further the aims of veterinary services. The new draft policy, however does not address all the parameters for the sustainable dipping practices. In order to address the identified shortcomings, the researcher has developed a model that incorporates a holistic approach to the future planning and implementation of cattle dipping in communal areas. This model suggests a multi-stakeholder approach that involves the participation of the broader dipping community and has been labelled the *Sustainable Community Cattle Dipping Model* (Figure 7.4).

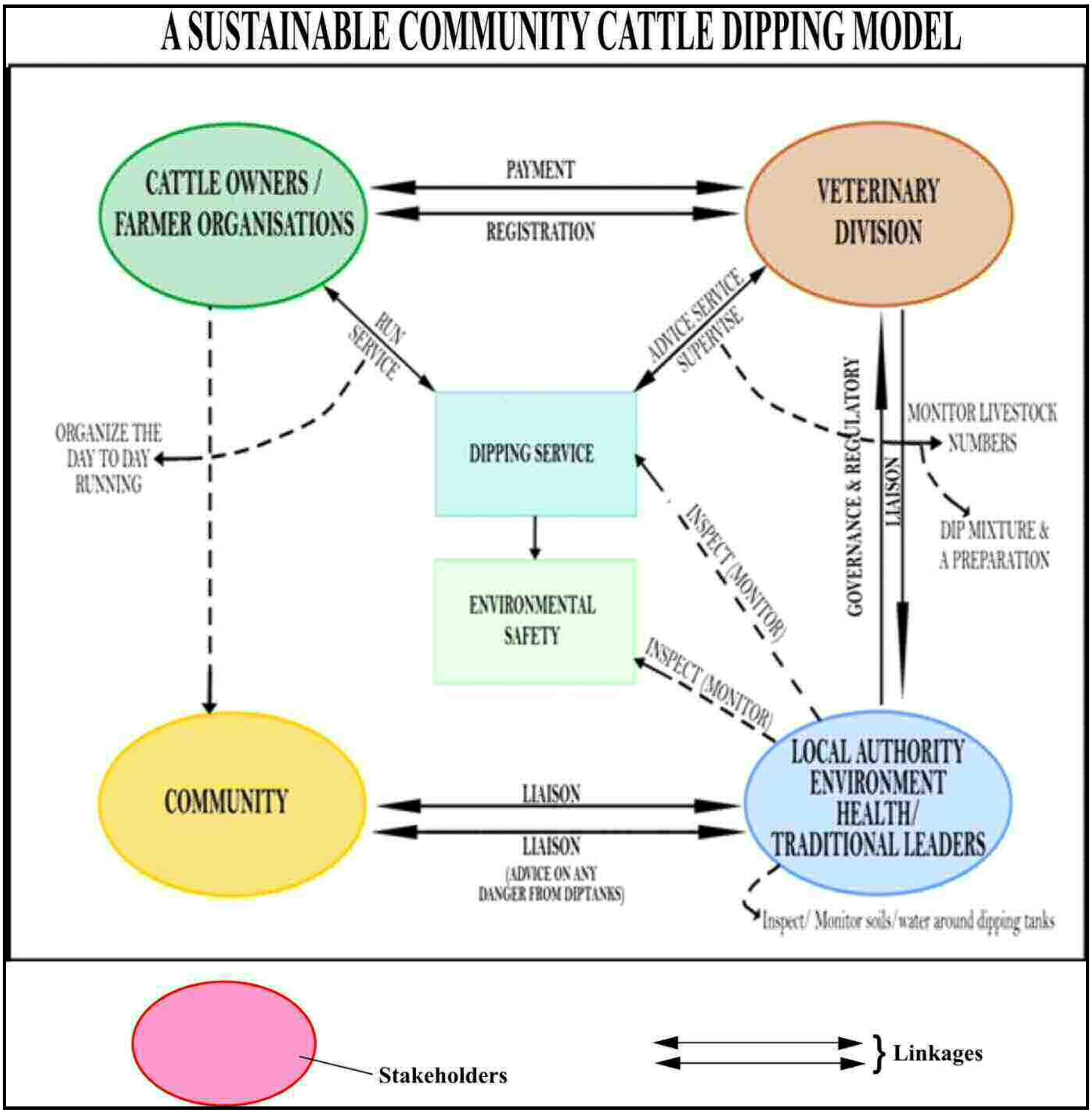


Fig 7.4 The Sustainable Community Cattle Dipping Model.

7.6.1 Structure and Functioning of the Sustainable Community Cattle Dipping Model

This section of the thesis illuminates the functioning and structure of the model. It focuses on the two main elements of the proposed Sustainable Community Cattle Dipping Model, namely: *Stakeholders* (7.6.1.1) - where the roles and responsibilities of the different role players in the dipping practice are discussed, followed by an explanation of *Links and interactions between stakeholders* (7.6.1.2), in which the functional links and the efficiency of resource flows, communication, information and decisionmaking between the different stakeholders is described. The final section (7.6.1.3) then concludes with the *Implications of* *the proposed model for the future of dipping policy* in Limpopo.

7.6.1.1 Stakeholders

The model consists of four major stakeholder groups, namely: cattle owners and farmer organisations; the veterinary division; the local communities and the government authorities and structures involved. This group of stakeholders is what Velasquez et al. (2005), call an *Innovative Community*. The concept refers to a group of people who have common interests and are able to bring about change and innovation in order to bring a sustainable society. In this regard, the innovative community is the one that is affected by cattle dipping. They include cattle owners, the Veterinary Services, the local authorities, and the local communities.

Cattle owners and farmer association

This group includes individual cattle owners and also the communal structures including cattle owners associations. These associations voluntarily maintain dip site infrastructure and they help to clean dips after use, as they percieve that these facilities are for their benefit and the longevity of their industry. These stakeholders share farming expertise and often resources, for instance they would collectively buy chemicals when they identify the need to dip, especially in the FMD free zone. They frequently offer their available resources, mainly physical labour and time, to the Veterinary Services to maintain and clean the dip infrastructure.

Veterinary Division

In this case a division of the Limpopo Provincial Government's Department of Agriculture, with each district having its own assigned officials, including the Manager: Veterinary Services for Vhembe District, as well as Animal Health Inspectors, Animal Health Technicians and Dipping Assistants. Their responsibility is to roll out technical veterinary services and advice to cattle owners and associations. In the infected zoned zones this division also provides dip chemicals and oversee the dipping operations on dipping days. In the FMD free and protection zones they only provide veterinary services when there is a need, or in cases of identified outbreaks.

Governance structures

Governance structures should include the District Municipalities and Local Municipalities, and traditional leaders in the respective regions. The municipalities are responsible for *inter alia* community and environmental health in their areas of jurusdiction; however, in practice most rural municiplaities do not have officials to perform or implement such responsibilities. The Veterinary Division is supposed to liaise with these depertments of the respective municipal structures, but to a large extent this cannot happen as there are very few persons or officials on the ground at municipalities to perform these responsiblilties. The people that do know about dip operations, traditions and practices are primarily the traditional leaders in the respective villages. In the pre-1994 practice of cattle dipping, traditional leaders would be the authorities collecting or receiving fines and cattle tax associated with dipping practice; for instance, cattle owners were fined for providing wrong information about cattle numbers. These leaders also have an institutional memory of dipping practice, protocols and the social dimensions thereof from former days.

The community

The community should include amongst others, local community members, schools, traditional leaders, and traditional healers. Dip tanks are located nearby settlements and in close proximity to watercourses. The community is therefore affected by the integrity of the maintenance and safety of dipping infrastructure, which includes the suitability of location. Socially, these facilities provide forums for empowering people about the benefits of dipping, and also for recreation on dipping days where bull fights and bare knuckled boxing bouts take place. Dipping days also provide opportunities for trade; for instance butchers buying cattle and selling meat, and cultural tourism; these days also provide various opportunities for informal trade and social interaction in general.

7.6.1.2 Links and interactions between stakeholders

Cattle owners and farmers associations and the Veterinary Division

Cattle owners should be stewards of the infrastructure and amenities that enable them to have healthy herds, i.e. the community dipping facilities. They can therefore take ownership of, and responsibility for, maintaining dip facilities through their respective associations. Through these associations they can also liaise more effectively with tribal and municipal authorities to secure subsidised chemicals from the Veterinary Division and to ensure that these services are programmed in the planning of the veterinary authorities. One way of successfully managing the local resources is to bring the local communities on board through the formation of functional farmers associations on an area basis, instead of them passively waiting for the assistance from the veterinary authorities. Community involvement promotes the spirit of ownership and appreciation.

Governance structures

The governance structures (local and traditional authorities) are the ones that deal with resource allocation and distribution, including the allocation and use of land within their jurisdiction. For this reason they should also be involved in the management of dips and they should provide legal and administrative guidelines with regard to the future establishment of dip tanks as well as the management of disused tank sides.

Community

Dips should not only be considered as entities that are associated with people who own cattle, but should also be appreciated as valuable capital resources belonging to communities. Also, the community should be aware of some dangers that are associated with dip tanks, especially with regard to the chemicals that are used. When this is the case, people can always remain vigilant and proactive when it comes to the worth and dangers that are associated with dipping. For instance, the community can understand when they are advised not to turn dip tank sites into other land uses. Also, parents can assist in keeping their children away from the dip sites. The involvement of communities may also reduce the problem of vandalism.

7.6.2 Implications of the model for the future dipping policy

The preceding section has demonstrated how this model can improve communication and understanding between the different role players involved with cattle dipping in Venda. In this final section conclusions are drawn about the benefits of the proposed model for better implementation of dipping practice.

Benefits to Veterinary Services

The potential benefits of the Veterinary Services division in adopting the *Sustainable Community Cattle Dipping Model* are firstly in terms of it better equipping them to market their services and disseminate information about the necessity of livestock dipping. The importance of veterinary services in general and cattle dipping in particular needs to be disseminated to the public (communities). Whereas the practice of cattle dipping was initially foreign to rural communities, as it was instituted in an era when the motives of the authorities were seriously questioned, yet over the ensuing decades the benefits of cattle dipping and the positives associated with the practice were gradually accepted and appreciated by rural cattle owners. It is also suggested that the Veterinary Division should investigate the possibility of providing a dipping and extension service wider than the present affected areas, i.e. that the policy be extended to include all rural communities, also encompassing the FMD free zone. The fact that the service was provided for free by the authorities up to 1994 also developed a legacy of dependency, which became evident when the service was withdrawn in most unaffected areas after 1994, subsequently leading to the collapse of the practice. This service could in future be rendered at a marginal or break-even cost, but at least this would place the responsibility of the Veterinary Division to inspect, liaise, train and interact with cattle owners on a regular basis and thereby enhance the safe practice and proficiency of all stakeholders associated with dipping.

A second benefit to the Veterinary Division if they adopt the *Sustainable Community Cattle Dipping Model*, is that it would help them to take responsibility for the environmental and human health impacts associated with dipping, and not just the rendering of the veterinary service. In other words, the Veterinary Division needs to take ownership of the environmental and human health implications and responsibilities that are associated with the service they render. This responsibility would include disseminating information and providing proper training to communities, cattle owners and government representatives about the safe handling of dipping materials and the application thereof. The model also makes the connection between the need for veterinary services to liaise much closer with governance structures such as municipalities, where these authorities already have the jurisdiction and responsibility of human health and environmental health. The veterinary services can present training and information dissemination to communities in conjunction with municipal and tribal authorities, thereby empowering not only the communities, but also aiding the responsible officials within governance structures.

This model can therefore aid the Veterinary Division in their planning and prioritising, especially with regard to liaising with traditional leaders, municipal structures and cattle owners and cattle associations and community representatives in general.

Implications for Governance structures

Local and tribal authorities have the responsibility of environmental health and land use allocation. This research and the development of the *Sustainable Community Cattle Dipping Model* have identified that these authorities should provide legal and administrative guidelines with regard to the establishment of dip tanks and the management of disused tank sites. Taking account of the fact that most of the records of the preceding 79 years of dipping went lost with the takeover of the provincial government (Northern Province Provincial Government) in 1994, these tribal and local authorities should develop a database of both the functional dip tanks and the disused ones before they can succeed in managing the disused dip sites and in providing guidelines for establishing new ones. The variables to be included in such a database should cover information indicating the actual location of the tanks, their respective ages, and also the record of the past and present chemicals; as such the database can form part of the environmental legal registers of the respective municipalities – i.e. the record of all the laws and regulations which must be observed and implemented by them. The development of a database can also be helpful to the municipal planners when it comes to the development of future land use plans through integrated development planning.

Communities

An endearment to cattle dipping practice still exists in rural African society today. From 1994 to the present the attachment of communities to dipping practice still lingers, as dipping practice has continued where cattle owners could afford it, while the social and economical activities and spinoffs of dipping days and events are still evident.

The development of the *Sustainable Community Cattle Dipping Model,* as an output of this research, has identified the intricate role that cattle dipping practice plays in rural communities, as it provides the spinoffs of economical and social intercourse apart from the direct benefit of improved primary animal healthcare and the direct economical benefits to cattle owners.

Communities also need to realise that the government may not necessarily always provide these services for free, as has happened before 1994, and they therefore need to take responsibility (and ownership) for the maintenance and upkeep of the dipping facilities and infrastructure in their respective areas.

The model therefore highlights that better integration between the needs of communities (social and economical) and the provision and planning of veterinary services and dipping infrastructure by the Veterinary Division is required.

7.7 CONCLUSION

The current governance of cattle dipping in the former Venda area is found to be unsustainable, mainly due to the downscaling of dipping operations from 1994 to 2004. Through this many gains made in the past have been lost, and the general momentum that the programme has had, has largely been lost. The sustainability of governance was assessed by investigating the acts, policies and current administration of the dipping service. The 2011 Limpopo Draft Cattle Dipping Policy was the main instrument of investigation, and was found to have various limitations that hamper sustainability and effective roll-out of dipping practice in the region.

To address this, a *Sustainable Community Cattle Dipping Model* was developed by the author, with the aim of providing answers and means to closing the identified shortcomings. The benefits of adopting the *Sustainable Community Cattle Dipping Model* can be summarised as follows:

1. It can provide informed inputs to the Limpopo Department of Agriculture to facilitate planning of dipping activities and infrastructure.
2. It can aid dipping practice and planning by adding a spatio-temporal dimension to it.
3. It can have a positive community empowerment aspect: persons previously saw dipping facilities merely as infrastructure and communities could not sustain dipping practice when these were scaled down after 1994. Implementing the model will also aid governance sustainability in the following ways:
    a. by helping to create awareness of the need for dipping;
    b. by reducing dependency on government providing the service;
    c. by disseminating knowledge with regard to risks associated with animal diseases such as FMD, ECF, as well as human health.

4. It can provide structure to the Limpopo Department of Agriculture and its Veterinary Division for the purpose of planning and implementing dipping services.
5. It addresses the role of local authorities, who are legally responsible for resource allocation, environmental health by, for example, formulating and incorporating bylaws, zoning and other measures pertaining to animal disease prevention and dipping practice.
6. It identifies the different role players necessary for sustainable dipping practice, and addresses the roles of, and interactions and linkages between different stakeholders. This will enhance planning and cooperation between stakeholders and pave the way for more effective planning, budgeting and implementation of the dipping service, while also making all stakeholders aware of their environmental and societal responsibilities.
7. It also provides a clearer understanding for stakeholders about the interaction required between different tiers of government and governance structures, including tribal authorities. This should enhance the administration and also facilitate the training of new agents required to administer dipping services.
8. It adds significantly to the sustainable roll-out and implementation of cattle dipping, in the following ways:
    a. as the environmental responsibilities of different role players are spelled out, it puts the onus on the appropriate role player to ensure that they are environmentally compliant, which will enhance environmental sustainability.
    b. the model can help different stakeholders to plan and budget more effectively for the roll-out of the dipping service, which will enhance its economic sustainability.
    c. the social sustainability will gain significantly as the dipping service and the sustainability of job opportunities associated therewith are placed in proper long-term perspective; the current human health risks will likewise be substantially reduced with proper planning, infrastructure provision and administration being put in place.
    d. the sustainability of governance can be enhanced as the model clearly describes stakeholders, linkages between them and the tiering of governance

structures, which will facilitate communication, consultation and decision-making between all stakeholders and governance structures.

The model therefore presents a conceptual framework which integrates the attainment of positive environmental, economic, social and governance outcomes by which the present policy can be improved if the model is adopted. Ultimately this should lead to sustainable dipping practice.

CHAPTER 8

CONCLUSION AND RECOMMENDATIONS

8.1 INTRODUCTION

Research for this thesis was motivated by the desire to evaluate and understand the sustainability of past cattle dipping practices in the communal areas of South Africa; specifically, that of the former Venda territory, which now forms part of the Vhembe District Municipality of the Limpopo Province. Cattle dipping was introduced in 1915 in this area, and the at the same time when it was introduced in the rest of South Africa, as an intervention strategy for controlling the spread of East Coast Fever (ECF). East Coast Fever is a cattle disease that is caused by the micro-organism *Theileria parva*, and is transmitted by brown ear ticks (*Rhicephalus appendiculatus*).

A concern about the environmental impacts and dangers associated with dips by communities in countries with a long history of stock dipping led those authorities, particularly Australia, Scotland, New Zealand, and the United States of America (USA) to formulate and establish some paramaters to guide dipping operations (New Zealand Ministry for the Environment, 2006). These guidelines cover aspects such as the suitable location of dip tanks; the running of dipping operations; the management of dips; and the remedial methods for mitigating environmental contamination and managing disused or abandoned dip tanks. From a sustainability point of view, such guidelines help in guarding against the contamination of soil and water; minimising safety and health risks to the surrounding communities; empowerment of local communities through knowledge dissemination, as well as other social benefits. It is against the background of these guidelines that the sustainable establishment and operation of cattle dipping in the communal areas of South Africa, and more specifically, the former Venda area, have been investigated in this research.

Cattle dipping in South Africa commenced early in the 20th century in Natal (KwaZulu Natal) in regions where cattle farming was prevalent. The practice had spread from the initial introduction in other cattle producing countries such as the USA, Australia, Scotland, England and New Zealand during the late 1800s – as control measure to address tick-borne diseases. The South African service was, however, accelerated during the formative years of the twentieth century, from approximatelty 1903 onwards, after the outbreak of the ECF disease in the country. This disease was preceded in 1886 by rinderpest, a cattle disease that nearly crippled the South African cattle industry. Cattle were subsequently imported from India and Australia to replenish the numbers that were depleted by rinderpest. En route to South Africa and Zimbabwe the imported cattle, however, picked up the ECF disease around Mombasa, Kenya, where it is endemic, while they were temporarily off-loaded for grazing before proceeding to the ports of Beira, Lourenzo Marques (both in Mozambique) and Durban (South Africa). As a result of cattle dipping and other supplementary measures inplemented during the first half of the 1900s, ECF was subsequently eradicated in South Africa by 1954.

The practise of stock dipping in South Africa was administered under various legal instruments and Acts, which are:

- Ordinance No 38 of 1904
- Diseases of Stock Act 14 of 1911
- Dipping Tanks (Advances) Act 20 of 1911
- Animal Disease and Parasite Act 13 of 1956
- Animal Disease Act 35 of 1984
- Animal Health Act 7 of 2002

During the 1910s commercial cattle farmers were responsible for the establishment of their own dips, while communal cattle owners were provided for by the then Native Affairs Department (NAD). The NAD provided both human resources for administration and technical skills, and capital infrastructure like the construction and maintenance of dipping tanks. Since there was no paddocking in the communal areas and cattle owners were scattered all over these areas, dip tanks were placed at central locations where one dip tank could serve cattle owners from several surrounding villages.

Dipping became a common activity in the communal areas from the time it was introduced, after about 1915, and has remained so up until today. It was used as an incentive to lure communities to accept villagisation after the report and recommendations by the Tomlinson Commission of 1955. The management of dipping services was later transferred to the departments of agriculture of the respective homeland admistrations when black territories were turned into homelands. However, the dipping service became a casualty of the new political dispensation in 1994, when the nation-wide dipping service to communal areas was terminated by the new government.

This research was approached by investigating the Venda context of cattle dipping practice from each of the three main pillars of sustainability, namely the environmental, the economic and the social perspective, as well as the fourth dimension of governance. For the practice to be sustainable there has to be a significant overlap of every one of these four spheres and an overall significant level of sustainability; or else it needs to be shown that sustainability in each of the spheres is sufficiently significant. The rationale behind this approach was to facilitate establishing a sustainable cattle dipping model in the area, as such a model can greatly aid the Veterinary Division of the Limpopo Department of Agriculture, who handles cattle dipping matters in Venda, in their process of developing a new cattle dipping policy.

In the light of the above aim, the following objectives were specifically pursued in this research:

1. An exploration of the historical background to the development of cattle dipping in Venda within the context of the South African political ecology was considered necessary due to the close association of dipping with the development of the South African political landscape of separate development.
2. In order to provide insight and understanding of cattle dipping practices, a comprehensive literature review was considered an essential element of this research. This review included the following aspects: the nature and characteristics of ticks, their life cycle and geographic distribution; the impact of ticks and tick-borne diseases; and tick control measures.
3. The research included an investigation of cattle dips localities, and mapping their distribution in the study area. The location of dip tanks was studied in terms of their proximity to residential areas and watercourses, as this information is relevant in analysing ecological and social sustainability.
4. An investigation of the ecological sustainability of dip tanks was undertaken by investigating the occurrence of chemical contaminants around the dip tank sites.
5. An analysis of the economic dynamics of cattle dipping in the former Venda area was similarly done to ascertain the economic sustainability of this practice.

6. An examination was also carried out of the social sustainability of dipping tanks in Venda in terms of social cohesion and capital.
7. Detailed research was made of the Limpopo Draft Cattle Dipping Policy of 2004, and its 2011 update, to ascertain the sustainability of current policy, within its institutional constraints and the legal framework that exists.
8. The deficiencies identified in the foregoing steps led to the development of a Sustainable Community Cattle Dipping Model (Chapter 7) for consideration for policy framework development and future implementation.

As the data in the study were geographical, it enabled the researcher to explain spatial issues. Several methods were employed for the collection of information, including literature and archival searches, various field methods and observations, focus group surveys and key informant interviews.

8.2 RESEARCH OBSERVATIONS

A number of observations and deductions can be made from this study. In line with the the sequence of the preceding chapters, the results are presented in the following order: 1) environmenmtal sustainability, 2) economic sustainability, 3) social sustainability, and finally 4) the sustainability of governance.

8.2.1 Observations on Environmental Sustainability

Elevated levels of bioavailable arsenic in mining soils, in agricultural areas, and around human habitats may potentially cause toxicity to plants, microbes and animals and negatively affect human health. The investigation of arsenic contamination in soils surrounding dip sites was done at ten dip sites; however, there are other dip tanks spread all over the area where arsenic has been used. It was observed in this study that there is a high persistence of arsenic at the places were the earlier communal dip tanks in the former Venda area are located, indicating that the occurrence of arsenic in the area is not geogenic but anthropogenic.

The extent of contamination in more than two thirds of the tested sites far exceeds the maximum allowable value of arsenic concentration in drinking water of 0.01mg/l, as laid down by the World Health Organisation (WHO, 1981). The high concentration of arsenic closer to the tanks could be attributed to the collection of dip effluent that was discharged either into the nearby poison pits or discarded onto the soil directly around the tank areas during cleaning, and also from the dripping of the dip solution from the cattle as they leave the dip tanks. Although arsenic contamination decreases with distance, it still shows higher concentrations some distance (20 m) from the tanks, which can be explained by the movement of cattle: the dip solution drips to the ground as they leave the dip tanks and move further away whilst their bodies are still wet. One other observation made is that the highest concentrations of arsenic contamination is found at sites where red clay and loamy soil with high organic content is present, which confirms that arsenic is more adsorptive to such soils.

There is a likelihood that the health of people who have been exposed to the chemical for a long time, for almost a century in this area, have been compromised. This could have happened when people worked with soil in the areas adjacent to the dips, as the chemical can be inhaled along with the dust to which it adheres (is adsorbed); it can also be ingested with food or directly. Clark (1946) reported cases of arsenic poisoning of humans resulting from cattle-dipping tanks as early as 1946. Furthermore, although the extent of underground water contamination was not determined in the current research, arsenic in these heavily contaminated soils surrounding dip tanks could have leached into the underground water; also due to the practice of arsenic contaminated water being discarded into unlined french drain pits and surrounding areas when the dip tanks were cleaned in the past. This is an aspect that needs to be investigated if the bigger picture of environmental contamination is to be established.

Based on these results, an inference can be made that all the dips in Venda where arsenic was used as a pesticide from 1915 to 1972 could be contaminated by the chemical. The dip tank sites should therefore not be taken as only the visible part of the rural landscape were cattle used to gather, and still gather for the control of ticks and tick borne diseases. It also has to be considered that such sites still pose risks to the natural environment and human health. Owing to a continuous threat of the outbreak of animal diseases, the current policy of the Limpopo Department of Agriculture is to continue with the provision of veterinary services in the communal areas. Apart from cattle dipping, this further involves the surveillance of controlled diseases such as Foot and Mouth Disease (FMD); monitoring the general health of cattle with the aim to establish an early warning system; conducting animal censuses; and rendering extension liason to cattle owners (Mampane, 2004; 2011).

The persistence of arsenic in high concentrations in the dip site areas of the communal areas, and its subsequent potential of contaminating and poisoning the surrounding soils, vegetation, microbes and watersources leads one to conlude that although the purpose of eradicating ECF was realised, the use of arsenic as a pesticide has not been ecologically sustainable.

The communal landscape in Venda is still dotted with functional and disused dip tank sites. Some sites are being encroached by expanding settlements, and in some cases the disused sites are turned into other land uses such as maize fields and sports fields. These aspects pose some challenges to the management of the dipping sites and the establishment of future dipping policy. Since they pose a threat to the health and wellbeing of surrounding communities and to the environment, their running must not be looked at in isolation; but has to be more integrated into land use considerations and stock disease control policies. Some recommendations that may assist in the management of cattle dips in the communal areas are suggested in Section 8.4.

8.2.2 Observations on Economic Sustainability

The economic pillar of sustainable development argues for the satisfaction of human needs in the long term, which means that sustainability ought to be directed towards the relationships between nature and society. Economy includes all services, institutions and infrastructure that are used for production and consists of formal, monetary and informal economic activities, as well as the consumption of the produced goods and services (Littig and Griessler, 2005).

With regard to the introduction of dipping in South Africa, it has been observed that because cattle dipping reduced cattle mortality and also kept animals in good health, it has helped sustaining the cattle industry and its related economies in Venda. Although the earlier administrative requirements associated with cattle dipping limited the selling and trade of cattle, the survival of cattle numbers through dipping helped to sustain the traditional economic system. An economic activity that stands out in this regard is the system of using cattle as a form of currency. This form of investment includes the use of cattle as a source of labour as draught animals for working the fields and to provide transport, and also to serve as payment for brides. Amongst the Venda people cattle remain of their most prized possessions.

Dipping also helped in the promotion and sustenance of the traditional informal economy. Dip tank sites became centres where local traders could sell their wares and they were also good sites for advertisement: when stock owners intended to sell live cattle or slaughtered animals for meat, it was mainly announced at the dip sites. Traders and local butchers also used the sites for buying stock.

The current state of affairs in Venda is that the existing dip tanks are not used to their maximum capacity, as the number of cattle in the communal area has decreased, while dipping continues. This poses a challenge in policy development, because for dipping to be viable in the real economic sense, the number of tanks should be reduced. However, given the ever present threat of FMD in the area, the economic gains achieved through dipping should not be jeopardised by limiting the current extent and use of cattle dipping facilities in the area, as this would negate gains already made.

8.2.3 Observations on Social Sustainability

The social dimension of sustainability encompasses the political, the cultural and all people-centred issues. It means ensuring that the basic conditions for human life to exist and flourish are not compromised. The conditions include the protection of people from harm, facilitating social interaction and sense of belonging, promotion of equity, empowerment through education, poverty alleviation and health care, amongst others.

The research findings in this study show that there have been some significant social positives and negatives associated with the provision of dipping. These aspects are discussed in the sections following.

8.2.3.1 Positive social aspects emanating from the introduction of dips

Firstly, had it not been for the introduction of dipping, ECF could have totally wiped out cattle husbandry in the communal areas, which could have negatively affected the social systems of the Venda community. Cattle have been highly treasured among the Venda community over centuries and this is still the case today. Cattle are used in marriage systems, worship rituals, burial rites, and so forth. An interesting aspect of the importance of cattle in the social realm of Venda is that even though cattle are usually no longer exchanged as payment for a bride (*lobola*), the tradition is still expressed in terms of the number of cattle paid for the bride; which is usually set at eight head of cattle.

Secondly, the introduction of dipping introduced the community, and cattle owners in particular, to the new innovations of minimizing the impact of tick infestations. Dipping did not only lead to the eradication of ECF, it also helped in the general improvement in the health of cattle. It also facilitated the extension of knowledge about cattle diseases, since while cattle owners were scattered over wide areas, it was at dip tank areas where important forums for interface between cattle owners and government veterinary officials took place. Cattle owners benefited in terms of education and training received on how to monitor and identify diseases in animals; this in turn contributed significantly to the elementof empowerment in social sustainability.

Thirdly, dipping in the communal areas promoted an element of social unity and cohesion. This was, and still is, evident in activities such as the cleaning of dip tanks, which is done collectively by all cattle owners; and a cultural recreation of bare-knuckled boxing tournaments that bring community members together during dip days. Furthermore, the coming together of cattle owners has helped with the control of stock theft in the past, since cattle owners became familiar with the herds of their cohorts. Also, the regular meetings of personnel from the veterinary division with cattle owners resulted in the formation of associations, some of which sustained the cattle owners during the time when there was a breakdown in service provision by the government between 1994 and 2004.

Fourthly, in general communities also benefited from dipping practices. Menfolk gathered at dip tank sites prior to dipping and shared and exchanged views on tribal issues. Linked to general community benefit was the aspect of recreation which assumed various forms: the dominant ones were bare-knuckled boxing tournaments amongst able bodied men from different villages, and bull fighting. Such recreational activities promoted social respect amongst the cohorts from different villages.

8.2.3.2 Negative social aspects observed from the study

Firstly, the proximity of dip tanks to rivers and villages suggests an element of environmental injustice as the fact that most of the tanks are not fenced and they are also poorly maintained implying that the location of the tanks poses safety and health risks to the surrounding communities. Furthermore, the issue of the future expansion of settlements was overlooked.

Secondly, where dip tanks are located closer to watercourses, dip effluent, especially during cleaning from the dips that are located up-gradient of streams, can easily flow into the streams. This has compromised, and ~~it~~ still compromises, the health of the communities that directly make use of streams as sources of water. Also, arsenic contaminants could have run into streams and contaminated aquatic life or accumulated in the stream sediments over the last century. Where water impoundments such as dams and weirs are constructed in places closer to the dip sites, the filling up of dams could have flooded the dip tanks. A case such as this has been recorded in the study area; the Musekwa dip tank was submerged when the Nzhelele Dam filled up in 1948 (National Archives of South Africa, NTS 10751 - Native Affairs 1951).

Thirdly, the issue of cattle dipping as a service that was provided for by the state promoted an element of dependency, as the state provided almost every aspect that was associated with cattle dipping up to 1994. Although cattle owners were expected to pay cattle tax, the amount was small compared to the cost of the service. The issue of dependency became more apparent between 1994 and 2003 when the government-sponsored dipping was withdrawn and cattle owners had to fend for themselves during that period. Very few cattle owners, especially those with large herds, managed to buy chemicals for their animals. Those who could not afford either relied on the crude methods of using old engine oil, paraffin, and traditional herbs to treat their animals, or they eventually sold their stock and abandoned cattle ownership.

8.2.4 Observations on Sustainability of Governance

Various pieces of legislation have been passed since 1911 to give impetus to the policy of cattle dipping in order to eradicate cattle-borne diseases, primarily ECF. The respective acts were in force during the different governance regimes affecting the Venda area throughout the last century, including when Venda was a Native Reserve (1913-1969), a Self Governing Territory (1969), a Homeland (1972-1978), and a Republic (1979-1994), as well as the time from 1994 to the present with the region is now being administered by the Limpopo Department of Agriculture. Throughout these changes of regime and administration, the staff involved remained reasonably constant, with mainly their head offices changing. It has nevertheless created considerable confusion, and the worst casualty occurred in 1994 with the termination of the dipping practice as it had been running for over 79 years.

The negative impacts of terminating the dipping service in Venda are the following:

1. Dip assistants who lost their livelihoods.
2. Loss of trust in the system and in government by cattle owners.
3. Deterioration of dipping infrastructure, where structures started to collapse, as no maintenance was done for nearly ten years. Siltation and vandalism of dip tanks also occurred, as well as the alternative and often hazardous uses of these facilities.
4. Loss of income and market by chemical suppliers.

Despite the gradual re-start of the dipping service since 2003-04, the many changes of regime and politico-administrative systems has ultimetely resulted in a loss of continuity and of institutional memory, but perhaps the worst tragedy has been the collapse and loss of most cattle census records which had been kept for nearly eight decades. The 2004 and 2011 Draft Limpopo Cattle Dipping Policy is seen as a positive contribution toward getting the service back on track, but it contains a number of limitations, most notably the following:

1. The strategy appears to focus on the enhancement of animal health, at the cost of other related aspects such as the relative location dip tanks, the discarding of dip effluent, and the management of disused dips. The use of compounds and related environmental health issues receive very little attention.
2. Government-sponsored cattle dipping service is currently only provided in the areas adjacent to the Kruger National Park (KNP), or the infected zones, and not in all communal areas as before. Areas away from the KNP are therefore excluded from the free service.
3. The policy does not consider the role of district and local municipal bylaws and how they affect Primary Animal Health Care (PAHC) and the management of dipping systems. The PAHC stakeholders that are referred to (State Veterinarians, Animal

Health Inspectors, Cattle Owners, and Community Based Animal Health Workers (CAHW)) appear in isolation, and the policy is not clear on how these stakeholders should interact.

4. The draft policy does not address the financial failure of the previous policy up to 1994. Issues of finances are central to the success or failure of any project. Since the draft policy does not address financial sources and management, it is possible that the success of PAHC may prove not to be as successful as hoped for by the authorities.
5. The issue of national coordination between provinces and areas of outbreak of infectious diseases is lacking in the policy document.

To again achieve the coverage of dipping and preventive animal health care that was in effect up to 1994, the present service needs to be enhanced considerable. Ultimately, cattle dipping should not be taken as an end to itself, but rather an implementing strategy that helps to achieve sustainable development goals.

8.3 SUMMARY

This thesis on the sustainability of past cattle dipping services in Venda has demonstrated that dip tanks are not entities that can be studied in isolation. They are not just physical structures, but part of socio-political realities that reflect structure-agency relationships which are influenced by societal and institutional rules and norms. These structures are dynamic and always in the state of becoming, and as such, there have to be measures put in place to accommodate and adapt to changes without jeopardising the structure-agency relationship.

After the outbreak of ECF, an extensive government-sponsored programme was introduced in Venda in 1915, which continued until 1994. In between, 1954 to be exact, the disease was eradicated. The government's objective of eradicating ECF, was thereby realised. Looking at cattle dipping from the sustainability perspective, however, the dipping programme had some limitations. The ecological aspect was not highly prioritised and as a result significant concentrations of arsenic as one of the dip chemicals has been found around most investigated dip tanks. Socially, the location and management of many dip tanks seem not to have adequately accommodated peoples' safety. Economically, when the government reached a point where it could not continue to sponsor the programme, the programme was abandoned. This has had repercussions for the local cattle farming community, as many community activities associated with dipping were curtailed.

A new challenge that arose in the realm of cattle rearing is the outbreak of FMD in 2004; which made the government consider the reinstatement of the dipping programme. As cattle dipping in the communal areas continues, a robust programme that considers all aspects of sustainability is therefore required. Currently, the Veterinary Division of the Limpopo Department of Agriculture has produced a draft policy about dipping. However, as it is outlined in Chapter 7 of this thesis, the policy has some limitations that need to be taken into consideration. In order to address these limitations and also to come up with an efficient communal dipping practice in future, this study proposed an all inclusive multi-stakehoder approach to be adopted in the management of cattle dips in the communal areas.

From the history of the establishment of cattle it is presumed in this research that the government has been the main stakeholder in providing the service, as other stakeholders including traditional leaders and cattle owners have played a more limited role. Because of this, the purpose of dipping was nearly defeated when the government withdrew the service in 1994.

The multi-stakeholder approach involves the partcipation of all concerned stakeholders, what Velasquez et al. (2005) call an *Innovative Community*. The concept refers to a group of people who have common interests and are able to bring about change and innovation to progress towards a sustainable society. In as far as cattle dipping is concerned, the stakeholders may include the veterinary division of the Limpopo Department of Agriculture, cattle owners, the general public, and the governance structures, namely, the traditional leadership and the local municipalities. The sustainability of cattle dipping in this context can be realised by adopting a suggested Sustainable Community Cattle Dipping Model which was developed as part of this thesis. It is envisaged that this model will change the manner in which the various dipping stakeholders perceive and interpret their environment and, therefore create a new avenue for accordant dipping management

8.4 RECOMMENDATIONS

8.4.1 Adopting the Sustainable Community Cattle Dipping Model

This model consists of four major stakeholder groups that interact around the provision of dipping services in the communal areas, and describes the interactive processes and mechanisms between them. The four groups are the local authorities and other governance structures; the Veterinary Division of the Department of Agriculture; the community and the cattle-owners (as subset of the community). A brief overview of the mechanism of this model is now provided.

As a public entity responsible for resource allocation and distribution, local authorities should ideally manage dip sites and their operations, including land management of disused sites. To do this effectively, they need to build up and maintain a database of operational and disused dips, which should include statistics like their location, age and condition, and record of chemicals used in the past. These databases can be beneficial with future land use planning, and also to form the core of environmental legal registers.

Dip tanks are the only viable meeting points for continued extension of veterinary knowledge to communal cattle owners by the Veterinary Division of the Department of Agriculture in Limpopo Province, who recognises their critical importance. Dip tanks will therefore always form a core part of livestock farmers' space and can be brought on board through the formation of functional farmers associations. Cattle owners can also participate through their respective associations in activities such the physical maintenance of dips.

The involvement of local communities in the planning and use of dip facilities can promote the spirit of ownership and appreciation, and can contribute to local resources being managed more effectively. For instance, dips should be appreciated as capital resources belonging to communities, while the occasions that they are in use can also be utilized as an opportunity to make the community aware of some dangers associated with dip tanks and associated chemicals, as well as the safe management and maintenance of dip sites. By having communities involved, parents will be better alerted to the dangers that these facilities pose to young children.

The handling and disposal of dip chemicals and effluent should be done by people with proper training concerning the safe handling of chemicals, while dip tanks close to settlements should be fenced in order to limit the many exposure pathways that children and rural societies are subjected to.

8.4.2 Further Recommendations

The extent of arsenical contamination in other sites where arsenic was used is not known. Soil tests need to be extended to other sites in order to have a better picture of the extent of contamination, as well as to have baseline information for uncontaminated areas. This will help in the identification and implementation of appropriate protective remediation measures.

Amongst others, such measures include:

1. Erection of warning signs around the perimeter of contaminated areas.
2. Removal of soil off the contaminated site to a secure storage area such as an official landfill.
3. Capping or sealing of contaminated sites using soil layers, asphalt or concrete.
4. Cleaning or rehabilitating the contaminated areas by planting arsenic tolerant plants that can reduce the amount of arsenic through absorption. This method is called bio-remediation.

Dip tanks that are found in areas that have a potential of being developed into residential areas or townships should be discontinued or relocated. If such tank sites are contaminated, soil can be excavated and replaced by clean soil and the contaminated areas completely rehabilitated thereafter. The public should also be dissuaded from turning disused dip site areas into other land uses such as cultivated lands or gardens for growing maize, vegetables, and fruit trees. It is in this regard that the keeping a database and bringing the public on board could be important. Furthermore, since dipping sites are not compatible with residential development, buffer zones may be established between dip sites and residential areas. A buffer zone of width 200m as recommended by the Lismore City Council in New South Wales, Australia, can be adopted (www.Lismore.nsw.au/ content/Chapter11_Buffer Areas.pdf).

Besides contamination, disused tanks that are found next to settlements can form water pools that may be the breeding areas of malaria carrying mosquitoes. This may happen in many areas in the lowveld. Such tanks should be sealed with concrete or be covered by soil.

Previously, when dip tanks were cleaned, effluent was either physically disposed of into the poison hole or to the areas adjacent to the tanks. This compromised the health of dip handlers, communities, and the surrounding environment. For the safe disposal of dip effluent, it should be pumped into the safe tanks and taken to safe areas of containment.

In the debate regarding the sustainability of cattle dipping in the communal areas in this research, one observes an element of paradox. The service directly and indirectly provided benefit to both commercial farmers and communal cattle owners in sustaining the cattle industry in their respective farming sectors. Even though only limited direct wealth benefits could be accounted for by the communal cattle owners, their wealth in cattle ownership was somehow sustained. Socially, cattle dipping promoted unity and social cohesion and also helped in the perpetuation of cultural systems. On the other hand, the introduction of dips has resulted in some negative social and environmental ills, most of which were either ignored or not taken seriously. For instance, the location decisions of placing dip tanks mostly overlooked public safety and health concerns, and the chemicals that were used earlier in dipping practice are now understood to have been toxic to the surrounding environment, biota and humans.

Owing to the fact that these old dip tank facilities still exist, while others are in disrepair or disuse, there is a challenge that the activity should be carefully implemented and managed because its impacts may continue to create ongoing and long term environmental problems. The policy to this effect would not only include the provision of service for the control of FMD, as it is proposed in the Limpopo Department of Agriculture's draft document, but it should also include how to protect the environment and to empower the public. The whole dipping exercise should be holistic and integrative as suggested in the recommendations above.

8.5 CONCLUDING STATEMENTS

This thesis has made the following contributions to research in geographic studies related to cattle dipping activities in the Venda area of South Africa:

> First, it has demonstrated that the activity of cattle dipping is a spatial entity that reflects the dynamics of structure-agency dynamics.
>
> Second, it has illustrated that there were some limitations of cattle dipping practice when examined from a sustainability perspective; for example, the occurrence of arsenic residues around the dip tanks suggests that cattle dipping has contributed to environmental contamination in the rural areas.
>
> Third, it was made apparent that the implementation of communal cattle dipping in the future is not sufficiently addressed by the current Draft Limpopo Cattle Dipping Policy but that it would be much enhanced by expanding it to incorporate the Sustainable Community Cattle Dipping Model which was developed in this thesis.

The overall aim of this geographic research was to explore and evaluate the ecological, economic and social realities of cattle dipping practices in the former Venda communal areas of the Limpopo Province. This has been premised on the concept of sustainable development discourse, according to which development aims should accommodate ecological, economic, and social goals, as well as governance aims. This argument proceeds from the viewpoint that human needs cannot be sufficiently met by providing only an ecologically stable and healthy environment, but that cultural needs ought equally be taken care of in a society committed to sustainability. Littig and Griessler (2005) therefore consider economic, social, and cultural conditions, efforts, and values as resources requiring preservation for future generations. DEAT (2008) add the dimension of governance to the sustainability mix, by recognising the embeddedness of social, economic and ecosystem factors within each other, which are underpinned by our systems of governance. Sustainability therefore implies the continuous and mutually compatible integration of these systems over time.

It is generally implied that these four components are integrated into development, and that change in one component unavoidably triggers responses in the other two (Shackleton et al., 2011), while Middleton (1995) regards the purpose of sustainable development as ensuring physical, social and economic continuity with the least disruption to the community. In line with this thinking, UNCED (1992) argue that the judicious exploitation of the natural environment is essential to ensure the continued livelihoods of communities.

In this thesis I have proven that the past cattle dipping practice in Venda can be regarded as sustainable only in terms of its economic component, while with its ecological, social and governance components, the scales tip away from sustainable outcomes. In this regard the service provider, Veterinary Division, will have to take ownership of, and responsibility for, the ecological and environmental impacts resulting from past and current dipping practices. Despite the social benefits of dipping practice in the past, the risk of arsenic contamination to soils and watercourses, and thus to human health, as well as the dangers posed to communities, especially children, by ill-maintained and derelict dipping facilities, outweigh the positives. The ceasing of dipping operations in the communal areas for the decade from 1994, with the exception of the 'infected zone' and 'protected zone' where dipping services were continued free of charge to prevent FMD outbreaks, had a serious effect on the gains made over nearly eight decades. Although legislation has been in place to deal with cattle dipping for over a hundred years, it now requires more responsibility allotted to the service provider, especially in terms of harm to the environment and to human health – in accordance with the polluter pays principle, before the governance component of dipping in Venda could be considered sustainable.

The conclusion is therefore that on three of the four sustainability measures, past cattle dipping practice in Venda should be considered unsustainable. To address this, a Sustainable Community Cattle Dipping Model which addresses the shortcomings of the existing 2011 Limpopo Draft Cattle Dipping Policy was proposed. If the proposals made in the model are adopted and implemented, future cattle dipping practice in the former Venda area can indeed be more sustainable, as it provides for a governance structure which will underpin and facilitate the integration of improved ecological, social and economical outcomes relating to cattle dipping in Limpopo.

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ANNEXURE A

DIPPING POLICY 2011
DEPARTMENT OF AGRICULTURE
LIMPOPO PROVINCE

1) DEFINITIONS

1.1) DIPPING SERVICE
The provision of a dipping compound, handling facilities and human resources to dip cattle at communal inspection points.

1.2) FOOT AND MOUTH CONTROL AREA
The Foot and Mouth Disease (FMD) control area is divided into two zones namely infected zone and protection zone. Apart from the mentioned zones, the rest of the RSA is an FMD-free area which includes an inspection area along the FMD control area.

1.3) DIPPING COMPOUND or DIP-STUFF
This is a compound that is used to control ticks. It can be applied in the form of plunge dipping, spray, or as a pour-on, depending on the prevailing dipping facilities and the support systems in place. The senior manager Veterinary services Limpopo Province will determine the dipping compound to be used. In his decision he will consult field personnel, industry, current contracts available, tick-resistance against acaricide, statistics and other scientific data to his availability.

Wherever possible, plunge dipping will be preferred over pour-on application as it is far much cheaper.

1.4) DEPARTMENT
The Department of Agriculture Limpopo Province

2) THE HISTORICAL SITUATION

In the past the government provided a dipping service, which included provision of dipping compound, maintenance of dipping facilities and personnel to dip animals in communal areas. Due to financial constraints, this service was then restricted to the Foot and Mouth Disease control area. There were many requests for extension of the service to other areas, but the limiting factor was the funding thereof.

Various initiatives were made by farmers, but in most cases, the service was ineffective due to usage of cheap, improper compounds or weak concentrations where the compound was the correct one. Many animals actually died from poisoning in some cases.

This shows that owners do have the will to dip their animals, with the limiting factors being affordability or failure to fully appreciate the benefits of dipping e.g. selling of some animals to buy dip-stuff to care for the others, ensuring good quality thereof.

In the Foot and Mouth Disease protection zone adjacent to the Kruger National Park, it is of utmost importance to inspect cattle weekly for symptoms of the disease. The above areas are also heavily infected with various species of ticks and other external parasites. A dipping service is necessary to lure the cattle owners to the inspection points, primarily to inspect the animals but also to give a tick control service back to the owners for their co-operation and efforts. Communities in the buffer zone adjacent to buffalo or where roaming buffalo may occur are also exposed to Corridor disease in cattle and regular dipping kills the brown ear tick which is the main vector.

Ticks also cause a host of other diseases which cause tremendous losses to communal farmers.

The advantages of dipping should be indicated in line with the Departmental goals of ensuring food security and eradicating poverty. Healthy livestock will go a long way in promoting these ideals. The importance of cattle in providing milk, meat and other products as well as draught power cannot be overemphasised. Generation of revenue through livestock sales had seen many needy families thrive and escaping from the poverty trap.

Many unemployed people are actually sustained by benefits from livestock.

Dipping ensures good animal health, obviating spending on costly drugs to treat tick-borne diseases and promotion of good udder health.

Presently the Department funds dipping which is coupled with inspection of animals for controlled animal diseases. Animal owners are encouraged to purchase their own dipping compounds to supplement the service while the provincial government is providing the facilities and the technical skills and also maintain the facilities.

Some of these facilities were renovated under the CASP programme, whilst some new ones had also been constructed. The establishment of dipping or livestock committees at each dippping tank was encouraged among animal owners, and with a few exceptions, these committees are working well.

In most cases, cattle owners contribute to a dipping compound fund administrated by the committee, and those not contributing are not allowed to dip their animals. Although many owners accept the responsibility of the welfare of their animals, there are also, those that do not care and their animals are a source of ticks and other diseases to the rest of the community. In some instances, these owners are not even allowed by the other owners to bring their cattle to the dipping tank for inspection, making it difficult for Veterinary Staff to do disease surveillance. This is discouraged as effective disease control revolves around almost all animals in a specific area being inspected. Disease control within a communal grazing system is very difficult for the individual farmer, and the government has an obligation to control and enforce animal health issues in these circumstances.

3) THE BENEFITS OF A DIPPING SERVICE

The benefits of a dipping service are two fold; those to the owner/community, and those for government.

3.1) THE FARMER / OWNER

To control ecto-parasites of animals in order to control / prevent tick-borne diseases such as heartwater, redwater, gallsickness, theilerioses, sweating sickness and reduce blood loss, tissue damage and irritation caused by ecto-parasites.

To control other ecto-parasitic and related diseases such as myasis, parafilariasis, trypanosomiasis.
Efficient tick control results in healthier animals, more milk production because of less udder tissue damage, higher calve percentages because of less tissue damage on genital organs, higher market value for skins again because of less tissue damage and this all leads to a better valued animal or product at the market place.

The dipping service provides a regular animal health advice and other advice service, to the farmer, at the inspection point. It also gives a regular communication and contact point with the Department from where specialist advice and services can be requested. This ensures services at regular intervals at ground level.

3.2 THE DEPARTMENT

Disease surveillance

Inspections in respect of controlled diseases such as Foot-and-Mouth Disease.
This function of international, national, provincial and local importance is based on compulsory inspections at various intervals and movement control of various intensities in the whole of the FMD controlled area, as well as on compulsory vaccinations in certain zones.
Through the decades, a situation developed in the communal controlled areas whereby these compulsory inspections and vaccinations, as well as movement control to a large extent, were performed at communal dip tanks. In practice cattle owners bring their cattle herds to be dipped at communal dip tanks at regular-intervals. The opportunity whereby cattle are physically concentrated at certain points is then utilised by the State to perform compulsory cattle inspections, vaccinations, movement control and other disease control practices.

Due to cattle herd sizes and numbers of herds in the communal areas and budgetary deficit affecting personnel, dipping compounds and transport provision, there is no other practical or affordable way of controlling FMD and other diseases in communal areas than the current method of assembling at a common inspection point.
For the sake of upholding our country's internationally acquired status of having a FMD free zone and our favourable status for other diseases, it is absolutely essential to maintain a satisfactory level of control of this disease in the controlled areas. Most of our control activities are coincidentally in the communal farming areas.

The ideal opportunity created by dipping for disease surveillance such as for brucellosis and tuberculosis, as well as for other controlled, notifiable and other conditions affecting the health of animals should be utilised to the full by the State, especially in communal areas.

For the same reasons as mentioned for FMD control, it is virtually impossible to perform disease surveillance properly and significantly in communal areas in the absence of the communal cattle dipping set up.

Surveillance of non-controlled diseases

Surveillance of the status of animals with respect to condition, general health, production, and reproduction as well as monitoring of mortalities is also made possible by the communal cattle dipping system. This regular inspection during dipping gives Veterinary Services the ability to establish an "Early Warning System" regarding any disease condition and precautionary measures can be activated.

Extension and liaison

The opportunity for effective extension, education, training, practical demonstrations and uptake of accurate census data and calculation of stock density, where many animal owners, managers and handlers are congregated at places due to the communal cattle dipping practice should be well appreciated. The costs of performing extension effectively without this opportunity would be enormous, rendering extension unaffordable and unachievable. The essential role of extension in the promotion of animal and human health and welfare in particular, and the RDP in general, is well known.

Animal census

The dipping service gives the opportunity to the Department to have accurate livestock census.

Image of the Department and building of relationships.

To uphold the good image of the department amongst its clients and the general public and to enhance public relations in particularly the FMD control zones with its movement restriction and regular inspections, etc. is of importance in the sense that effective animal disease control and promotion of animal and human health and welfare without a positive image and sound public relations is virtually unachievable. Because of the perception and obvious benefit of dipping to farmers, the effect that dipping has on the image of the department is immense.

Immunity against tick-borne diseases

Whilst intensive dipping can lead to a minimal disease situation with low immunity, it is believed that this seldom occurs in practice, due to heavy tick challenge and/or irregular dipping frequency because of various reasons such as water supply problems and weather conditions. Jointly managed strategic dipping between the dipping committees and the Department will result in efficient immunity status within cattle groups.

Ectoparasite resistance against ectoparasiticides

This is a problem of major concern and is in many cases a result of indiscriminate use and alteration of ectoparasiticides. Being involved in the dipping service in these disease risk areas will give the Department knowledge and a role to play in this important facet of animal health.

Environmental considerations

The effect of dipping on demographics and therefore on overgrazing and the possible risk of environmental pollution should be considered in planning and execution of dipping programs. The uncontrolled use of ectoparasiticides may lead to poisoning of animals. The Department will now be able to control this. Only dipping compounds without adverse effects to the environment will be used.

Veterinary public health
The uncontrolled use of registered and unregistered chemicals to control ticks may lead to the presence of residues of such chemicals in the human food chain, which is highly undesirable. The involvement of the Department will reduce these occurrences.

4) POSSIBLE CONSEQUENCES IF NO DIPPING SERVICE IS PROVIDED

Farmers / owners and the Department will not have the benefits as discussed above.

The status of FMD will not be known in the FMD control zone. No guarantees can be issued to trade partners.

If FMD occurs in the control zone, it might have spread some distance before being detected and this might cause a more complicated and costly eradication campaign. If FMD spreads out of the control zones, South Africa will lose its free status and that will result in export bans and subsequent financial losses for the country and farmers.

Other diseases can cause problems if allowed to be established in herds if an Early Warning System is not operational.

Farmers /owners will have financial losses because of ticks and tick borne diseases and deaths.

PROVISION AND FREQUENCY OF DIPPING

The Department will provide a dipping service for cattle in the communal areas of the province.
The dipping service will be done at established dip tanks and inspection points.

Dipping will be weekly in the FMD-protection zone adjacent to the Kruger Park and adjoining reserves,

Fortnightly in the remainder of the FMD-protection zone

Every 28 days in the rest of the communal farming area of the province. Where a desire for more frequent dipping arises, this can be organized at the farmers' expense.

If on the day of dipping, during the routine inspection, the dipping committee and the responsible animal health technician decide jointly that dipping is not necessary on that day; the dipping can be postponed to the next dipping opportunity. The dipping when tick numbers justify dipping is called Strategic dipping and this type of dipping program is encouraged because it gives livestock the best opportunity to develop and maintain an immunity against tick borne diseases and less chance of tick resistance being build up against the dipping compound.

This service will cover only communal farmers. Other categories of farmers either than communal farmers will be encouraged to have a sustainable tick control system at own cost, with the Department providing the technical skills.

FINANCIAL IMPLICATIONS FOR THE DEPARTMENT

The Department will fund the dipping service fully.

The Policy will be revised whenever necessary.

The End